Earned Schedule

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Session I

Basics of Earned Value

We are here to know……

“HOW TO GUIDE OUR PROJECT BY PROJECT MANAGEMENT TOOLS”

time management

Project Monitoring

- “Monitoring is collecting, recording, and reporting information concerning any and all aspects of project performances that the project manager and all other in the organization wish to know.”

(Jack R. Meredith, Samuel J. Mantel)

Monitor (PMBOK® 3rd & 4th* Editions)

- Collect project performance data with respect to a plan, produce performance measures, and report and disseminate performance information.

* Yet to be released

Project Monitoring

- What tools can I use?
  - Meetings
  - Reports on progress
  - Reports on finances
  - ERP (enterprise resource planning)
    - comprehensive concept about providing communicating network between projects, programs and portfolios management system

Project Controlling

- "Controlling is determining what is being accomplished, that is, evaluating performance and if necessary, apply corrective measure so that the performance takes place according to plan."

(George R. Terry)

Control (PMBOK® 3rd & 4th* Editions)

- Comparing actual performance with planned performance, analyzing variances, assessing trends to effect process improvements, evaluating possible alternatives, and recommending appropriate corrective action as needed.

* Yet to be released

Project Controlling

- ALL about controlling;
  - Establishing standard- Performance Management Baseline (PMB)
  - Measuring performance against these standards
  - Correcting variations from standard
- How can I Monitor & Control my project;
  - Gantt Charts
  - Variance Analysis
  - Leading parameter technique
  - Activity based ratios
  - Earned value & Earned Schedule

Construction Projects…. Today's Situation

- 70% of projects are:
  - Over budget
  - Behind schedule
- 62% of projects finish at 25-30% more than initial budget
- And after huge investments of time and money answer is simply……
- ……."Still….Not….Finish"
- Source: The Standish Group

How to answer the question:

"Have we done what we said we'd do?"

- Manager is always worried about:
  - % of Budget spent
  - % of work done
  - % of time elapsed

- Answer… "Earned Value Management"

SO……Is it new?

- Earned Value Management (EVM)
  - It's been around since the sixties.
  - "cost/schedule control system criteria" (C/SCSC)
  - 1990s, EVM emerged as a project management methodology by DOD (Department of Defense) in U.S.

Despite PMI's efforts …

- Many PM's still do not understand EVM
- Many ignore reality; crank formulas; just produce reports
- Need to use common sense
- Need to know the Basics
- Don't know how to use EVM for Managing

EVM is a key Tool for Program Managers

What's Important to the Project Manager

- Are we ahead of or behind schedule?
- How efficiently are we using our time?
- When is the project likely to be completed?
- Are we currently under or over our budget?
- How efficiently are we using our resources?
- What is the remaining work likely to cost?
- What is the entire project likely to cost?
- How much will we be under or over budget at the end?

time management

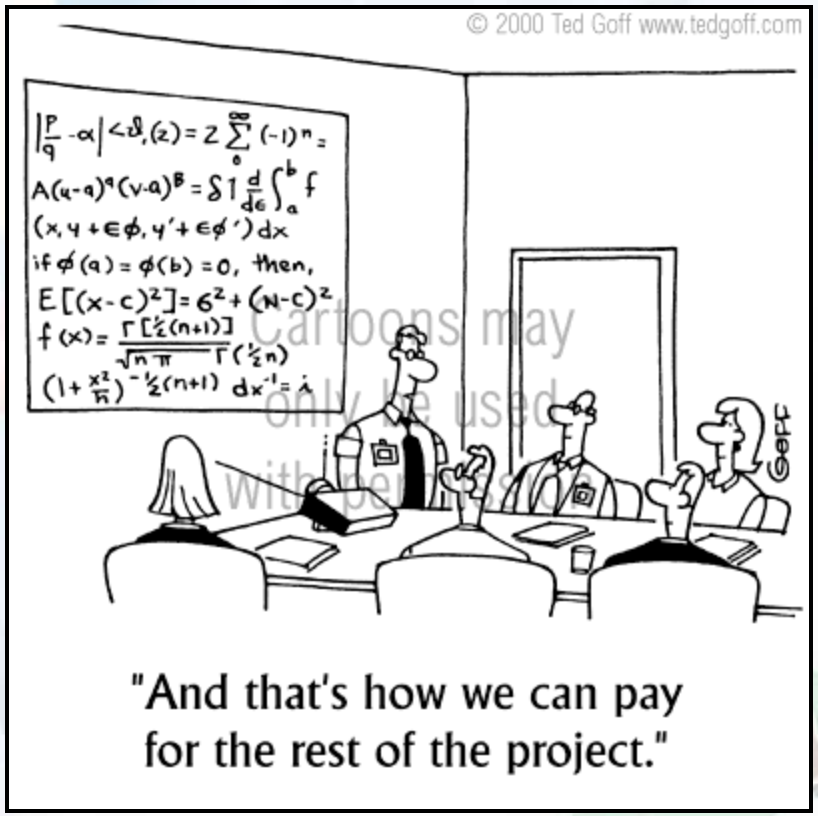
EVM answers it all!

- EVM methodology helps identify
  - Where problems are occurring.
  - Whether the problems are critical or not.
  - What it will take to get the project back on track.

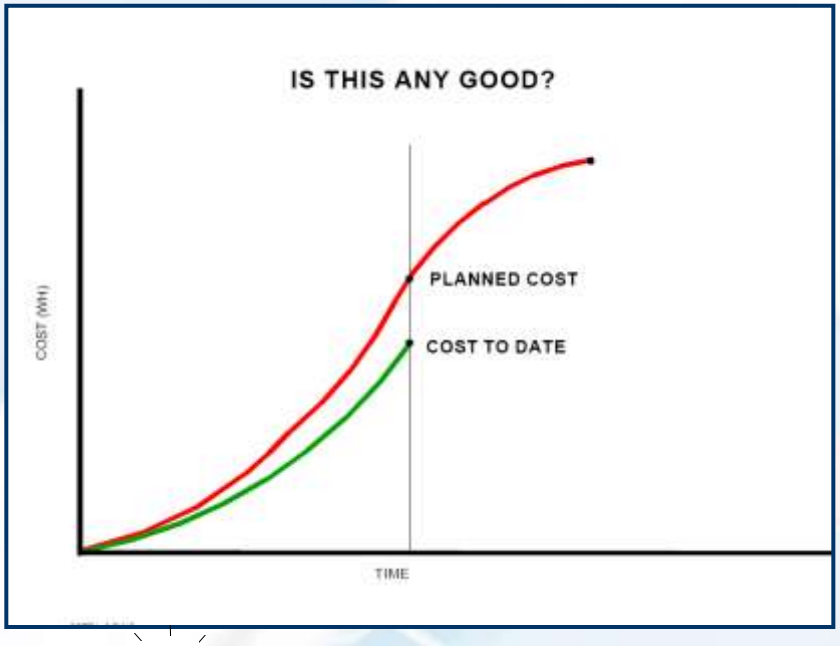
Source: EVM practice standard, PMI

Earned Value is needed because...

- Provides an “Early Warning” signal for prompt corrective action.
  - Gives time to recover
  - Facilitates timely request for additional funds



Traditional variance analysis



- Compare Planned cost & Actual cost
- No idea about work completed
- "Actual Cost is not an indication of work progress, only an indication of money spent."

time management

Enter….
"Earned Value Analysis"

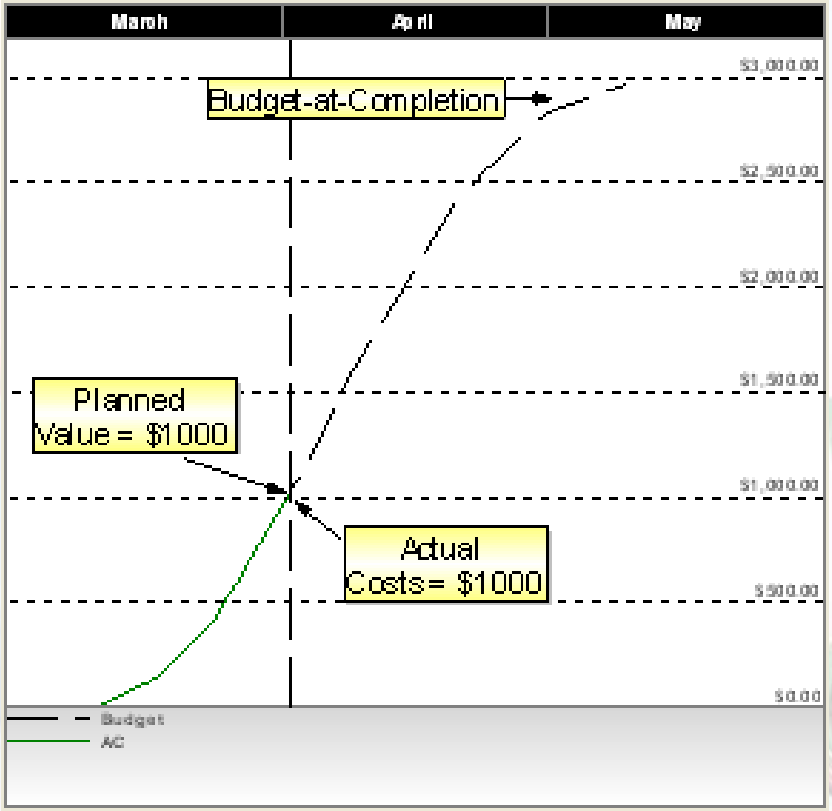
- Work is "Earned" or credited as it is completed.
- "Earned Value Analysis":
  - Measures a project's progress,
  - Forecasts its completion date and final cost, &
  - Provides schedule and budget variances along the way.
- HOW?
  - By integrating three elements, it provides consistent, numerical indicators with which you can evaluate and compare projects.

