Earned Schedule
Contribution to
Project Management
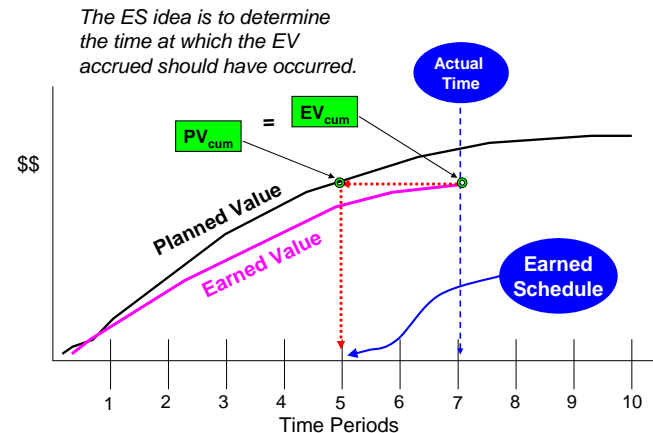
Walt Lipke

PMI® - Oklahoma City

+1 405 364 1594

waltlipke@cox.net

www.earnedschedule.com

The ES idea is to determine the time at which the EV accrued should have occurred.

Abstract

First introduced in 2003, Earned Schedule (ES) is a schedule analysis method extending the benefits of Earned Value Management. Presently, the ES method is used globally for all types and sizes of projects. It is being taught in universities, is now included in project management textbooks as well as the PMI® Practice Standard for Earned Value Management, and is a topic of graduate level research. This workshop discusses its beginnings and the evolution of the techniques and capabilities occurring over the last decade. ES is shown to be useful to project managers for analysis and control of schedule performance.
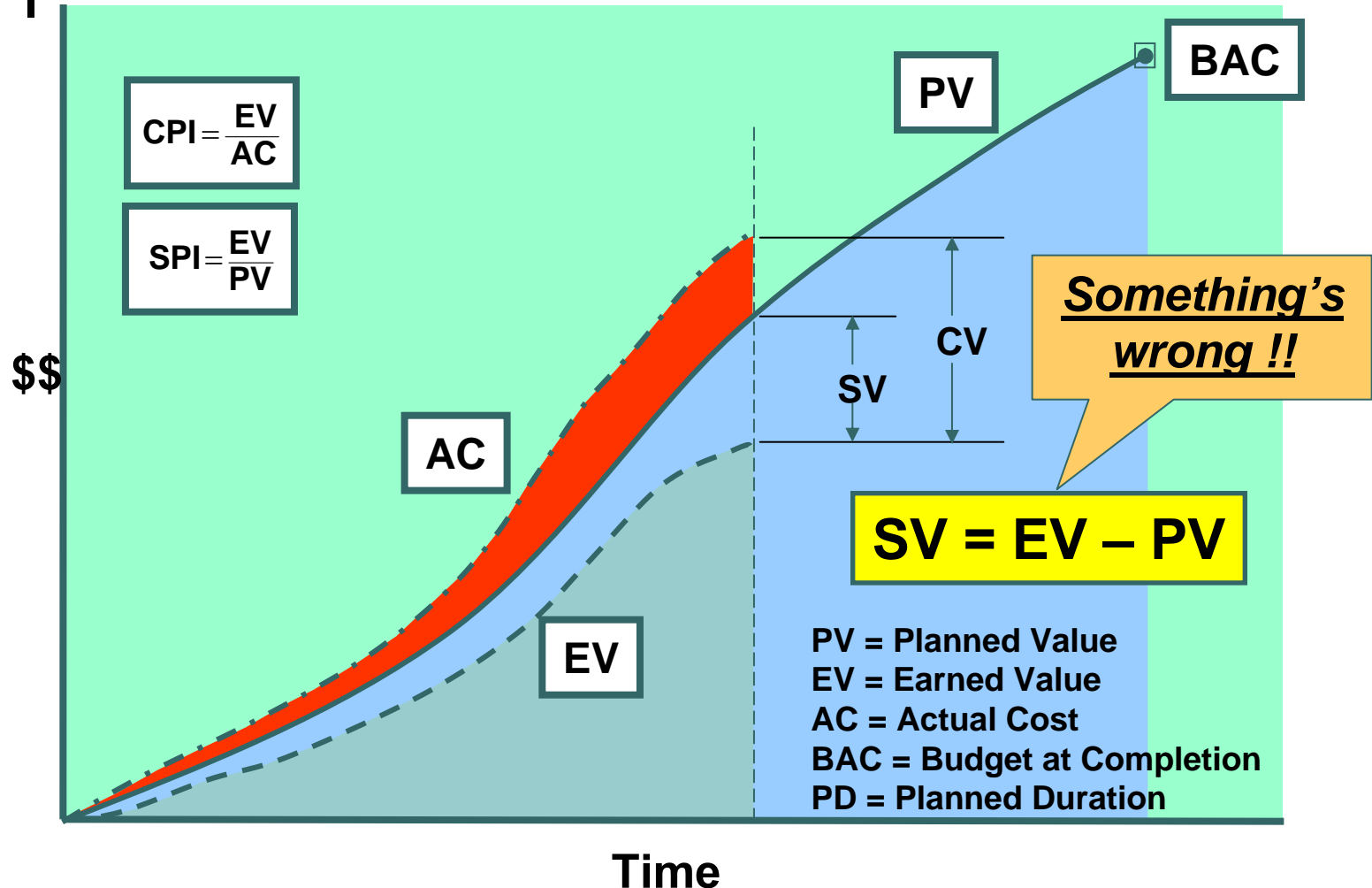
Objectives

- What is Earned Schedule?
- How does it relate to EVM?
- What can I do with ES?
- Are ES results reliable?
- Are other methods better?
- Does it take a lot of extra work?
- Will ES help me manage?

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Overview

- EVM Introduction / Problem
- Earned Schedule Measure & Indicators
- Forecasting & Prediction
- Application to Critical Path
- Schedule Adherence
- Small Projects
- Longest Path
- Statistical Planning & Forecasting
- Summary
- Application Help

EVM Introduction/Problem

$$CPI = \frac{EV}{AC}$$

$$SPI = \frac{EV}{PV}$$

BAC

PV

AC

EV

CV

SV

Something's wrong !!

SV = EV – PV

PV = Planned Value
EV = Earned Value
AC = Actual Cost
BAC = Budget at Completion
PD = Planned Duration

$$

Time

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$$
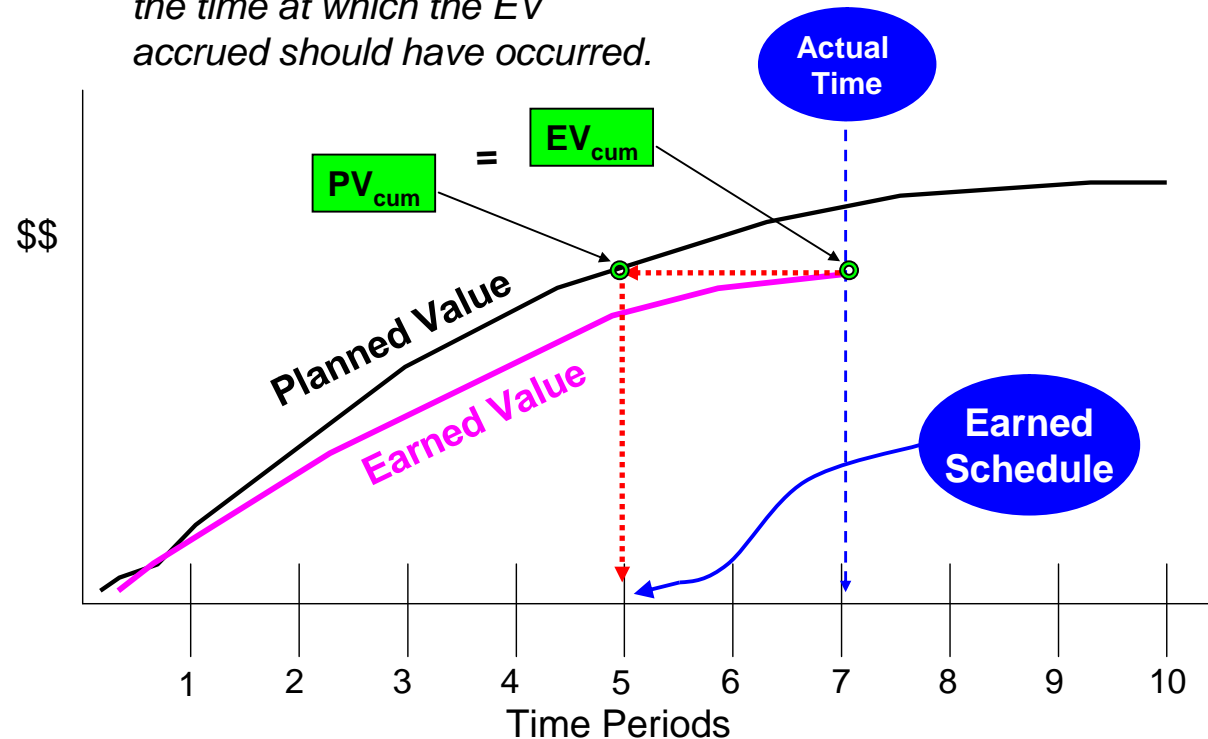
Earned Schedule Concept

- ES introduced in 2003

The ES idea is to determine the time at which the EV accrued should have occurred.