Three Elements? Building Blocks

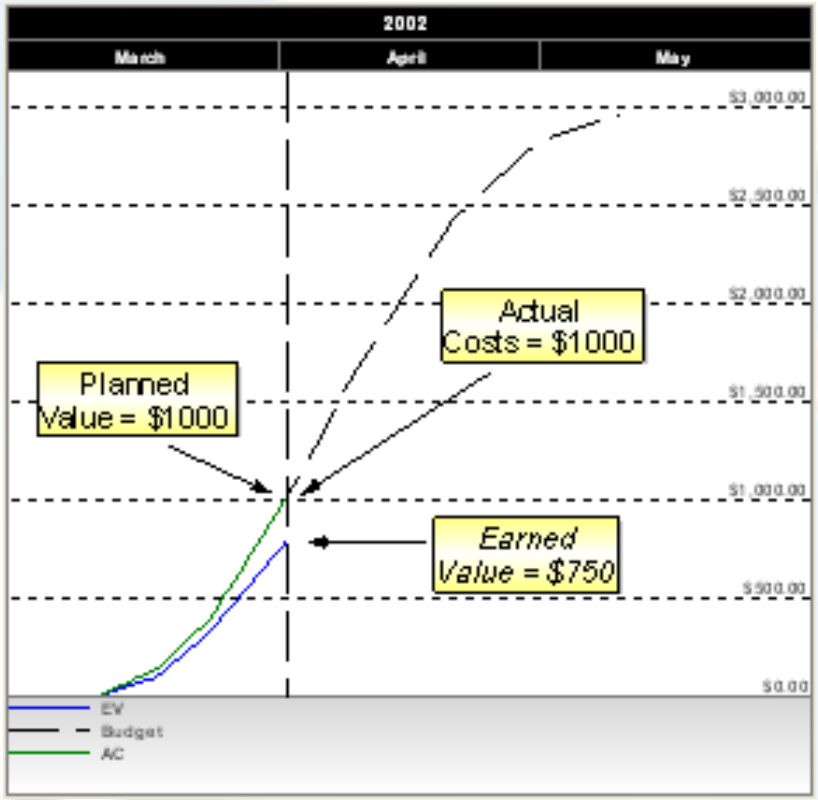
- Planned value <PV> (Budgeted Cost of Work Scheduled)
  - “how much do we plan to spend?”
  - Project baseline (PMB): Cumulative planned value for work scheduled.
- Actual cost <AC> (Actual Cost of Work Performed)
  - The actual cost to accomplish the work at specific date
  - “how much did we actually spend ?”

Example

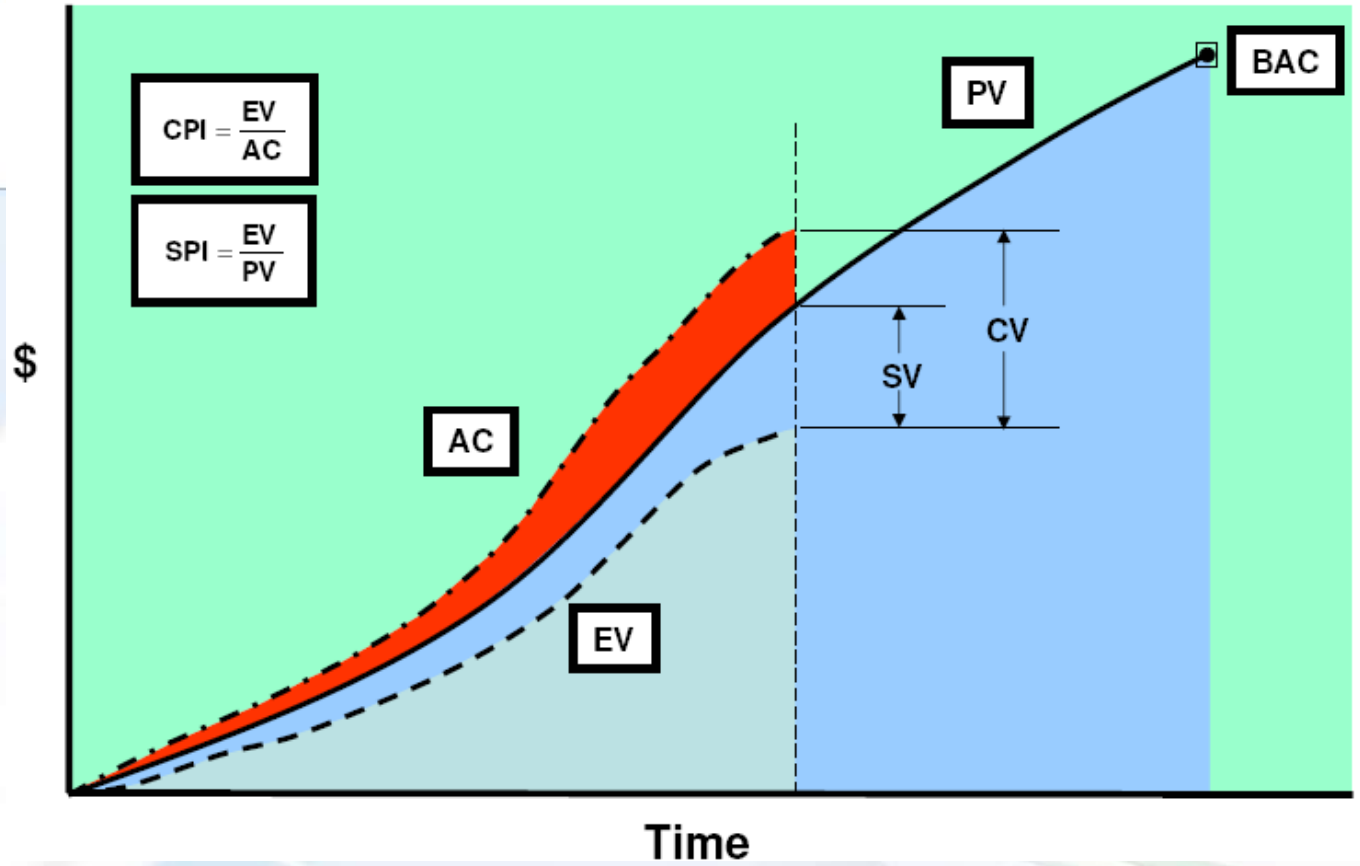
- A task has a planned value (PV) of $1000, and actual costs (AC) of $1000.
- It appears this task has perfect cost performance, and is in good shape to finish on-budget (Figure 1).



Example (contd.)



- However, if physical progress is taken into account, the results may differ.
- In Figure 2, the project has spent $1000 in actual costs, but is behind schedule and has only achieved $750 of Earned Value.
- This is called a cost overrun, and this project would have a Cost Variance (CV) of -$250.



The Whole Story…… (see Earned Value graph above)

Earned Value <EV> (Budgeted Cost of Work Performed)

This is the cost originally budgeted to accomplish the work that has been completed.

“how much work has been actually completed ?”

Earned value parameters

- A] Indicators
  - Schedule Indicators
    - Schedule Variance (SV)
      - “Are We Ahead Or Behind Schedule?”
      - A negative variance means project is behind schedule
      - SV = EV – PV = $750 - $1000 = -$250
      - SV% = SV / PV = -$250/$1000 = -25%
    - Schedule Performance Index (SPI)
      - “How efficiently are we using time?”
      - SPI greater than 1 indicates project ahead of schedule
      - SPI = EV / PV = $750/$1000 = 0.75

Earned value parameters

- A] Indicators
  - Cost Indicators
    - Cost Variance (CV)
      - “Are we under or over our budget?”
      - Negative variance indicates over budget
      - CV = EV – AC = $750 - $1000 = -$250
      - CV% = CV / EV = -$250/$1000 = -25%
    - Cost Performance Index (CPI)
      - “How efficiently are we using our resources?”
      - CPI greater than 1 indicates within budget
      - CPI = EV / AC = $750/$1000 = 0.75

Earned value parameters

- A] Indicators
  - Critical ratio (CR)
    - “overall performance of project “
    - CR=CPI*SPI = 0.75*0.75 = 0.5625

Earned value parameters

- B] Predictors
  - To-Complete Performance Index (TCPI)
    - "How efficiently must we use our remaining resources?"
    - TCPI > 1 indicates a need for increased performance for the remaining work in order to stay within budget
    - TCPI = (BAC - EV) / (BAC - AC)
      - = ($3000-$750)/($3000-$1000) = 1.125
  - Estimate at Completion (EAC)
    - "What is the project likely to cost?"
    - EAC1 = AC + [(BAC – EV)/CPI] = BAC/CPI
      - =$1000+[($3000-$750)/0.75] = $4000
    - EAC2= AC + [(BAC – EV)/ (CPI*SPI)]
      - =$1000+[($3000-$750)/0.5625] = $5000

Earned value parameters

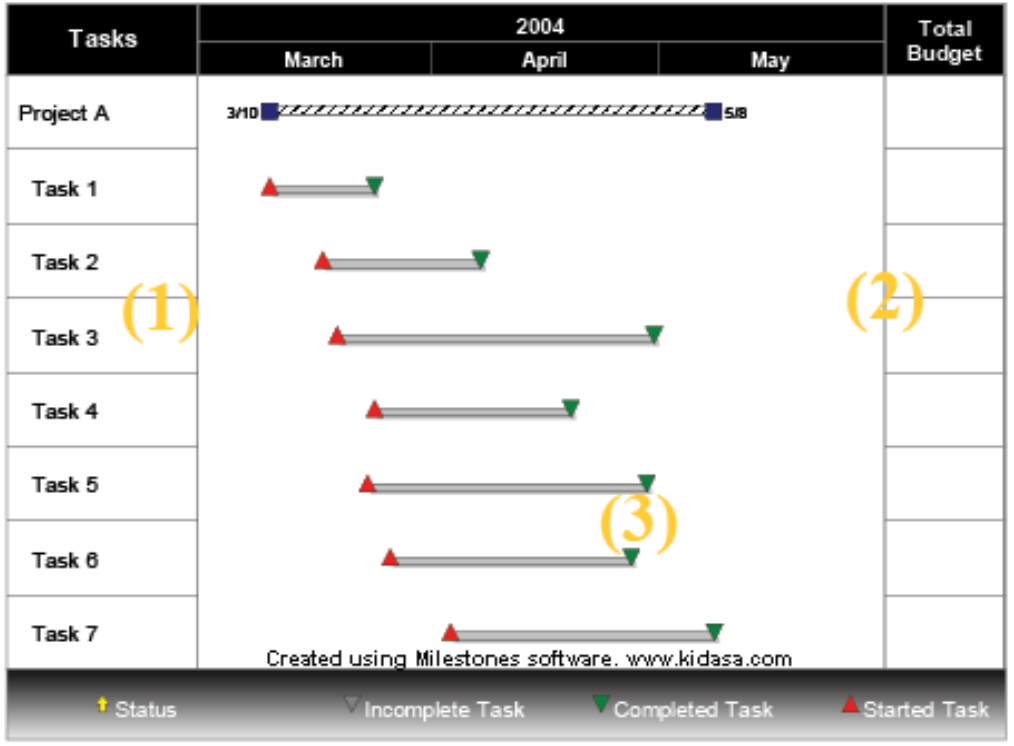
- B] Predictors
  - Variance at Completion (VAC)
    - "Will we be under or over budget?"
    - VAC1 = BAC - EAC1 = $3000-$4000 = -$1000
    - VAC2= BAC – EAC2 = $3000-$5000 = -$2000
  - Estimate to Complete (ETC)
    - "What will the remaining work cost?"
    - ETC = (BAC - EV) / CPI
      - = ($3000-$750)/0.75 = $3000
    - ETC = EAC – AC
      - = $4000 - $1000 = $3000
      - = $5000 - $1000 = $4000