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ES Metric

- ES measure requires the PMB and EV accrued
- Determined from formula, ES = C + I

  where C is number of periodic time units of the PMB for which $EV \geq PV_C$

  and $I = [(EV - PV_C) / (PV_{C+1} - PV_C)] * 1$ period

- At completion, just as EV = BAC, ES = PD where PD = Planned Duration

ES Indicators

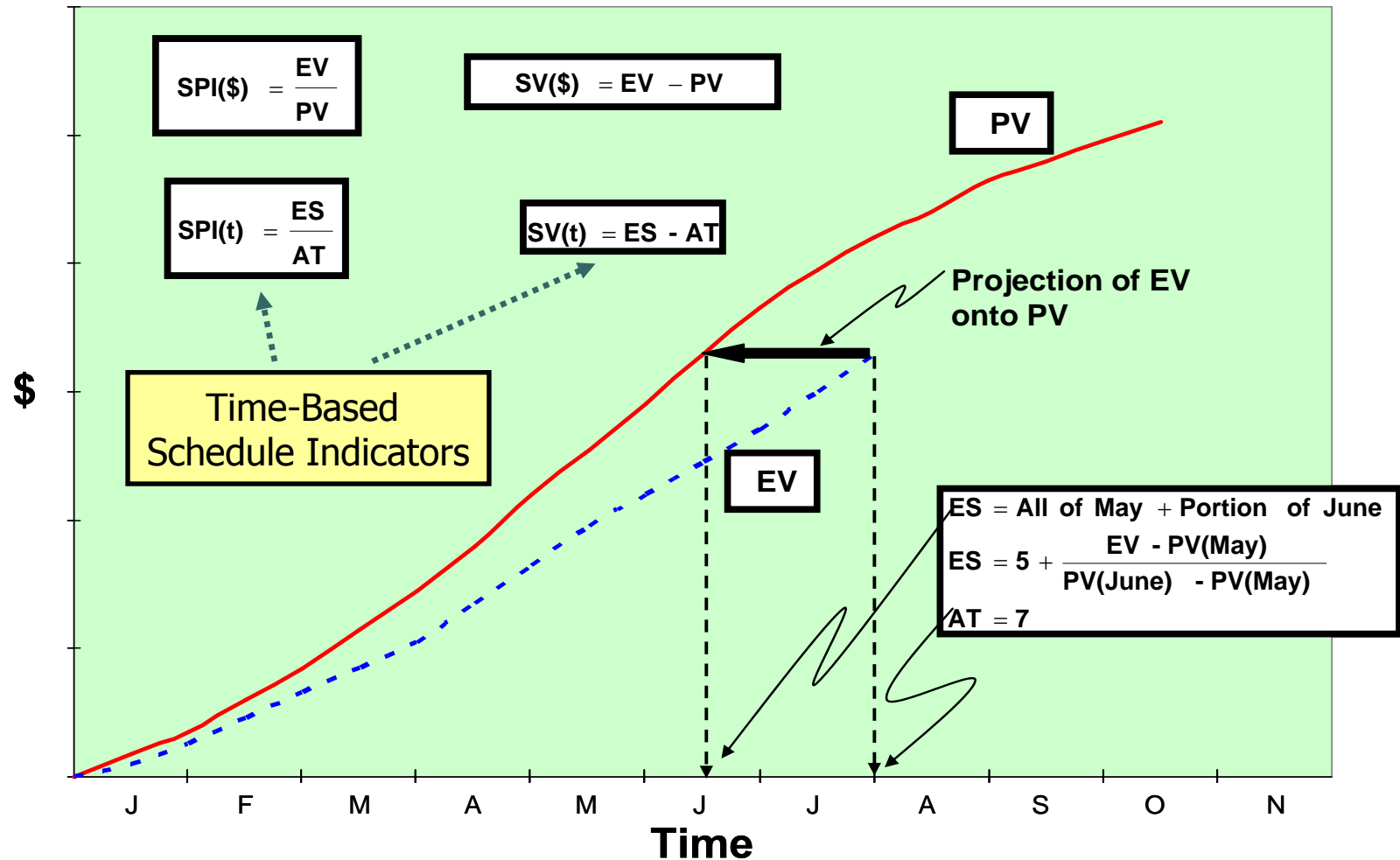- The ES measure leads to reliable indicators for the entire duration of the project

$$SV(t) = ES - AT$$
$$SPI(t) = ES / AT$$

cumulative

$$SV(t)_n = (ES_n - ES_{n-1}) - 1$$
$$SPI(t)_n = (ES_n - ES_{n-1}) / 1$$

periodic

where AT is the number of status periods

ES Computation Example

$$SPI(\$) = \frac{EV}{PV}$$

$$SV(\$) = EV - PV$$

PV

$$SPI(t) = \frac{ES}{AT}$$

$$SV(t) = ES - AT$$

Projection of EV onto PV

Time-Based Schedule Indicators

EV

ES = All of May + Portion of June

$$ES = 5 + \frac{EV - PV(May)}{PV(June) - PV(May)}$$

$$AT = 7$$

$

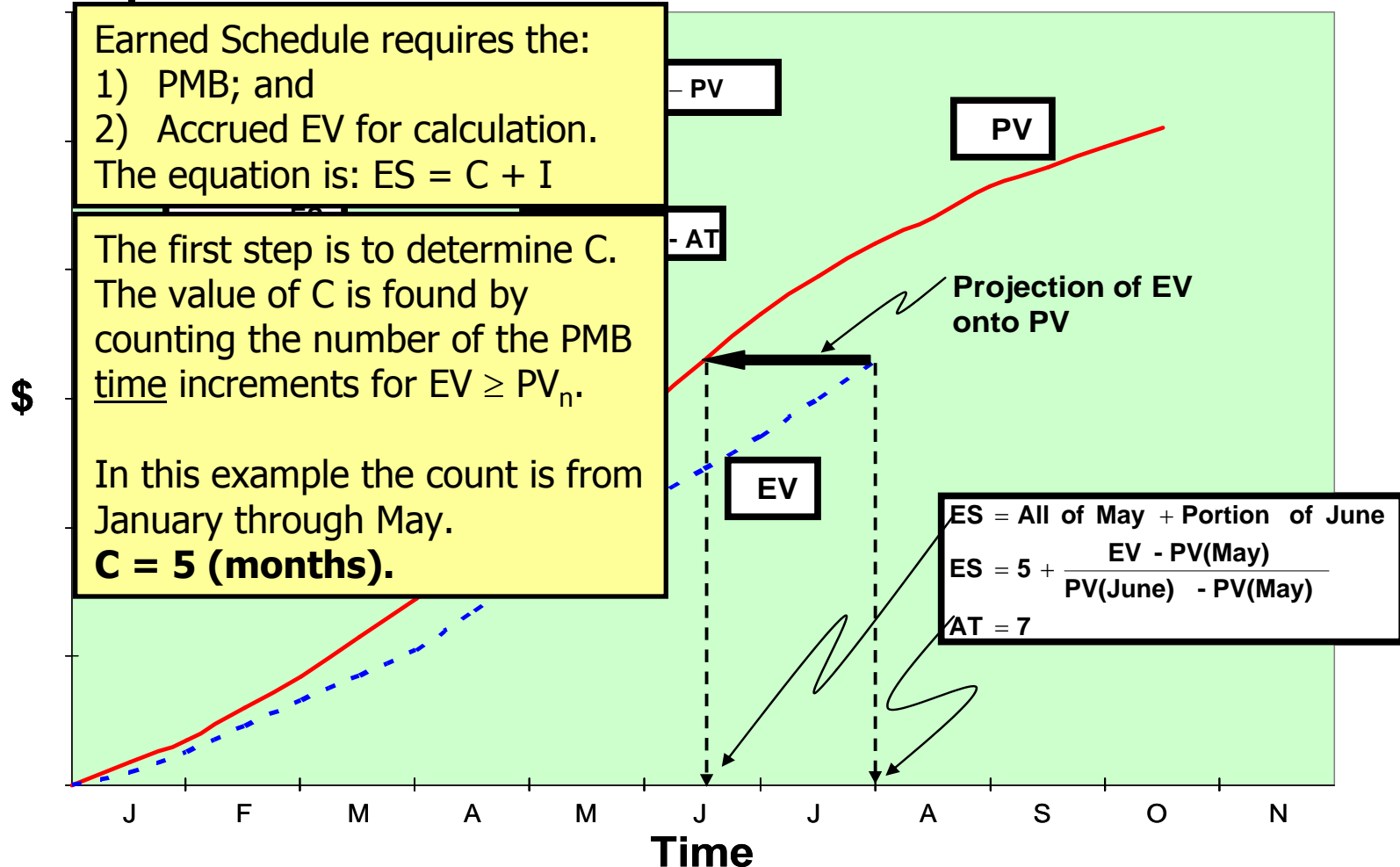**Time**

J F M A M J J A S O N

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ES Computation Example

Earned Schedule requires the:
1) PMB; and
2) Accrued EV for calculation.
The equation is: ES = C + I

The first step is to determine C. The value of C is found by counting the number of the PMB __time__ increments for $EV \geq PV_n$.

In this example the count is from January through May.
C = 5 (months).

PV

Projection of EV onto PV

EV

$ES = All\ of\ May + Portion\ of\ June$

$ES = 5 + \dfrac{EV - PV(May)}{PV(June) - PV(May)}$

$AT = 7$

$

| J | F | M | A | M | J | J | A | S | O | N |

Time

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ES Computation Example

Thus far, ES = 5 + I (months).
In the small box at the lower right,
is the equation for calculating I.
For the example, let
1) EV = 100
2) PV_5 (May) = 90
3) PV_6 (June) = 110.

Let's calculate I:
I = (100 − 90) / (110 − 90) = 0.5

ES = 5 + 0.5 = 5.5 (months)

From ES (5.5 months) we can now
calculate the ES indicators:
SV(t) and SPI(t).

The EV is reported at Actual Time
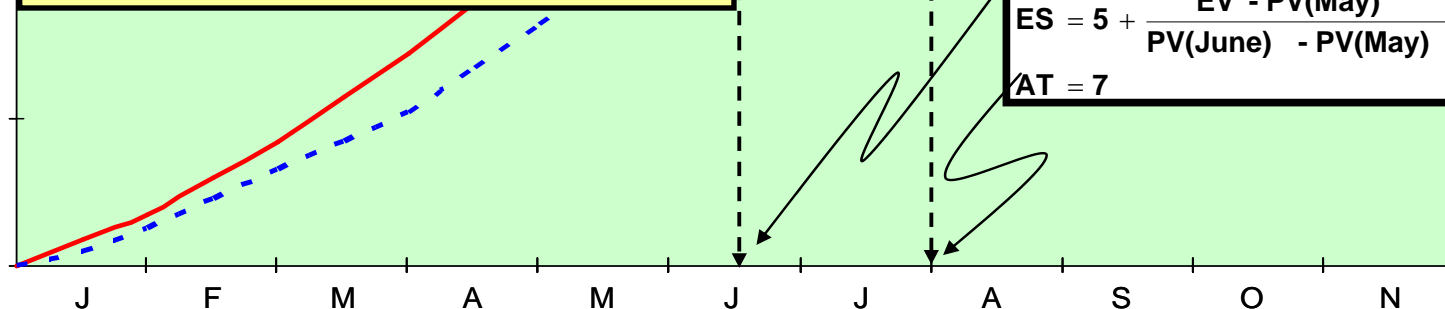AT = 7, the end of July.

SV(t) = 5.5 − 7 = - 1.5 months

SPI(t) = 5.5 / 7 = 0.79

EV

$$ES = All\ of\ May\ +\ Portion\ of\ June$$

$$ES = 5 + \frac{EV\ -\ PV(May)}{PV(June)\ -\ PV(May)}$$

AT = 7

Time

J F M A M J J A S O N

$

ES Prediction

- 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

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ES Prediction

- At 1.10, for modest increases in EV, the rate of change of TSPI becomes increasingly larger
- Once the threshold is exceeded, there is little hope that management intervention can have positive impact …the project is very rapidly becoming "out of control"

TSPI Behavior

Legend: TSPI — SPI(t) — Threshold

X-axis: Fraction Complete (0.0 to 1.0)
Y-axis: Index Value (0.7 to 1.3)

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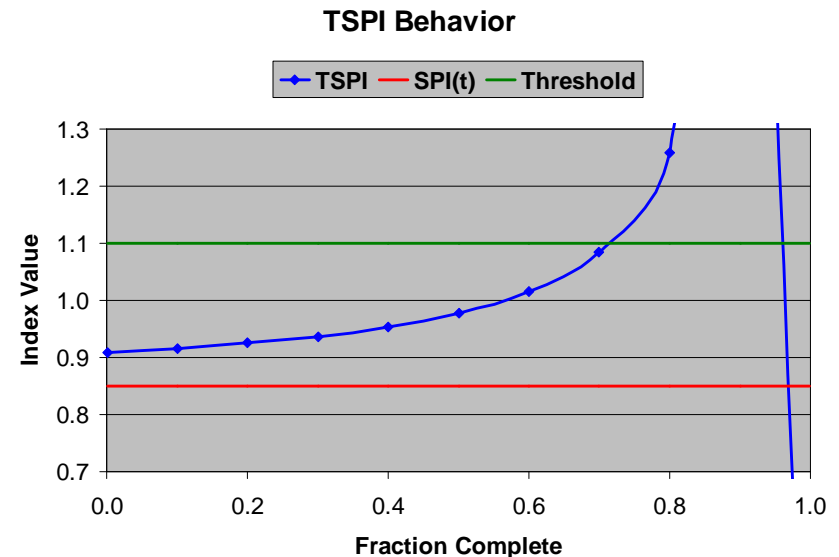
ES Forecasting

- Long time goal of EVM …Forecasting of total project duration from present schedule status
- 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 forecast final cost
- Independent Estimated Completion Date (IECD)
  - IECD = Start Date + IEAC(t)

ES 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	$SV(t)$	$SV(t) = ES - AT$
		$SV(t)\%$	$SV(t)\% = (ES - AT) / ES$
	Schedule Performance Index	$SPI(t)$	$SPI(t) = ES / AT$
	To Complete Schedule Performance Index	$TSPI$	$TSPI = (PD - ES) / (PD - AT)$
			$TSPI = (PD - ES) / (ED - AT)$
Predictors	Independent Estimate at Completion (time)	$IEAC(t)$	$IEAC(t) = PD / SPI(t)$
			$IEAC(t) = AT + (PD - ES) / PF(t)$
	Variance at Completion	$VAC(t)$	$VAC(t) = PD - IEAC(t)$ or ED

Critical Path

Critical Path Application

- Critical Path – the sequence of planned tasks having the longest duration

- Traditionally, management focuses on performance of the CP …believing by so doing project duration is minimized

- Schedulers forecast completion by adding the remaining planned task durations of the CP to the actual duration
  - The forecast doesn't take into account the schedule performance efficiency of the accomplished work

Critical Path Application

- Are there ways ES can be used to analyze CP performance?

- EVM provides no measure of CP performance …EV accrual can come from any task

- First method – compare IEAC(t) to the CP forecast

  - BAH has used this method – execution problems were identified earlier from the ES forecast

  - Henderson achieved similar results

  - Although method is not applied directly to CP …it does infer that typical CP forecasting is unreliable

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Critical Path Application

- Second method – use the CP tasks as if they comprise the project
  - Create PMB from CP tasks only
  - Use EV from these tasks to compute ES
  - Compare $SPI(t)_{CP}$ to $SPI(t)$ for total project
  - Method provides management additional information regarding critical and non-critical performance …and brings more focus to network schedule execution

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Critical Path Application

○ Second method – Compare $SPI(t)_{CP}$ to $SPI(t)$ for total project

- When $SPI(t)_{CP} \cong SPI(t)$ – balanced execution, minimizes project duration

- When $SPI(t)_{CP} \neq SPI(t)$ – problems can be expected, duration forecast will likely worsen

Critical Path Application

- Both methods are considerably less effort than bottom up analysis
  - The significant analysis effort advantage offered by IEAC(t) & SPI(t) CP methods does not mean to imply that detailed schedule analysis should never be performed …a bottom-up remaining schedule estimation should be performed, in addition, for critical decisions
- Traditionally, EVM has been restricted to cost performance analysis …ES provides the link to extend EVM to CP performance analysis
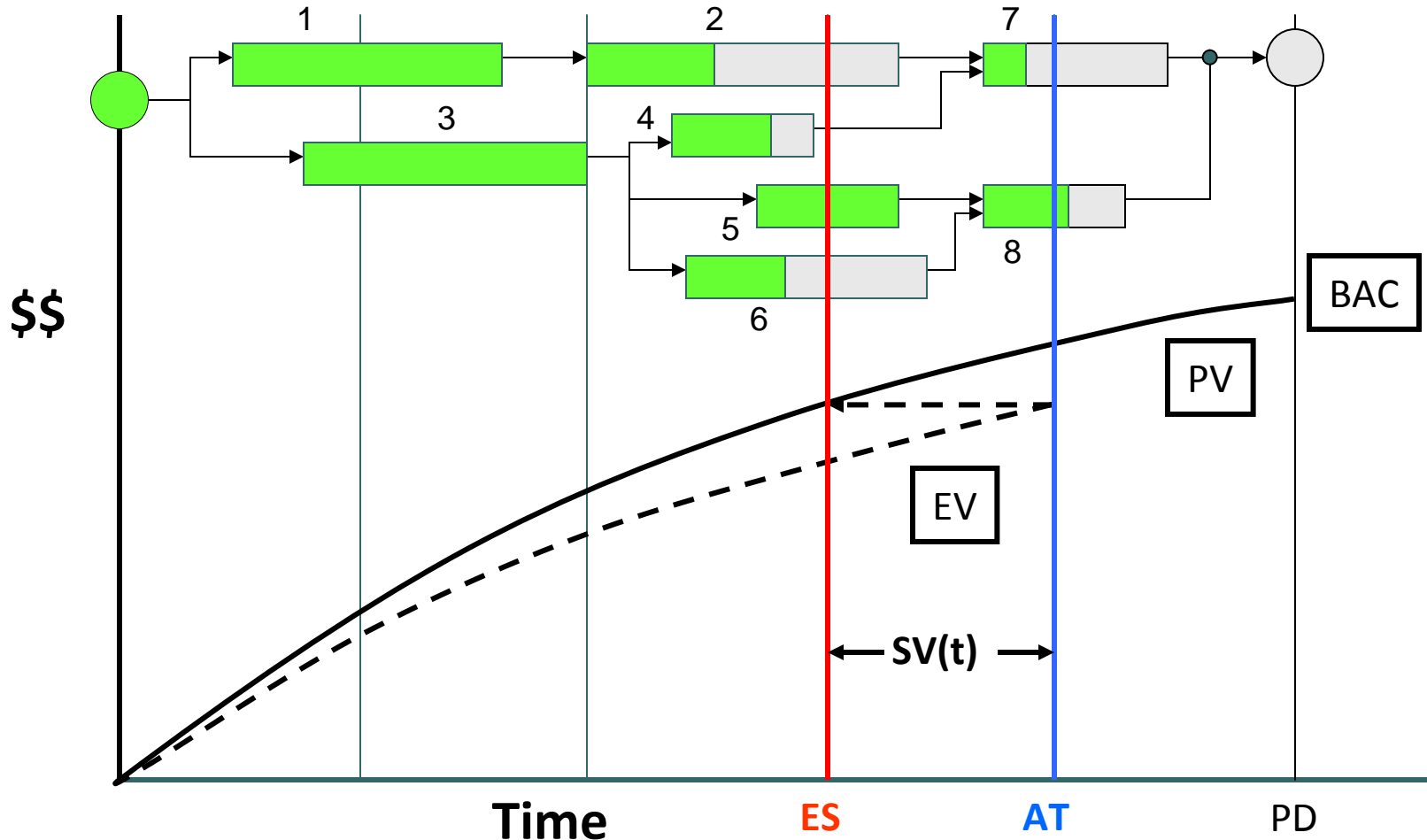
Schedule Adherence

Schedule Adherence

- Recall the initiatives to improve project performance and quality over the last 25 years: SPC, TQM, SEI CMM®, and ISO 9001
- What was their message?

Undisciplined project execution leads to inefficient performance and defective products.

- Then …doesn't it make sense to measure how well the plan (process) is being followed?