Earned value parameters

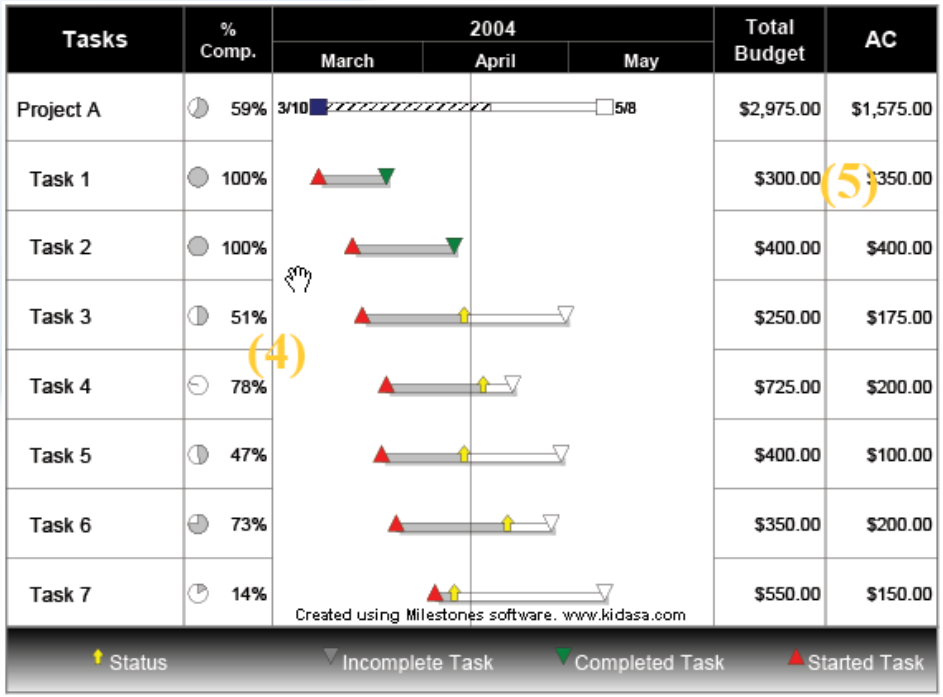
- B] Predictors
  - Independent Schedule at Completion (ISAC)
    - Calculate final cost depending upon schedule performance at that date
    - ISAC = BAC/ SPI = $3000/0.75 = $4000

Getting Started with EVM…

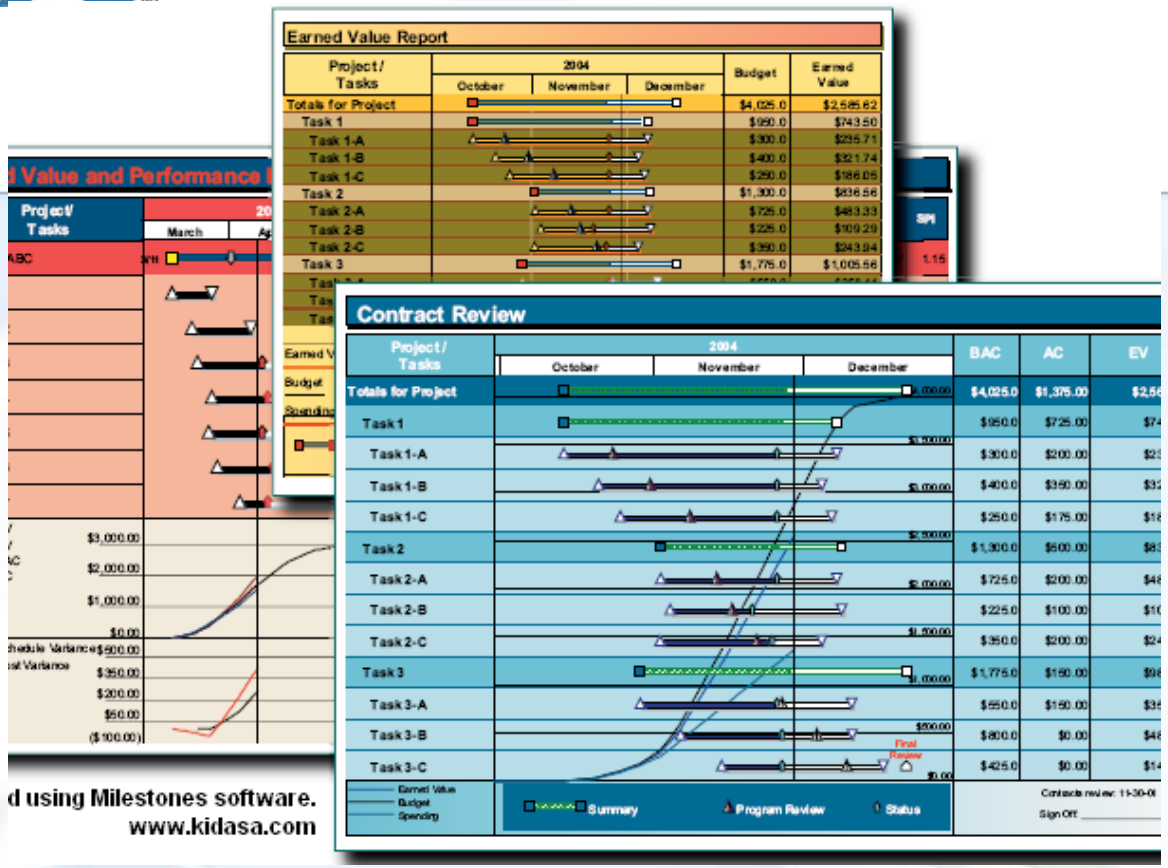
1. Create WBS and Task List
2. Assign Budget to each Task
3. Assign Duration to each Task



Getting started with EVM…



4. As project progresses, % complete for each task should be updated and monitored
5. Also maintain actual costs accrued for each task



Getting started with EVM…

Use the Data to Make Informed Decisions

Further analysis can be performed, including schedule and cost variances, performance efficiency, and estimates-at-completion.

We have just completed the section on Basics of Earned Value

ANY QUESTIONS?

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Congratulations!

Before proceeding to the advanced concepts of Earned Schedule...

LET'S BREAK!

Session II

Basics of Earned Schedule

EVM Limitations

- While EVM has many very significant achievements in analyzing project cost performance, this success has not extended to schedule performance.

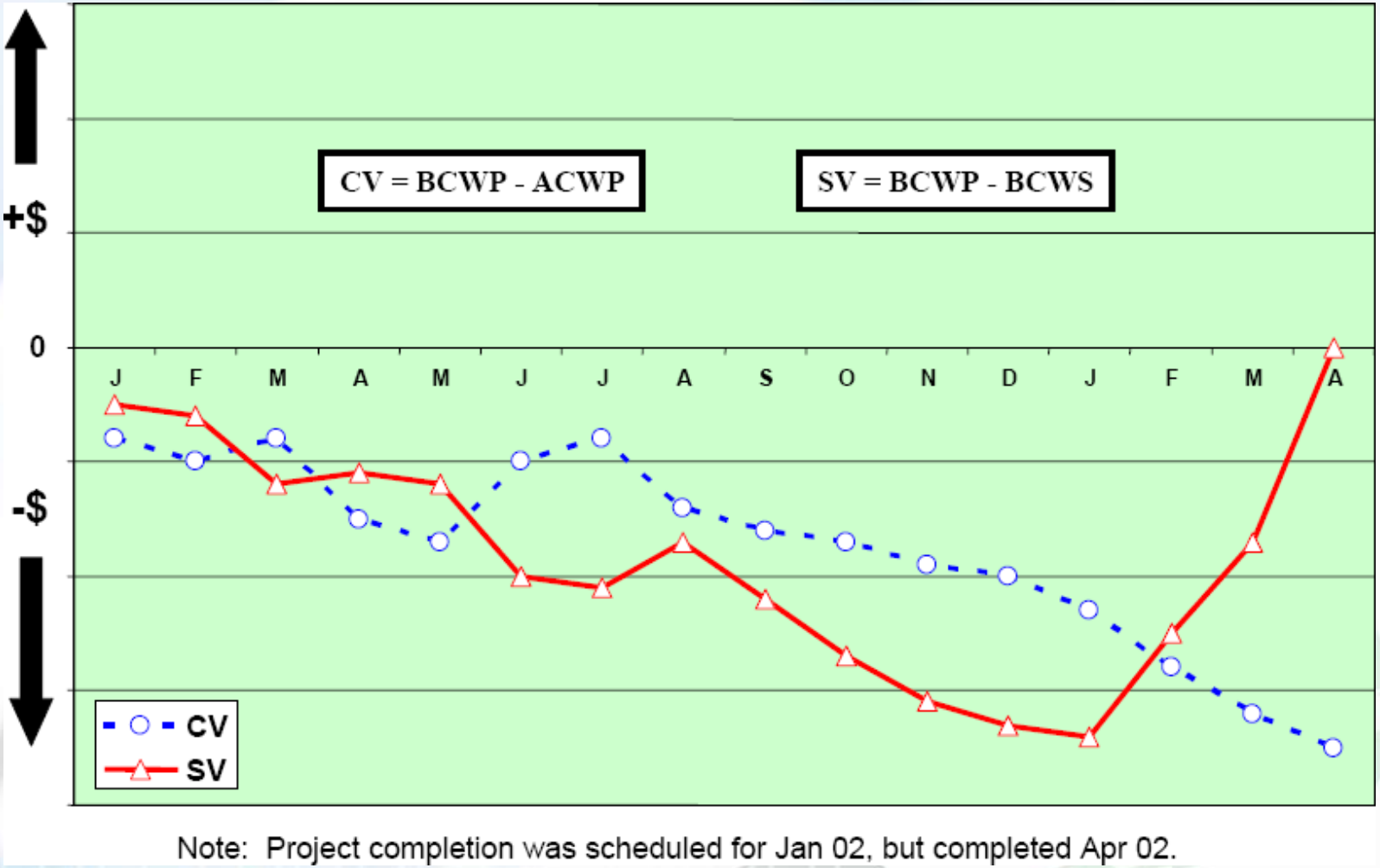
So, what's the problem?

- Traditional schedule EVM metrics are good at beginning of project
  - Show schedule performance trends
- But the metrics don't reflect real schedule performance at end
  - Traditional schedule metrics lose their predictive ability over the last third of project
    - Impacts schedule predictions, EAC predictions
- Project managers don't understand schedule performance in terms of budget
  - Like most of us!

EVM Schedule Indicators

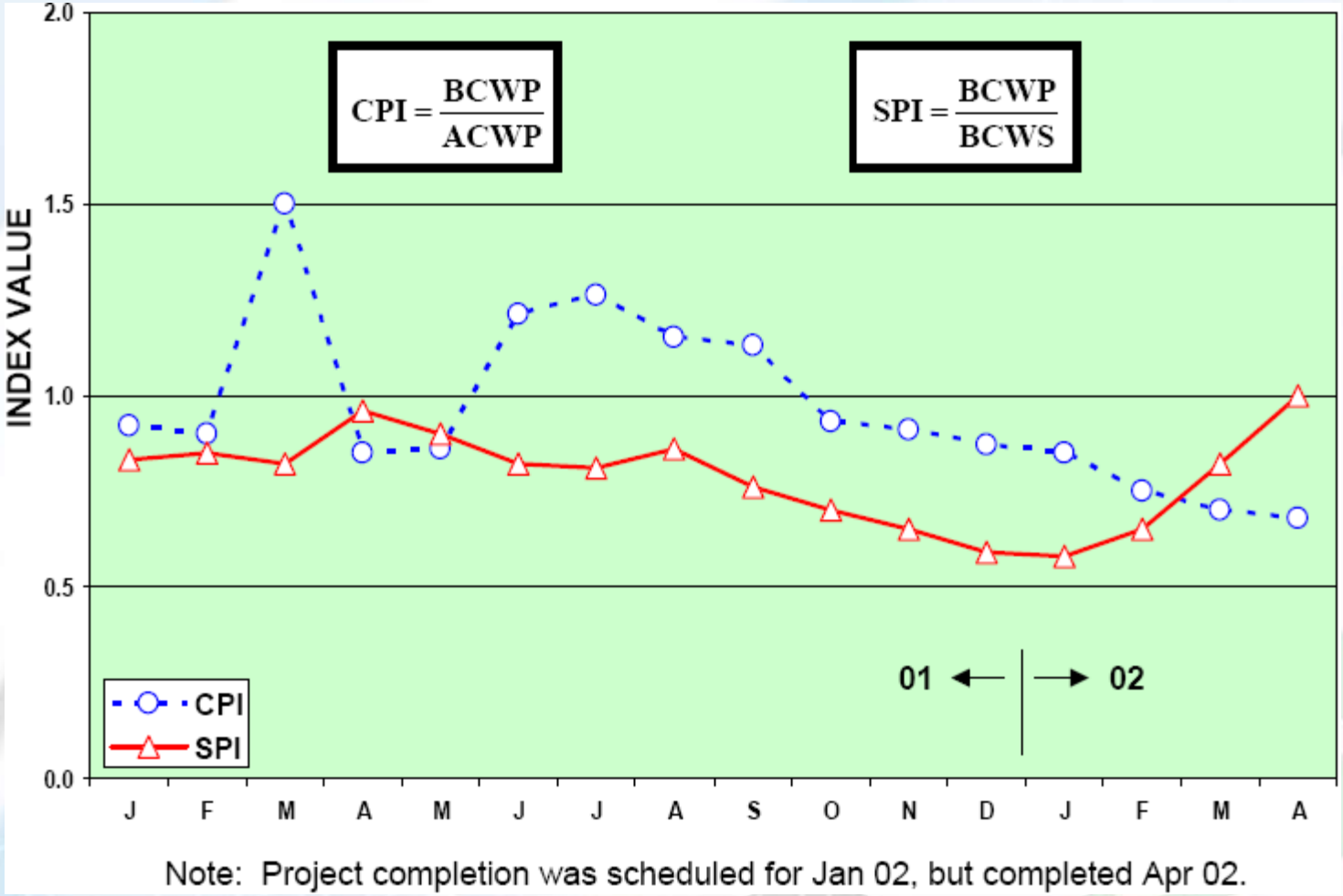
- Why does this happen?
  - SV = EV – PV
  - SPI = EV / PV
- Eventually, all “budget” will be earned as the work is completed, no matter how late you finish
  - At planned completion PV = BAC
  - At actual completion EV = BAC
- When actual > planned completion
  - SV improves and ends up at $0 variance at end of project
    - SV = BAC – BAC = $000
  - SPI improves and ends up at 1.00 at end of project
    - SPI = BAC / BAC = 1.00
- Regardless of lateness !!

Cost and Schedule Variances



Note: Project completion was scheduled for Jan 02, but completed Apr 02.

Cost and Schedule Performance Indices



Note: Project completion was scheduled for Jan 02, but completed Apr 02.

So….Do we have any key……..?

- Solution
  - Mr. Walt Lipke
    - “Schedule is Different”
    - (The Measurable News) 2003
    - Training- “ Earned Schedule” (PMI Sydney Chapter, Australia)
  - “Earned schedule”
    - It’s a Extension to EVM theory
    - Time based measurement to help Project Manager

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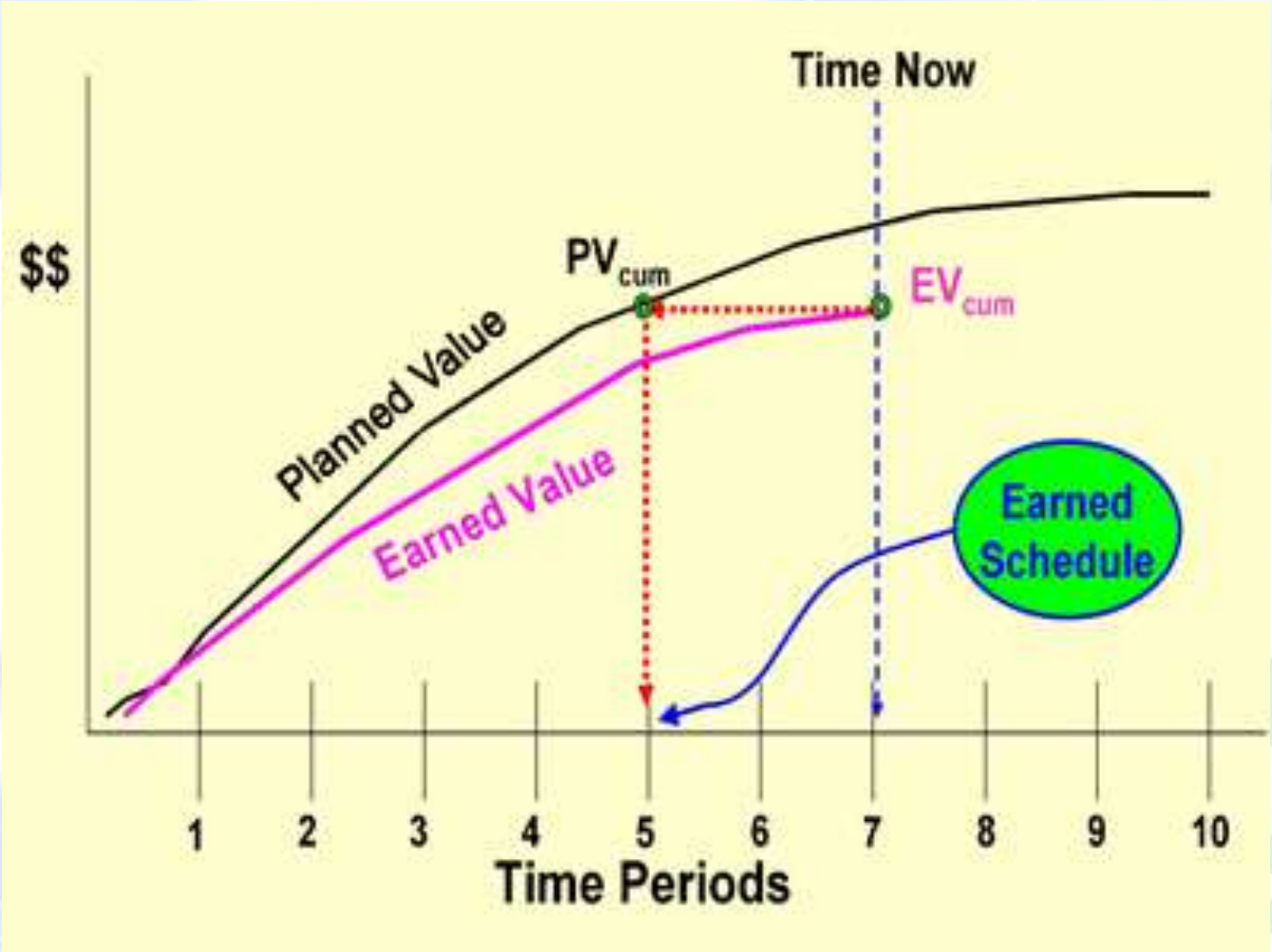
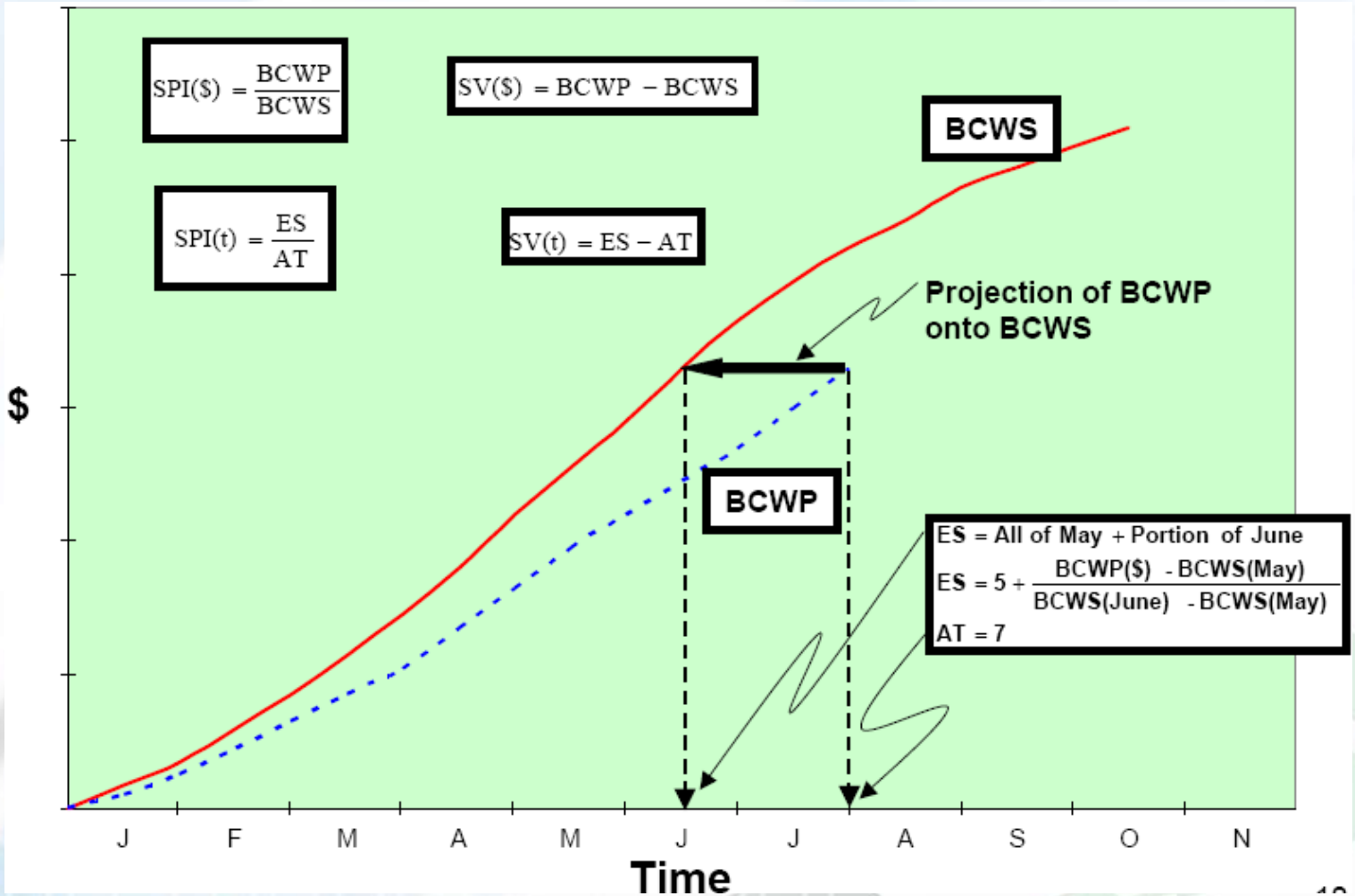
How it works