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Measuring Schedule Adherence

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Measuring Schedule Adherence

- By measuring the portion of the EV accrued that is congruent with the planned schedule we can have an indicator for controlling the process

- Schedule Adherence is defined as:

$$P = \Sigma EV_j / \Sigma PV_j$$

  where the subscript j denotes the identity of the tasks

  comprising the planned accomplishment

- The value of ΣPV_j is equal to the EV accrued at AT

- ΣEV_j is the amount of EV for the j tasks, limited by the value of the corresponding PV_j

Measuring Schedule Adherence

- <u>Tasks behind</u> – indicates the possibility of impediments or constraints

- <u>Tasks ahead</u> – indicates the likelihood of future rework

- Both, lagging & ahead cause poor performance efficiency …ahead performance is most likely caused by the lagging tasks

Concentrating management efforts on alleviating impediments & constraints will have the greatest positive impact on project performance

SA - Analysis Example
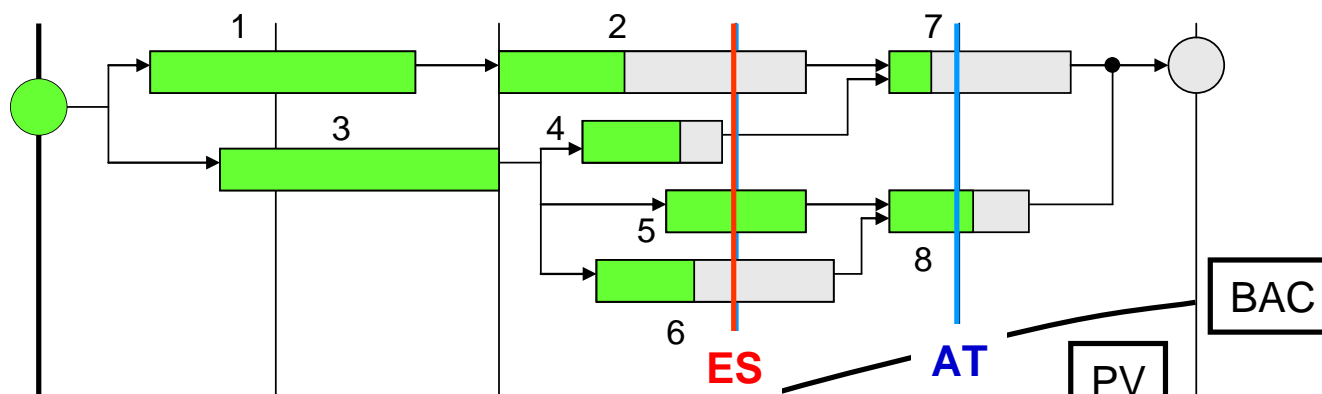
Task	PV	PV@ES	EV@AT	EV - PV	I/C or R
1	10	10	10	0	
2	12	9	5	-4	I/C
3	10	10	10	0	
4	5	5	3	-2	I/C
5	5	2	5	+3	R
6	8	4	3	-1	I/C
7	7	0	1	+1	R
8	5	0	3	+3	R
Total	62	40	40	0	

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Example Application

○ What is the value of the P-Factor for this example?

Task	PV	PV@ES	EV@AT	EV - PV	I/C or R
1	10	10	10	0	
2	12	9	5	-4	I/C
3	10	10	10	0	
4	5	5	3	-2	I/C
5	5	2	5	+3	R
6	8	4	3	-1	I/C
7	7	0	1	+1	R
8	5	0	3	+3	R
Total	62	40	40	0	

○ It is seen that PV@ES = EV@AT … PV@ES identifies the tasks which should be in-work/complete: 1 through 6

Example Application

Task	PV	PV@ES	EV@AT	EV - PV	I/C or R
1	10	10	10	0	
2	12	9	5	-4	I/C
3	10	10	10	0	
4	5	5	3	-2	I/C
5	5	2	5	+3	R
6	8	4	3	-1	I/C
7	7	0	1	+1	R
8	5	0	3	+3	R
Total	62	40	40	0	

- Sum of EV@AT for 1 thru 6 is equal to 36 …but the amount of EV for task 5 is +3 with respect to its corresponding task PV ...and thus, $\Sigma EV_j = 36 - 3 = 33$
- The P-Factor can now be calculated:

$$P = \Sigma EV_j / \Sigma PV_j = 33 / 40 = 0.825$$

Example Application

- From the value of P …~80 percent of the execution is in conformance with the schedule

- Presuming all of the claimed accomplishment not in agreement with the schedule requires rework, i.e. 7 units ….then:

  - ~18 percent of claimed EV requires rework

  - Without a large amount of MR, successful completion is unlikely

  - The PM has much to do to save this project …however, without the P-Factor indicator and the analysis ES facilitates, it is unclear as to what he/she should investigate and take action to correct

SA - Real Data

- The next chart is a graph of CPI, SPI(t) and the P-Factor versus Percent Complete using actual project data

- Observe the following:
  - Values of P from 20% through 40% complete
  - Values of CPI & SPI(t) throughout
  - Overall behavior of the P-Factor

What can be said about this project?

SA - Real Data

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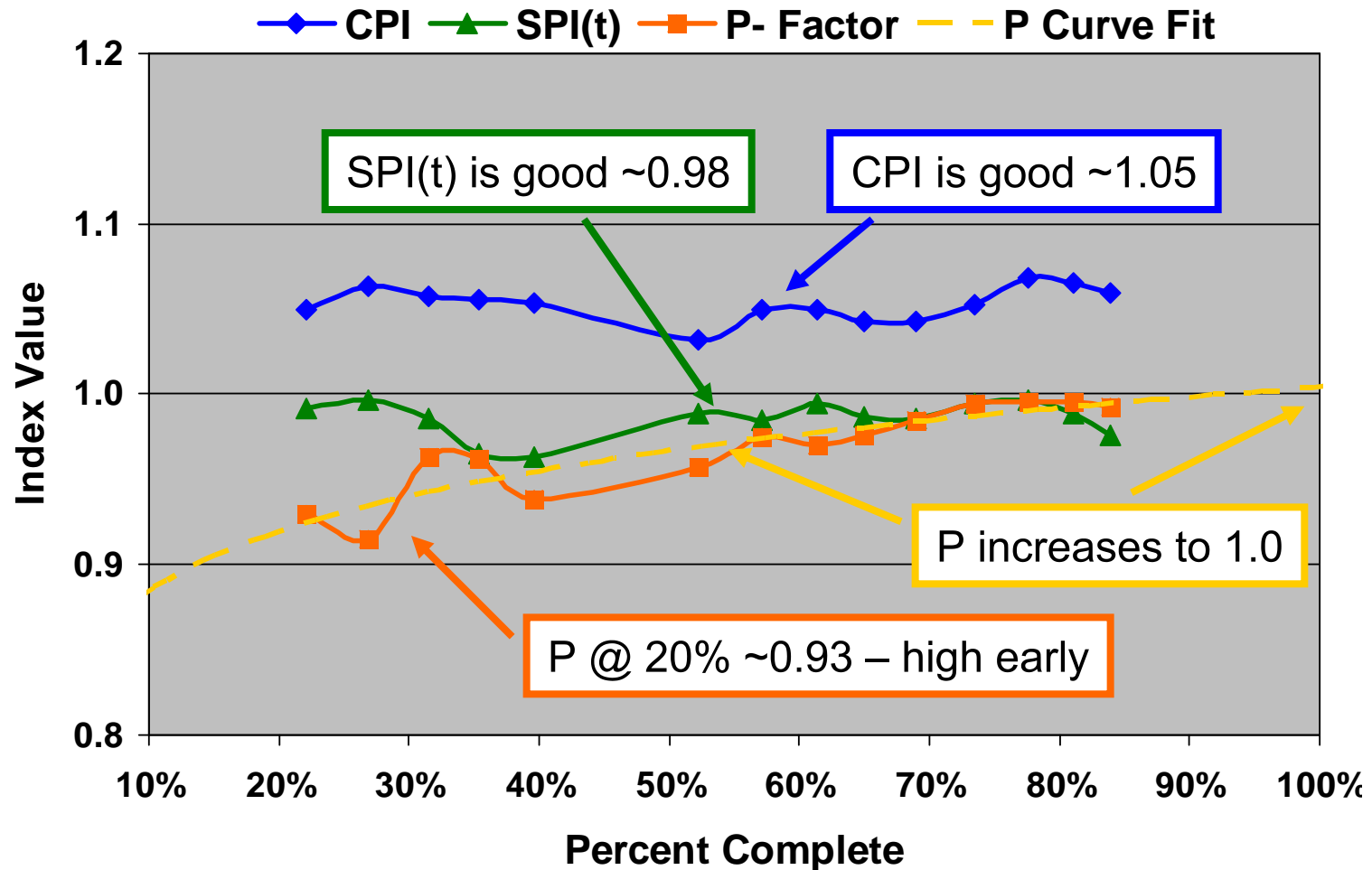
SA - Real Data

- The outcome forecast indicates the project will complete under budget and slightly past the planned date …*a successful project*

- A logical conjecture is ...when the planned schedule is closely followed output performance is maximized …the project has the greatest opportunity for success

- Also …when the indicators are all good, especially early in the project, we can deduce the project planning was excellent, as well as management and employee performance

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SA Summary

- Independent from schedule efficiency (SPI(t))
- Measured as ratio of EV conforming to the PV which should have been earned (P-Factor)
- Allows analysis which identifies tasks having impediments or constraints
- Identifies tasks which are likely to have future rework and enhances forecasting
- Leads to Schedule Adherence Index and improved control
- Facilitates calculation of induced rework

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Rework

Rework Computation
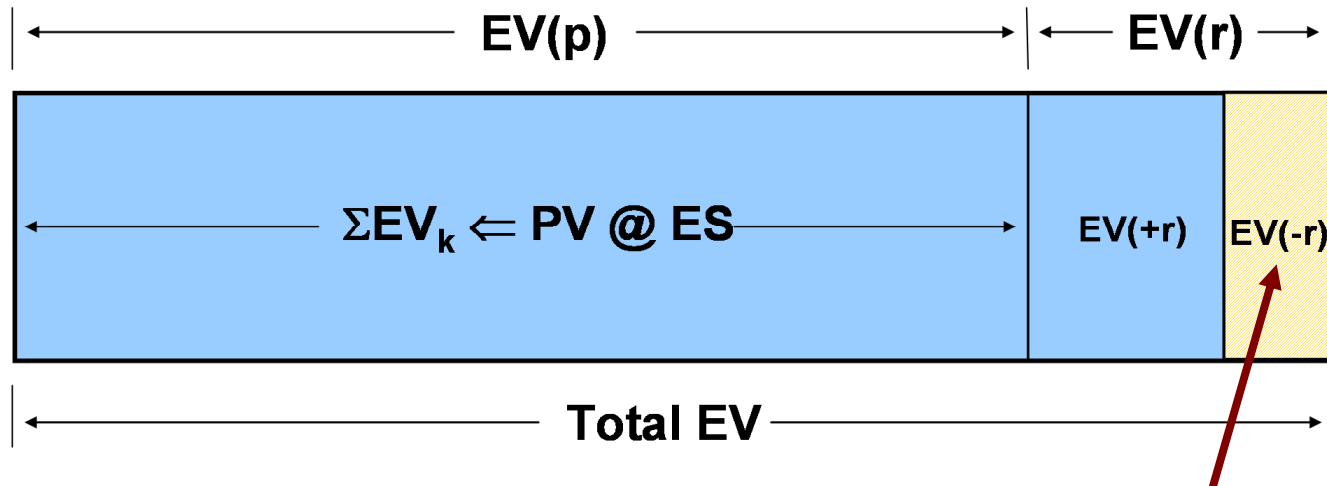
Rework

$$R = EV(-r) = f(r) \bullet (1 - P) \bullet EV$$

Rework & P-Factor

- The value computed for R represents the cost of rework forecast for the remainder of the project due to the present value of P