Time Now
$$
PV cum
EV cum
Planned Value
Earned Value
Earned Schedule
1
2
3
4
5
6
7
8
9
10
Time Periods

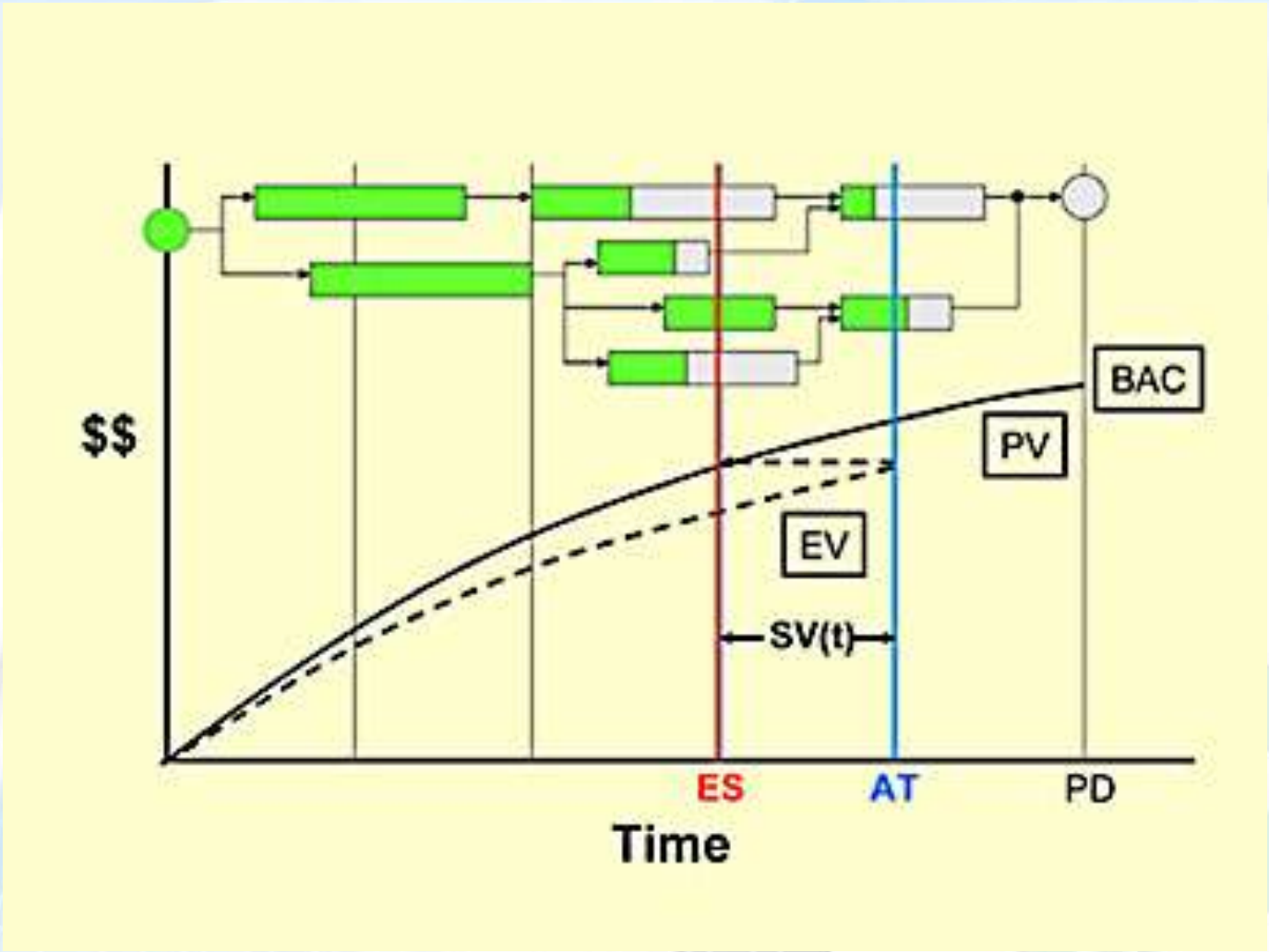
Earned Schedule Concept



Earned Schedule Metrics

- Required measures
  - Performance Management Baseline (PMB)
    - the time phased planned values (PV) from project start to completion
  - Earned Value (EV)
    - the planned value which has been “earned”
  - Actual Time (AT)
    - the actual time duration from the project beginning to the time at which project status is assessed
  - All measures available from EVM

Connecting Earned Value to Schedule



Earned Schedule Metrics

- ES_{cum} is the:
  - Number of completed PV time increments EV exceeds + the fraction of the incomplete PV increment
- $ES_{cum} = C + I$ where:
  - C = number of time increments for EV ≥ PV
  - $I = (EV - PV_C) / (PV_{C+1} - PV_C)$
- $ES_{period(n)} = ES_{cum(n)} - ES_{cum(n-1)} = \Delta ES_{cum}$
- ATcum
- $AT_{period(n)} = AT_{cum(n)} - AT_{cum(n-1)} = \Delta AT_{cum}$
  - ΔAT_{cum} is normally equal to 1

Earned Schedule Indicators

- Schedule Variance: SV(t)
  - Cumulative: $SV(t) = ES_{cum} - AT_{cum}$
  - Period: $\Delta SV(t) = \Delta ES_{cum} - \Delta AT_{cum}$
- Schedule Performance Index: SPI(t)
  - Cumulative: $SPI(t) = ES_{cum} / AT_{cum}$
  - Period: $\Delta SPI(t) = \Delta ES_{cum} / \Delta AT_{cum}$

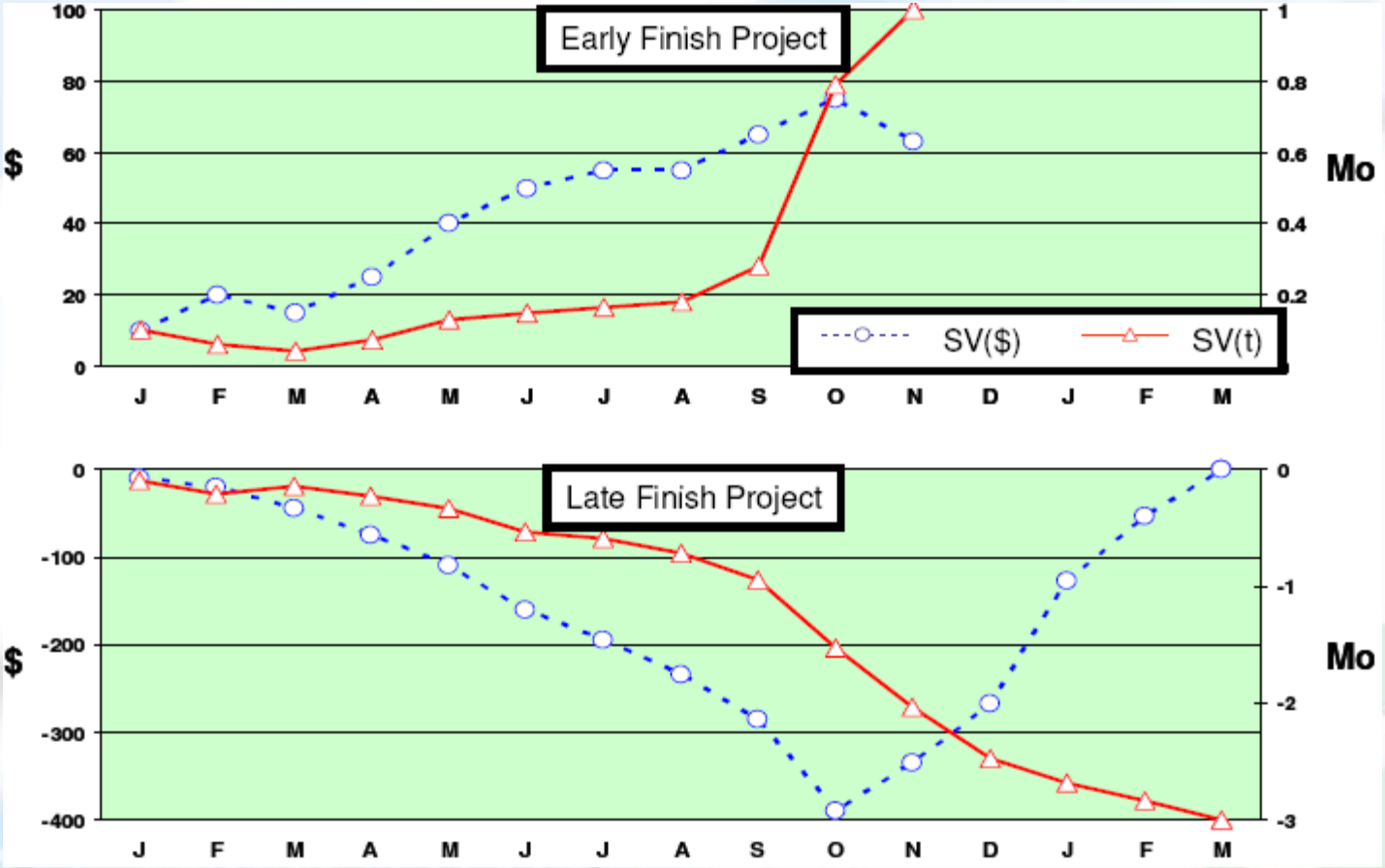
Earned Schedule Indicators

- What happens to the ES indicators, SV(t) & SPI(t), when the planned project duration (PD) is exceeded (PV = BAC)?
  - They Still Work …Correctly!!
- ES will be ≤ PD, while AT > PD
  - SV(t) will be negative (time behind schedule)
  - SPI(t) will be < 1.00
  - Reliable Values from Start to Finish !!

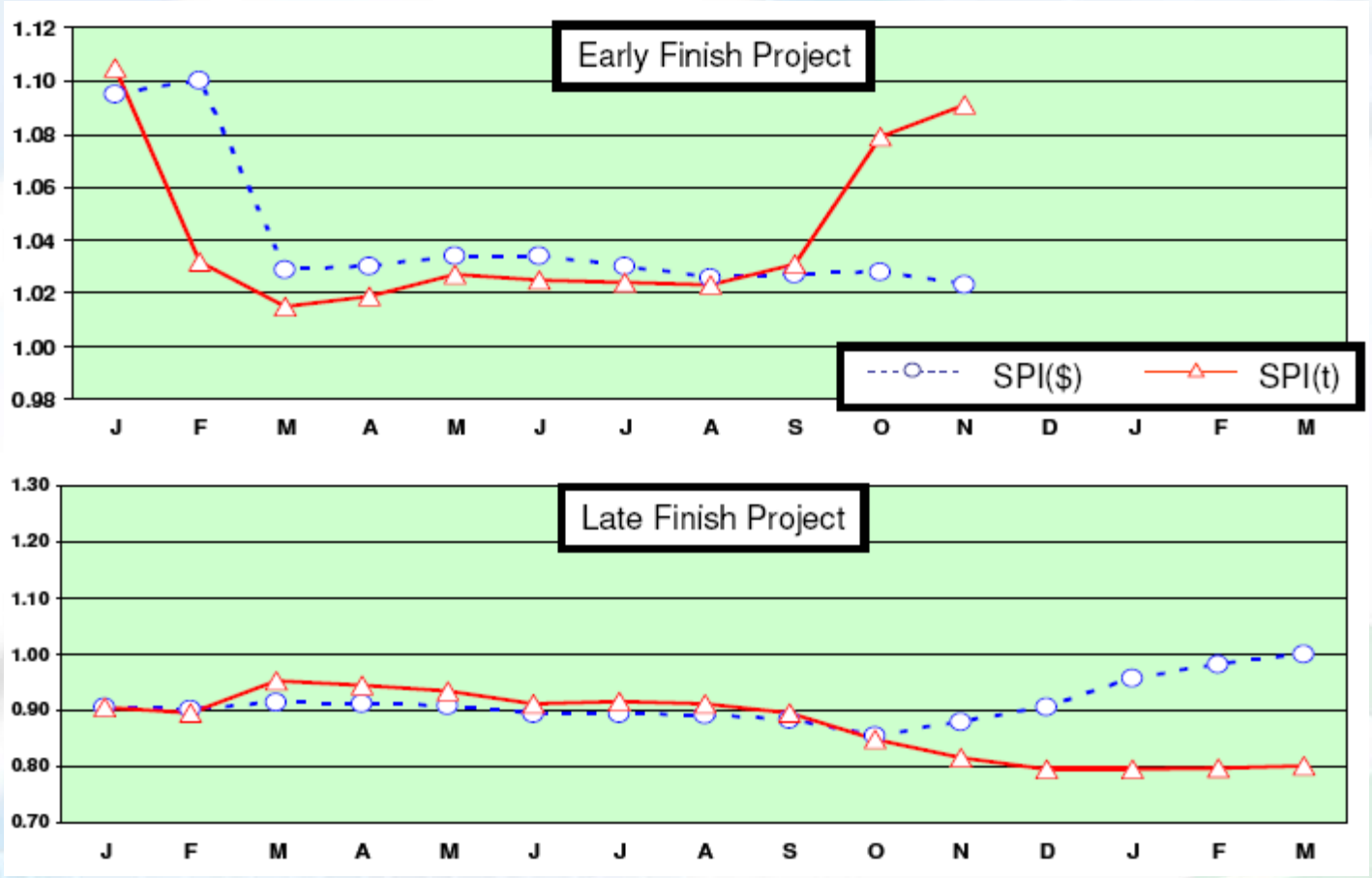
Earned Schedule Indicators

- Key Points:
  - ES Indicators constructed to behave in an analogous manner to the EVM Cost Indicators, CV and CPI
  - SV(t) and SPI(t) are not constrained by BCWS calculation reference
  - SV(t) and SPI(t) provide duration based measures of schedule performance

SV Comparison



SPI Comparison



Earned Schedule Predictors

- Can the project be completed as planned?
  - TSPI = Plan Remaining / Time Remaining
  - = (PD – ES) / (PD – AT)
    - where (PD – ES) = PDWR
    - PDWR = Planned Duration for Work Remaining
- …completed as estimated?
  - TSPI = (PD – ES) / (ED – AT)
  - where ED = Estimated Duration