- Although of some interest, P is not particularly useful for PMs

- Regardless of effort invested to improve, P increases as project progresses and concludes at 1.0 at completion

- Thus, R does not yield trend information, nor can it lead to a forecast of total cost of rework

Rework ⟹ SA Index

○ R can be transformed to a useful indicator by dividing by the work remaining (BAC – EV):
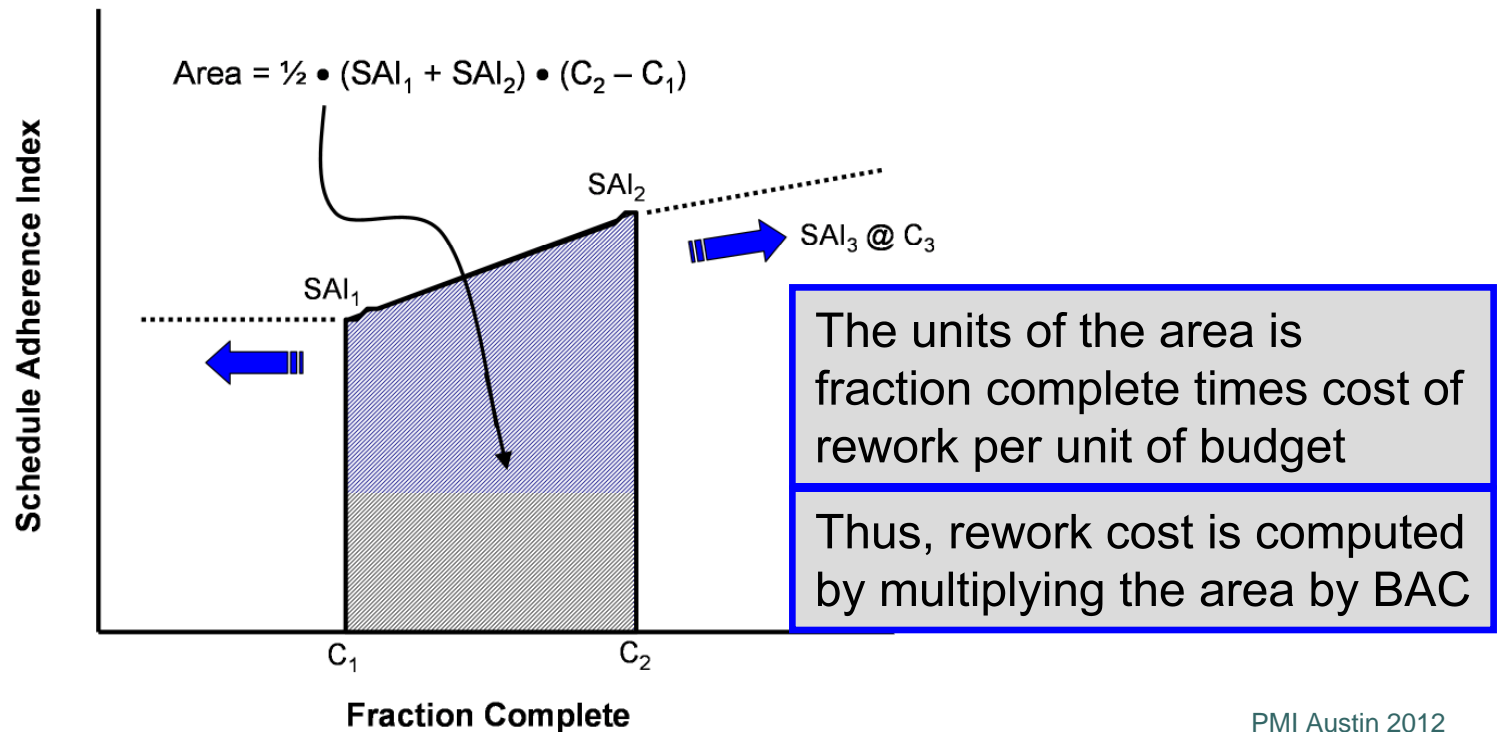
$$SAI = R/(BAC – EV)$$

where SAI = Schedule Adherence Index

○ SAI is useful for detecting trends …thus a management tool for gauging actions taken

- SAI increasing with EV $\Rightarrow$ SA worsening
- SAI decreasing with EV $\Rightarrow$ SA improving

Computation Method

- Having SAI facilitates the calculation of rework within a performance period

Area $= \frac{1}{2} \cdot (SAI_1 + SAI_2) \cdot (C_2 - C_1)$

SAI_2

$SAI_3 @ C_3$

SAI_1

Schedule Adherence Index

C_1 C_2

Fraction Complete

The units of the area is fraction complete times cost of rework per unit of budget

Thus, rework cost is computed by multiplying the area by BAC

Rework Forecast

- To obtain the rework cost for period n:

$$R_p(n) = BAC \bullet [\tfrac{1}{2} \bullet (SAI_n + SAI_{n-1}) \bullet (C_n - C_{n-1})]$$

  For n = 0 and N: SAI = 0.0

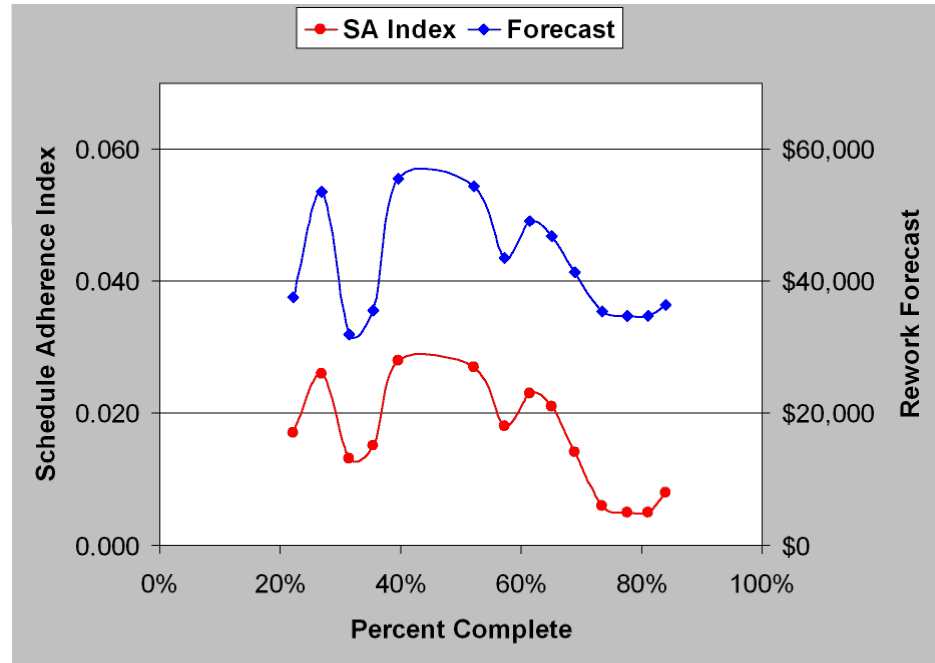- The cumulative accrual is the sum of the periodic values:

$$R_{cum} = \Sigma \, R_p(n)$$

- The formula for total rework forecast is:

$$R_{tot} = R_{cum} + SAI \bullet (BAC - EV)$$

Rework - Real Example

- BAC $\cong$ $2.5 million, P = 0.930 $\Rightarrow$ 0.995
- CPI $\cong$ 1.05, SPI(t) $\cong$ 0.98
- EV(r) $\cong$ $80K, Rework Forecast $<$ $40K

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Rework Wrap Up

- Ability to determine amount of out of sequence EV and forecast rework cost heightens management attention to schedule execution

- Increases ability of oversight functions to identify EV "gaming"

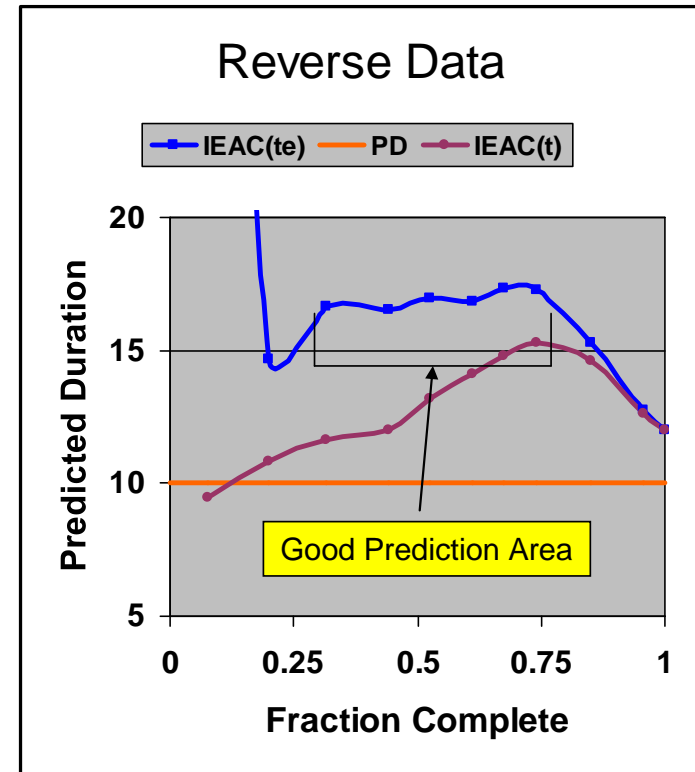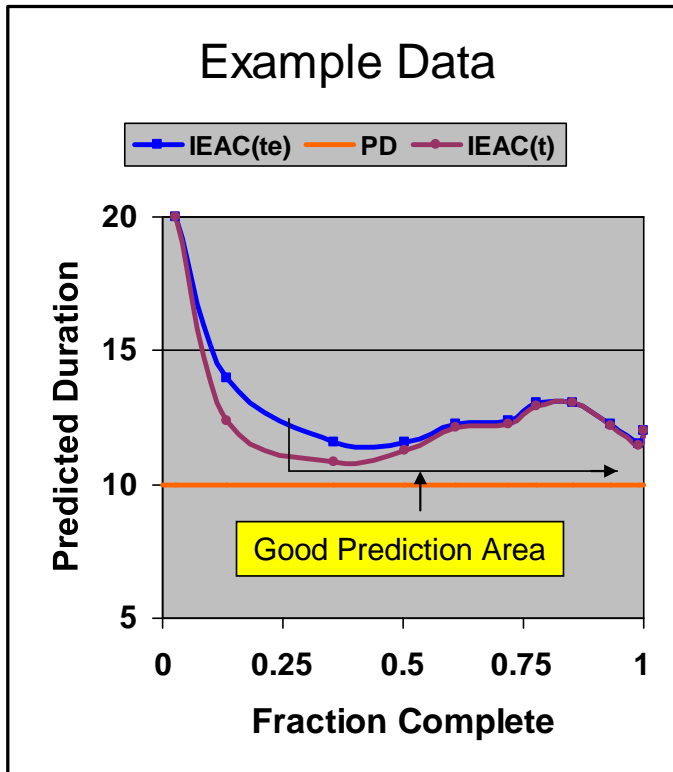- Improved schedule adherence hypothesized to improve both cost and schedule performance efficiencies