TSPI Value	Predicted Outcome
≤1.00	Achievable
>1.10	Not Achievable

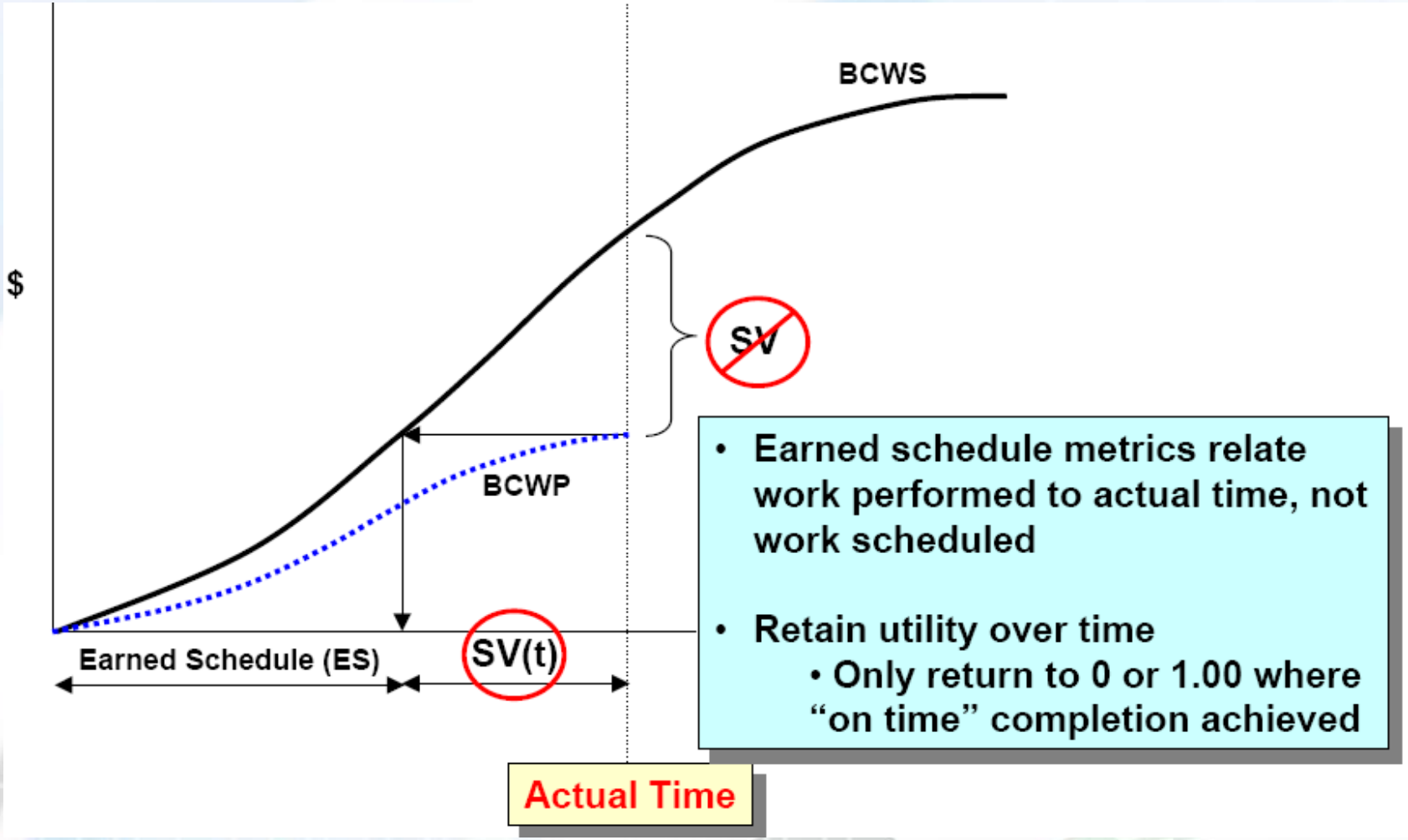
Earned Schedule Predictors

- Long time desire of EVM practitioners…
  - Prediction of total project duration from EVM data
- Independent Estimate at Completion (time)
  - IEAC(t) = PD / SPI(t)
  - IEAC(t) = AT + (PD – ES) / PF(t)
    - where PF(t) is the Performance Factor (time)
  - Analogous to IEAC used to predict final cost
- Independent Estimated Completion Date (IECD)
  - IECD = Start Date + IEAC(t)

Earned Schedule Key Points

- ES Indicators constructed to behave in an analogous manner to the EVM Cost Indicators, CV and CPI
- SV(t) and SPI(t)
  - Not constrained by PV calculation reference
  - Provide duration based measures of schedule performance
  - Valid for entire project, including early and late finish
- Facilitates integrated Cost/Schedule Management (using EVM with ES)

SV($) versus SV(t)



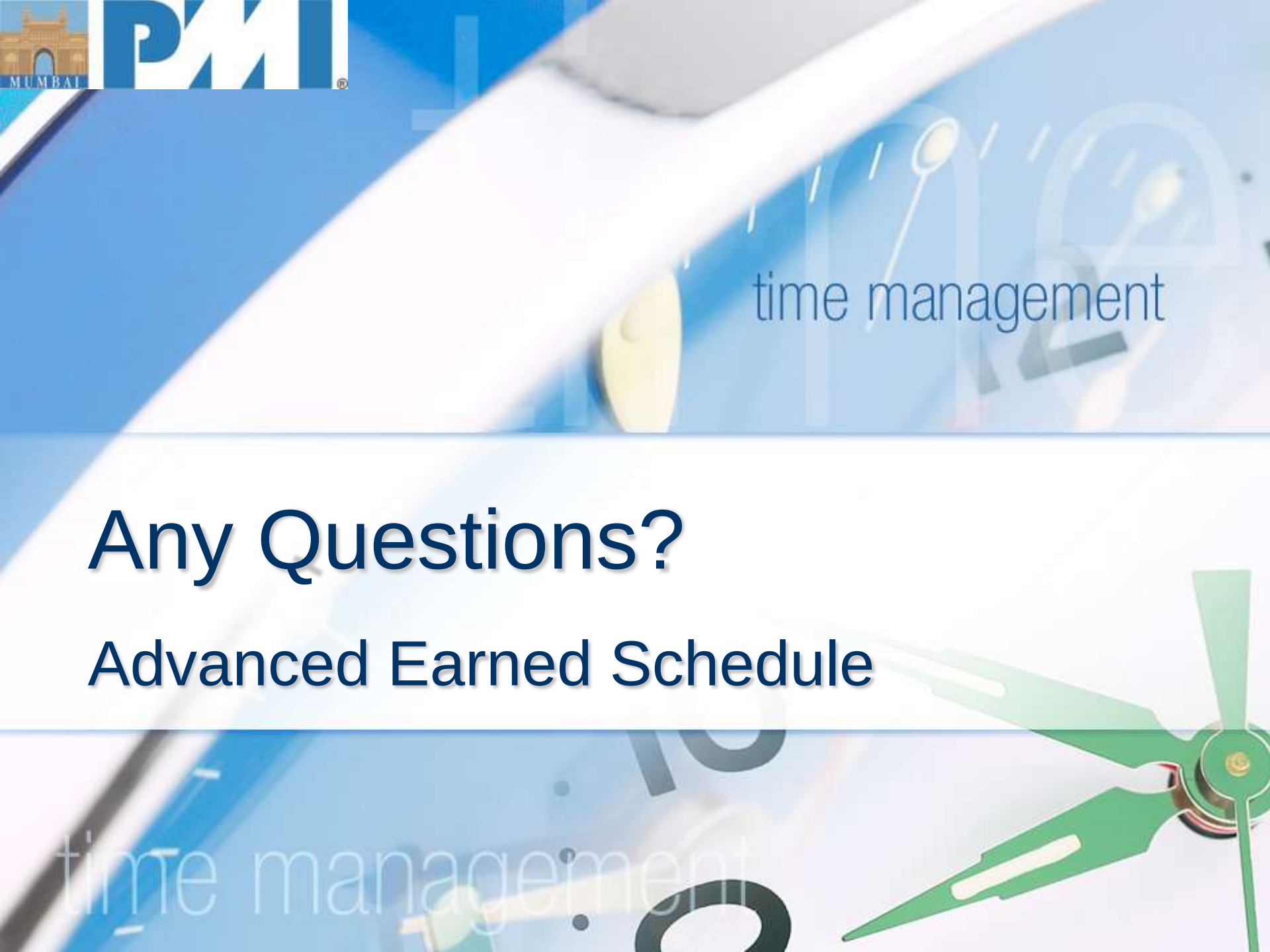
- Earned schedule metrics relate work performed to actual time, not work scheduled
- Retain utility over time
  - Only return to 0 or 1.00 where "on time" completion achieved

Earned schedule terminology

	EVM	Earned schedule
Status	Earned value (EV)	Earned schedule (ES)
	Actual cost (AC)	Actual time (AT)
	SV	SV(t)
	SPI	SPI(t)
Future work	Budgeted cost of work remaining (BCWR)	Planned duration for work complete (PDWR)
	Estimate to complete (ETC)	Estimate to complete (time) ETC(t)
Prediction	Variance at completion (VAC)	Variance at completion (time) VAC(t)
	Estimate at completion (EAC)	Estimate at completion (time) EAC(t)
	Independent EAC	Independent (time) IEAC(t)
	To complete performance index (TCPI)	To complete schedule performance index (TSPI)

Earned schedule terminology

Metrics	Earned Schedule	ES_{cum}	ES = C + I number of complete periods (C) plus an incomplete portion (I)
	Actual Time	AT_{cum}	AT = number of periods executed
Indicators	Schedule Variance	SV(t)	SV(t) = ES - AT
	Schedule Performance Index	SPI(t)	SPI(t) = ES / AT
	To Complete Schedule Performance Index	TSPI(t)	TSPI(t) = (PD – ES) / (PD – AT)
			TSPI(t) = (PD – ES) / (ED – AT)
Predictors	Independent Estimate at Completion (time)	IEAC(t)	IEAC(t) = PD / SPI(t)
			IEAC(t) = AT + (PD – ES) / PF(t)



Any Questions?

Advanced Earned Schedule

Re-Planning Effects

- Are indicators affected by a project re-plan?
  - No when requirements are added or deleted
  - Yes when changes are made to the present estimates for task duration and effort
- When planned values for tasks are changed, essentially a new project is created
  - Measures (EV, AC, PV) prior to the re-plan should not be co-mingled with those occurring after

Re-Planning Effects

- How are indicators reported when the estimates are changed?
  - Essentially a new Project begins at the coordinates of the accrued Actual Cost and the Actual Date
  - Performance is closed out on the portion of the project completed
  - New cumulative indicators are begun for the revised portion of the project

Re-Planning Effects

- For purpose of calculating indicators …
  - New Project Duration =
    Revised Completion Date – Actual Date
  - New Planned Duration =
    New Project Duration – Revised Schedule Reserve
  - New TAB* = Revised TAB – Actual Cost
  - New BAC = New TAB – Revised MR
  - The indicators are calculated using measures of EV, PV and AC for the portion of the project from the re-plan to completion

*TAB Total Allocated Budget

Re-Planning Effects

- For calculating predictions after a re-plan …
  - Cost:

    IEAC(total) = AC(re-plan) + IEAC(new)

    where IEAC(new) is the prediction for the portion of the project after the re-plan
  - Schedule:

    IEAC(t)(total) = AT(re-plan) + IEAC(t)(new)

    where IEAC(t)(new) is the prediction for the portion of the project after the re-plan

Example

Example Data				
Period	**ACmo**	**ACcum**	**EVmo**	**EVcum**
1	35	35	40	40
2	50	85	45	85
3	85	170	75	160
4	100	270	90	250
5	115	385	100	350
6	110	495	85	435
7	105	600	75	510
8	115	715	60	570
9	110	825	85	655
10	100	925	95	750
***** Re-Plan *****				
11	100	100	105	105
12	115	215	105	210
13	120	335	130	340
14	105	440	115	455
Questions				
1. What is the value of CPIcum at the end of period 14?				
2. After the re-plan BAC = 2500. Calculate IEAC after period 14.				

Example (contd.)