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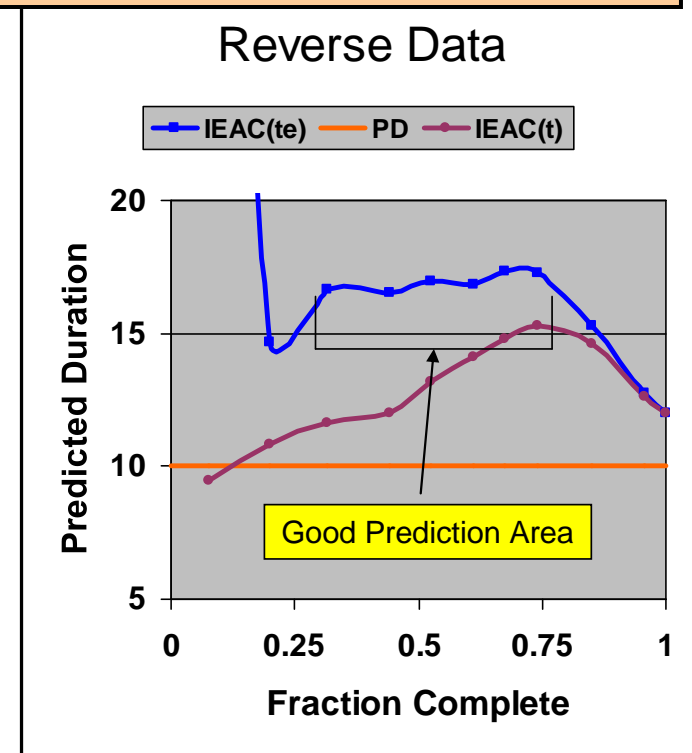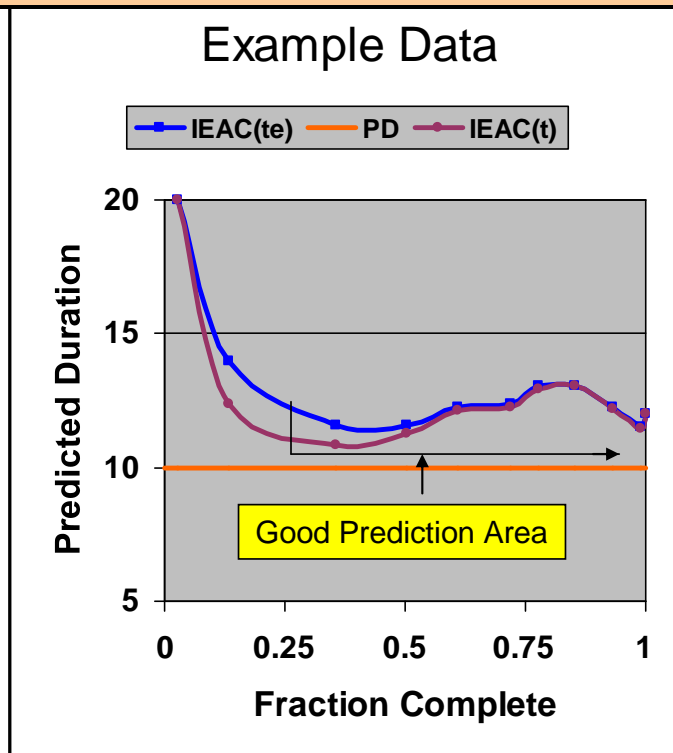
Effective Earned Value

Effective Earned Value

- EV(e) = EV – R
- Effective ES is computed using EV(e) …*i.e., ES(e)*
- Effective EV and ES indicators/predictors/forecast ..

	Cost	Schedule
Indicators	CV(e) = EV(e) - AC	SV(te) = ES(e) - AT
	CPI(e) = EV(e) / AC	SPI(te) = ES(e) / AT
Predictors	TCPI = [BAC – EV(e)] / [BAC – AC]	TSPI = [PD – ES(e)] / [PD – AT]
	TCPI = [BAC – EV(e)] / [EAC – AC]	TSPI = [PD – ES(e)] / [ED – AT]
Forecast	IEAC(e) = BAC / CPI(e)	IEAC(te) = PD / SPI(te)

Effective EV Forecasting

Example Data — chart with legend IEAC(te), PD, IEAC(t); Predicted Duration (y-axis, 5 to 20) vs Fraction Complete (x-axis, 0 to 1); Good Prediction Area

Reverse Data — chart with legend IEAC(te), PD, IEAC(t); Predicted Duration (y-axis, 5 to 20) vs Fraction Complete (x-axis, 0 to 1); Good Prediction Area

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These graphs were created with notional data. The graph on the left shows the behavior of IEAC(t) and IEAC(te) when schedule adherence is good. As can be seen beginning at 0.25 until ~0.60 complete, IEAC(te) provides a better forecast. Thereafter the two forecasts are nearly identical.

Example Data

Legend: IEAC(te) — PD — IEAC(t)

Y-axis: Predicted Duration (5, 10, 15, 20)
X-axis: Fraction Complete (0, 0.25, 0.5, 0.75, 1)

Good Prediction Area

Reverse Data

Legend: IEAC(te) — PD — IEAC(t)

Y-axis: Predicted Duration (5, 10, 15, 20)
X-axis: Fraction Complete (0, 0.25, 0.5, 0.75, 1)

Good Prediction Area

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The graph on the right shows the effect when schedule adherence during project execution is very poor. For the data set, completion was confined to be identical to the example in the left graph. Thus, the forecasting from 0.75 to completion is not representative in comparing IEAC(t) and IEAC(te). In the portion labeled "Good Forecasting Area," IEAC(t) is observed to continually worsen. However, the IEAC(te) forecast over the range shows very consistent forecast values …displaying the value of EV(e).

Good Prediction Area

Good Prediction Area
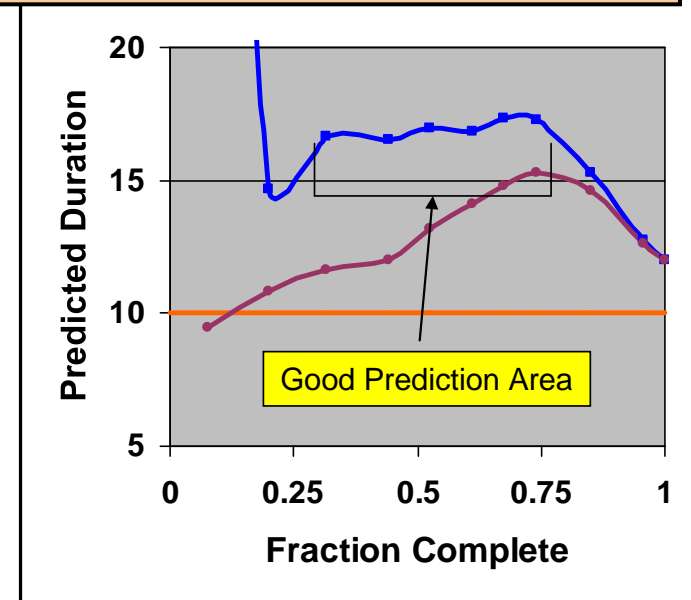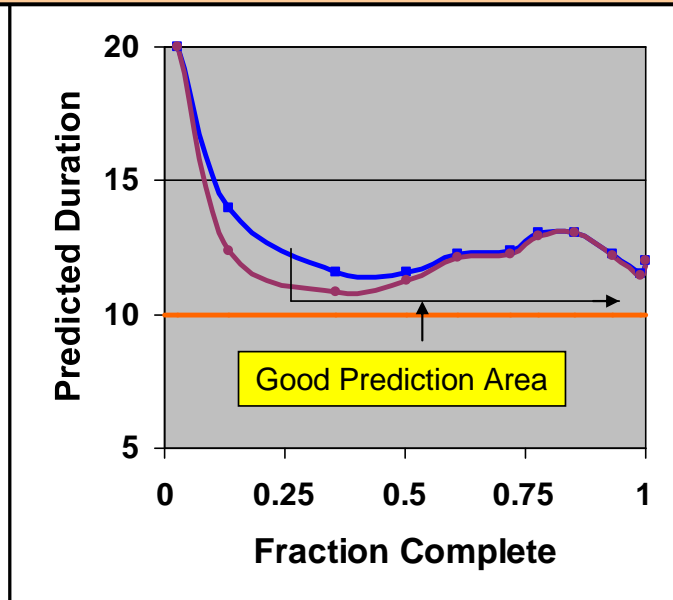
Summary: Effective EV

- Lack of adherence to the schedule causes EV to misrepresent project progress

- Effective EV calculable from P, f(r), and EV accrued

- Approximation method available …when appropriate

- EV(e) analysis most useful during early portion of project execution and when performance suffers from poor process discipline

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Small Projects

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Small Projects

- Over several years of research and application, ES has shown to be a reliable schedule analysis extension to EVM

- For large projects, *Stop Work* and *Down Time* conditions for small portions of the project may not have much impact on the ES indicators and forecast values

- For small projects, the interrupting conditions will distort ES indicators and forecasts and possibly impact management decisions

Down Time & Stop Work

- Down Time – *periods within the schedule where no work is planned*
  - *Down Time* extends the planned period of performance
  - Management has the prerogative to work, instead
- Stop Work – *periods during execution where management has halted performance*
  - When management imposes a *Stop Work* the opportunity has been removed for accruing EV
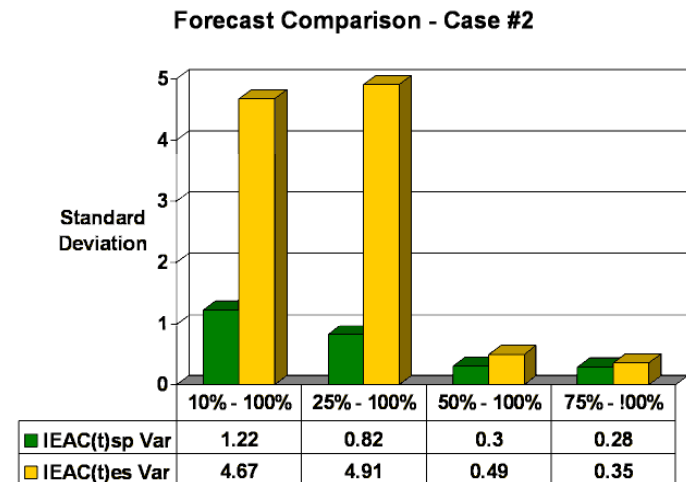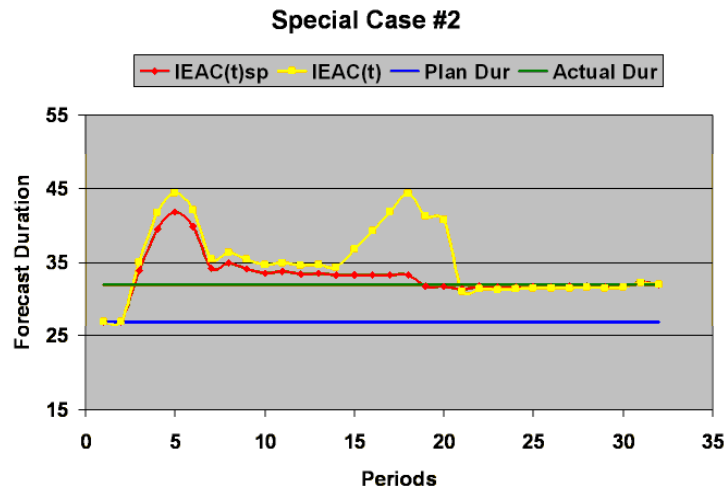
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Special Case Forecasts

- Before proceeding it is worthy to note that ES forecasts using the normal index values will always converge to the actual duration

- Well then …if this is the case …*Why bother?*

The improvement is significant enough to warrant using the special case calculation method

- Special Case – an initial forecast is made as if interrupting conditions are not present. The interruption effects are then introduced to calculate the special forecast

Forecast Comparison

Special Case #2

Legend: IEAC(t)sp · IEAC(t) · Plan Dur · Actual Dur

Forecast Duration vs *Periods*

Forecast Comparison - Case #2

	10% - 100%	25% - 100%	50% - 100%	75% - !00%
IEAC(t)sp Var	1.22	0.82	0.3	0.28
IEAC(t)es Var	4.67	4.91	0.49	0.35

Late Finish – 4 periods of down time (15-18)

- The normal forecast has a larger increase for the down time and requires longer to converge to the final duration

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Special Case Summary

- The special case forecasts are more accurate for every set of computed values after the first period

- The column charts clearly indicate better forecasting and convergence for all data ranges

- When interruptions of *Stop Work* and *Down Time* are encountered the special forecasting method can be expected to produce more reliable results

Longest Path

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Longest Path Forecasting

- The forecasting formula IEAC(t) = PD / SPI(t) has proven to be reasonably good
  - Kym Henderson (real data) – 2004
  - Vanhoucke & Vandevoorde (simulation) – 2007
  - Lipke (EVM conversion) - 2008
- Recent research indicates ES forecasting more reliable for serial schedules and less so for parallel (Vanhoucke 2009)
- Recommended solution – combining two techniques – ES & SRA (Vanhoucke 2012)

Longest Path Theory

- Forecasts from serial schedules have been shown to be most reliable …thus, the possible serial paths to completion of the network are identified for forecasting

- The longest forecast determined from the various paths at each performance period converges to the actual final duration with less variation than any other path

- If true, it follows that the set of longest forecasts resolves the parallel topology issue of ES forecasting applied to the total project

Project Schedule Paths
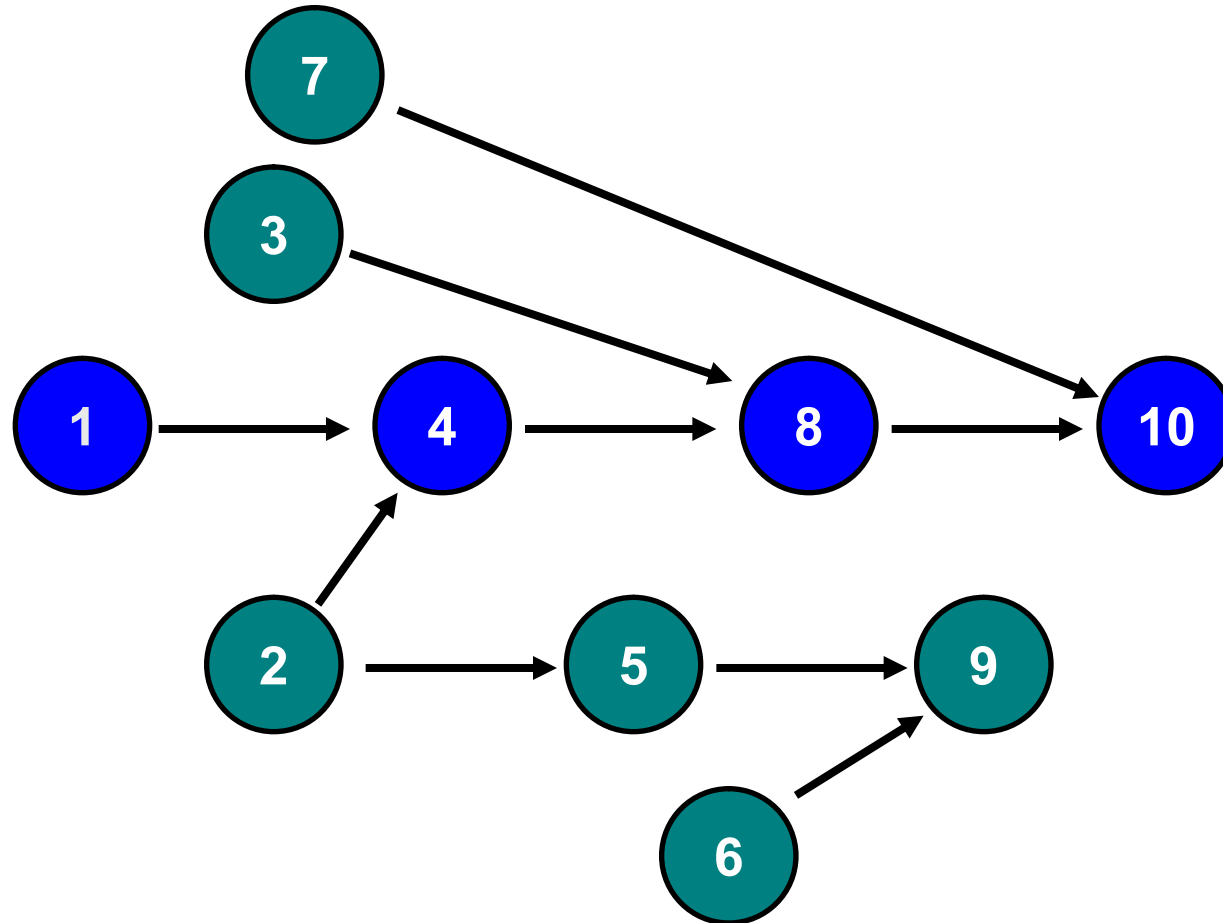
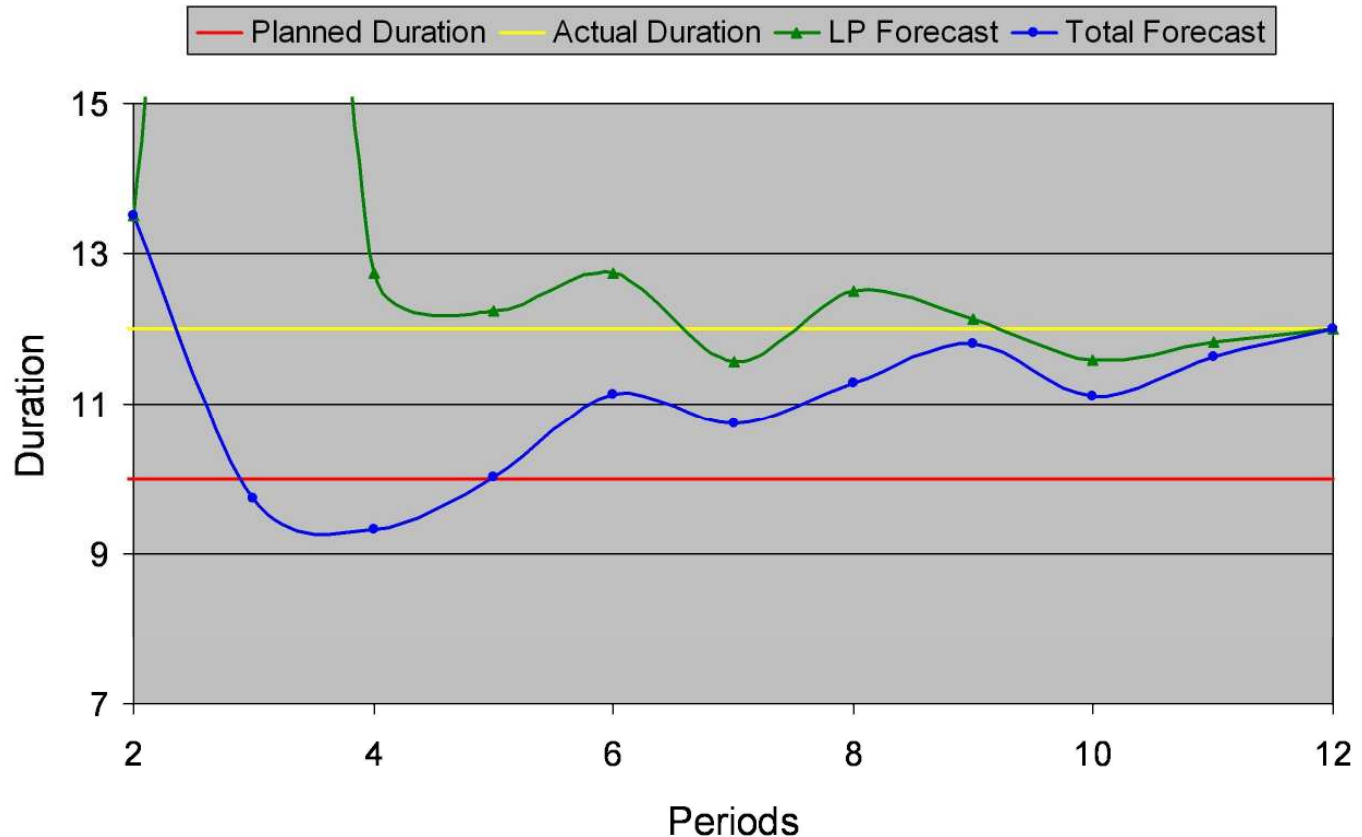Copyright © Lipke 2012