	Answers	Wrong			
1	1.0341	0.8828			
2	2448	2832	2832		
	After Replan				
	CPIcum(AR) = EV(AR) / AC(AR)				
	IEAC = AC(R) + {BAC(rev) - AC(R)} / CPIcum(AR)				
or …	IEAC = AC(R) + [AC(AR) + {(BAC(AR) - EV(AR)} / CPIcum(AR)]				2448
	where				
	R = at Replan				
	AR = After Replan				
	BAC(AR) = BAC(rev) - AC(R)				
	AC(AR) = ACcum - AC(R)				
	EV(AR) = EVcum - EV(R)				

ES vs. EVM Comparison

Earned Schedule	Earned Value
SV(t) and SPI(t) valid for entire project, including early and late finish	SV($) and SPI($) validity limited to early finish projects
Duration based predictive capability analogous to EVM's cost based indicators	Limited prediction capability No predictive capability after planned completion date exceeded
Facilitates Cost – Schedule Management (using EVM and ES)	EVM Management focused to Cost

Recent E-mail from Walt dtd. 03 Dec 2008

- Everyone ...my study of the goodness of Earned Schedule for forecasting final project duration versus other EVM methods has now been published in CrossTalk. Earned Schedule is shown to be superior to the other methods used in the study. Regards ....walt
- ...If interested, you can access and download the article from the CrossTalk website: http://www.stsc.hill.af.mil/crosstalk/2008/12/0812Lipke.html

Time-Based Schedule Measures – – An Emerging EVM Practice

- Inclusion of Emerging Practice Insert into PMI -EVM Practice Standard
  - Dr. John Singley, VP of CPM
- Included in Box 3-1 of EVM Practice Standard
  - Describes basic principles of "Earned Schedule"
  - Provides foundation for further development of and research intended to result in Earned Schedule acceptance as a valid extension to EVM
- EVM Practice Standard released at 2004 IPMC Conference

Box 3-1: Time-Based Schedule Measures – An Emerging EVM Practice

In the current practice of EVM, schedule variance and schedule performance are both measures of work scope, not time. The work is represented by its budgeted cost as recorded in the performance measurement baseline. The EVM schedule variance is the difference between work performed and work scheduled, and the schedule performance index is the ratio of work performed to work scheduled. For Project EZ, these measures indicate that work is not being accomplished as quickly or as efficiently as planned:

SV = EV - PV = 32 - 48 = -16 **SPI = EV / PV = 32 / 48 = 0.67**

If the work were to continue at this rate, then all of the work of Project EZ would take 18 months to accomplish instead of the 12 months planned (12 / 0.6667 = 18).

These SV and SPI measures are useful indicators and predictors of performance and results. But, because they are based on work and not time, they can behave in ways that are not normally expected of schedule indicators and predictors. The problem can be illustrated with Project EZ: Whether all of the work is completed as planned at 12 months or at 18 months as predicted by the four-month SPI of 0.67, it will be completed eventually and at that time the work-based schedule variance and performance index will indicate perfect performance. For when the work is completed: EV = PV, and so SV = 0 and SPI = 1.0. This is fine if the work is being accomplished according to plan, but problematic if it is not. If Project EZ does take 18 months, SV will nonetheless equal 0 and SPI equal 1.0, when it's clear that Project EZ is 6 months late and averaged only 67% efficiency.

There is an emerging practice in EVM, which uses time-based measures of schedule variance and schedule performance as an alternative or supplement to the traditional work-based measures. This new method avoids the problems of the work-based method illustrated above. Whereas the traditional work-based method compares work performed and work scheduled at or to a point in time, the time-based method compares the actual time with the planned time for the work performed. In the case of Project EZ, the work performed after four months (AT = 4) had a planned time of three months (PT = 3) [refer to Figures 2-6 and 2-7]. In a manner that parallels the use of AC and EV in traditional EVM, practitioners are beginning to use actual time (AT) and planned time (PT) to compute SV and SPI:

SV(t) = PT - AT = 3 - 4 = - 1 month **SPI(t) = PT / AT = 3 / 4 = 0.75**

While the work- and time-based methods provide comparable results at the four-month point in Project EZ, look at the difference at project completion after 18 months:

SV(t) = PT - AT = 12 - 18 = - 6 months **SPI(t) = PT / AT = 12 / 18 = 0.67**

SV($) = EV - PV = 150 - 150 = 0 **SPI($) = EV / PV = 150 / 150 = 1.0**

Foreseen Uses of Earned Schedule

- Enables independent evaluation of schedule estimates: ETC(t), IEAC(t)
  - Client, Contractor, Program and Project Manager ….
- Facilitates insight into network schedule performance
  - Duration based Schedule indicators
  - Identification of impediments/constraints and potential future rework
  - Evaluation of adherence to plan
- Improvement to Schedule and Cost prediction
  - Client, Contractor, Program and Project Manager ….
- Application of direct statistical analysis of schedule performance

Inputs from Mr. Namjoshi, (Ex-Toyo Engineering)

- Method is being followed by Japanese Engineering companies for nearly 2 decades
- Catch in the ES technique
  - May not give projection derived by Network Analysis
    - E.g. If on data date most activities covered are having floats, you may not be actually behind schedule although ES may predict so.
    - Hence, conclusion should be drawn by studying SV($), SV(t) and network analysis
    - In such cases SV($) gives more accurate predictions as compared to SV(t)
    - It removes the uncertainty regarding whether the activities covered are with or without float
    - If one considers only activities on critical path then both methods are equally valid

Summary

- Derived from EVM data … only
- Provides time-based schedule indicators
- Indicators do not fail for late finish projects
- Application is scalable up/down, just as is EVM
- Schedule prediction is better than any other EVM method presently used
  - SPI(t) behaves similarly to CPI
  - IEAC(t) = PD / SPI(t) behaves similarly to IEAC = BAC / CPI

Summary

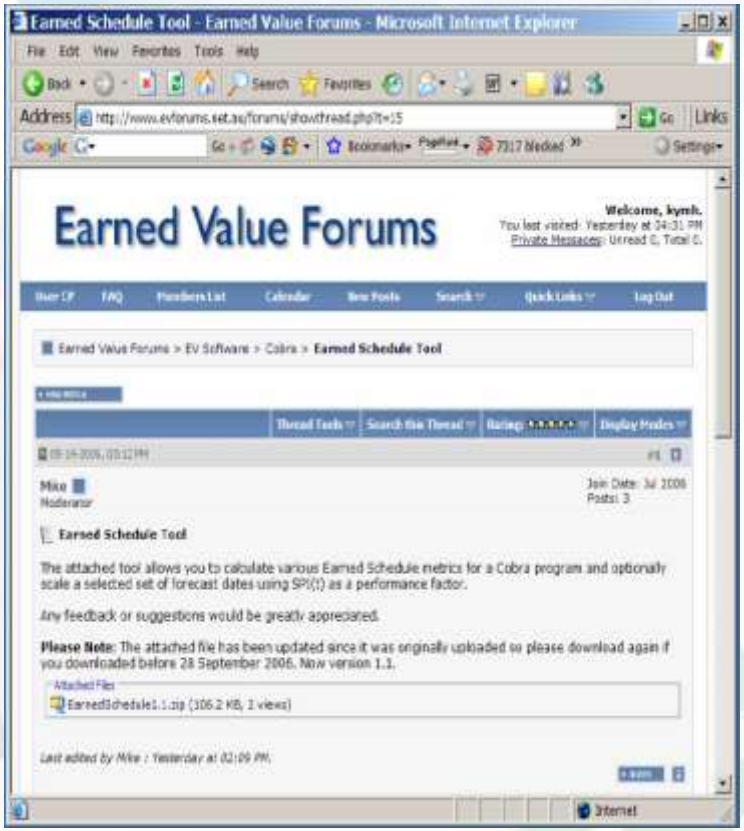
- Schedule prediction – much easier and possibly better than “bottoms-up” schedule analysis
- Application is growing in both small and large projects
- Practice recognized as “Emerging Practice”
- Resource availability enhanced with ES website and Wikipedia

Available Resources Papers and Presentations

- PMI-Sydney Chapter
  - http://sydney.pmichapters-australia.org.au/
  - Repository for ES Papers and Presentations
- Earned Schedule Website
  - http://www.earnedschedule.com/
  - Established February 2006
  - Contains News, Papers, Presentations
  - ES Terminology
  - Identifies Contacts to assist with application
- Wikipedia references Earned Schedule
  - http://en.wikipedia.org/wiki/Earned_Schedule

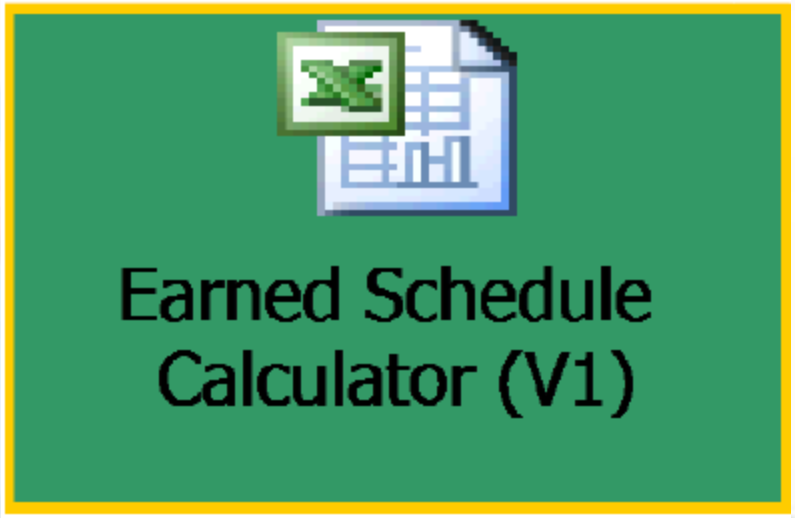
Available Resources Tools

- Freely available add on tool for the Deltek Cobra product
- Available from:
- http://www.evforums.net.au/forums/showthread.php?t=15
- (Requires registration to Earned Value Forums)
- Contact:
  - Mike Boulton
  - WST Pacific
  - mboulton@wstpacific.com.au
  - +61 8 8150 5500



Available Resources Calculators

- Excel based Earned Schedule calculators available from http://www.earnedschedule.com



Conclusion

- "Whatever can be done using EVM for Cost Analysis can also be done using Earned Schedule for Schedule Analysis"
- Earned Schedule
  - A powerful new dimension to Integrated Project Performance Management (IPPM)
  - A breakthrough in theory and application

Thank You!

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