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Performance Analysis

- Execution of the various tasks does not necessarily coincide with the plan …voids are seen in the EV and PV data

- The project did not complete on the Critical Path

- Two paths completed two periods past the planned duration of 10 periods, 2-5-9 and 6-9

LP Forecast Results

Performance Path	**** **** **** Period **** **** ****											
	1	2	3	4	5	6	7	8	9	10	11	12
1-4-8-10		13.50	9.33	7.82	9.00	11.00	9.96	9.75	11.00	10.00		
2-4-8-10			28.67	10.89	10.00	12.67	10.51	10.00	11.33	10.00		
2-5-9				8.00	8.38	8.83	10.00	11.75	11.75	11.45	11.75	12.00
3-8-10			12.00	9.62	10.00	12.67	10.51	10.00	11.33	10.00		
7-10				12.75	12.24	12.75	11.57	10.78	11.40	10.00		
6-9						9.17	10.00	12.50	12.14	11.58	11.82	12.00
Total Project		13.50	9.75	9.33	10.03	11.12	10.74	11.29	11.81	11.11	11.64	12.00

- The forecasts are shown in the table with the longest path identified by the lime color
- The longest path changes during execution
- The project finished late ⟹ IEAC(t)$_{LP}$ ≥ IEAC(t) at every period
- Both IEAC(t)$_{LP}$ & IEAC(t) converge to the actual final duration, 12 periods

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LP Forecast Results

Legend: Planned Duration | Actual Duration | LP Forecast | Total Forecast

- Convergence and forecasting characteristics are readily seen from graph – LP forecast is more accurate and less variable

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LP Forecast Summary

- Schedule topology affects the "goodness" of ES forecasting – as the schedule becomes more parallel the forecasting accuracy decreases

- The idea of "longest path" (LP) was proposed and tested with notional data

  - The LP forecast provided better results in every instance

  - It is reasonable to assume IEAC(t) is the lower bound when the LP forecast is consistently greater

  - The LP forecast appears to be a significant improvement – more testing is needed before declaring the method resolves the ES forecasting problem for parallel topology schedules

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Statistical Forecasting

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Statistical Forecasting

- An objective of project management is to have the capability to reliably predict cost and schedule outcomes

- The application of statistical methods to the cost and schedule indicators from EVM and ES is a well-founded means for providing the project management objective
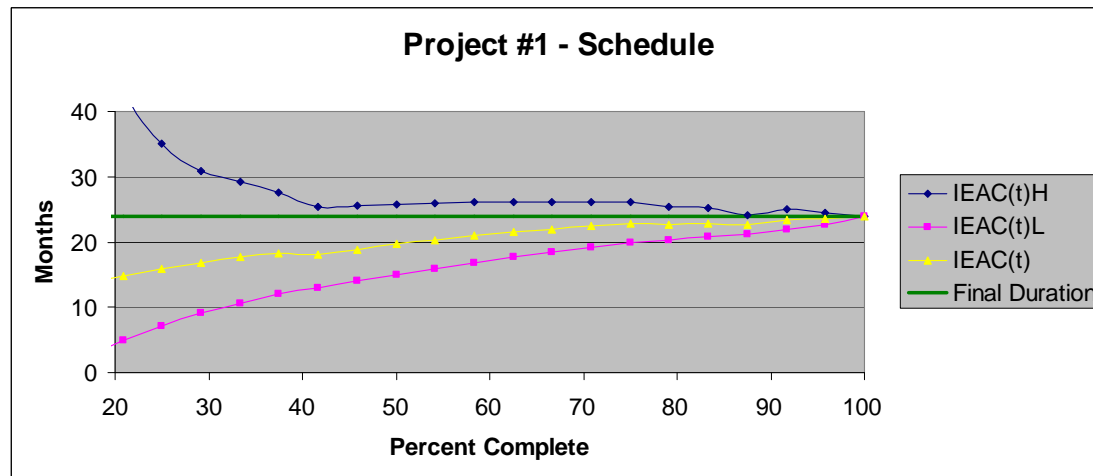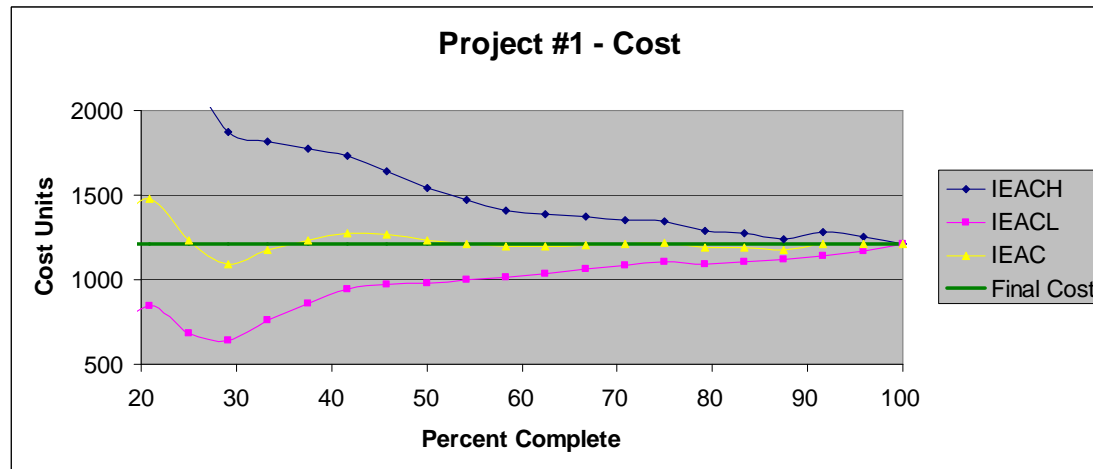
Confidence Limits

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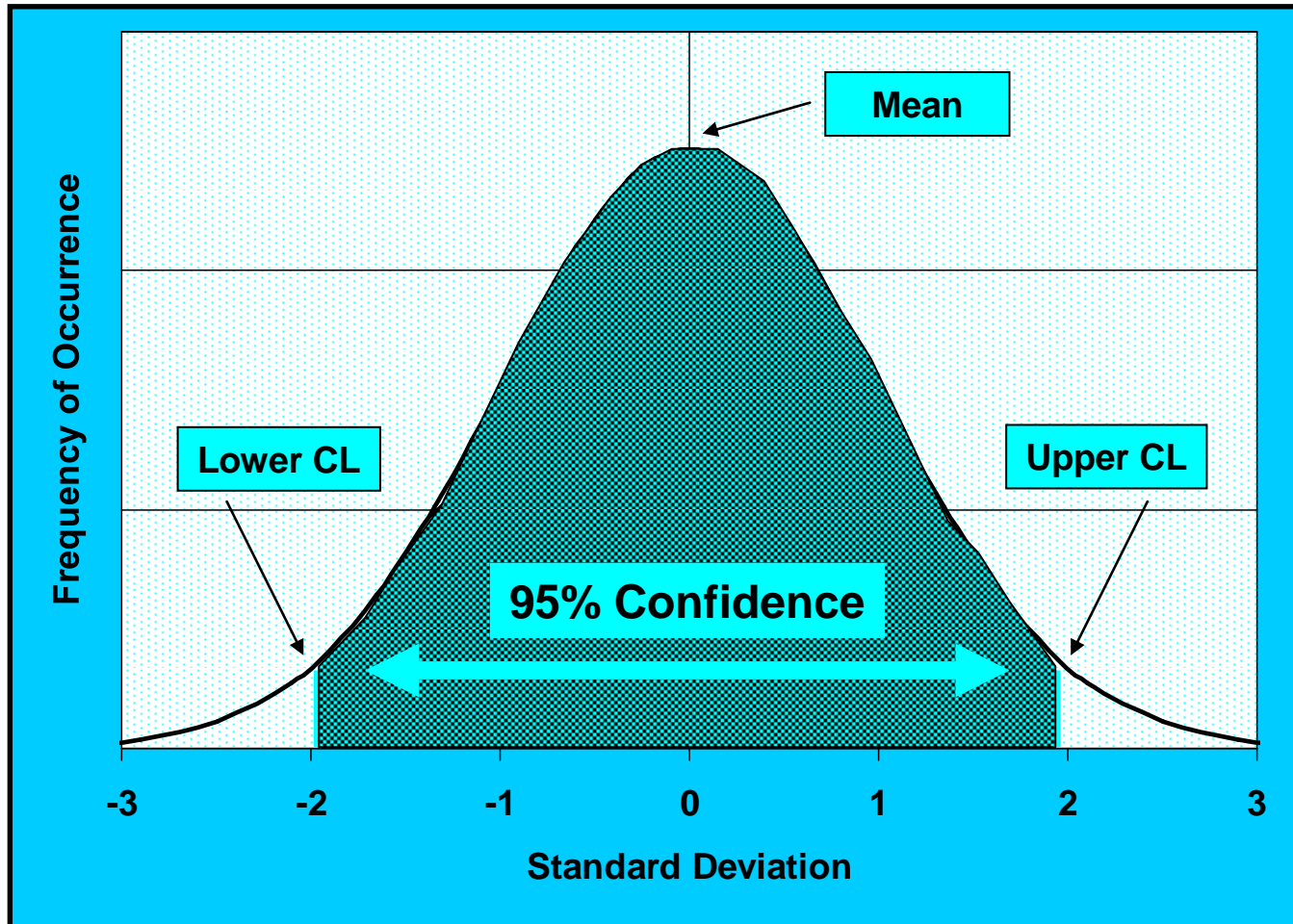
Use of Confidence Limits

- Confidence Limits of the performance indexes, using the finite population adjustment, have been shown to produce reliable forecasts of bounds for cost and schedule outcomes

- $CL_{(\pm)} = \ln \text{index(cum)} \pm Z * (\sigma/\sqrt{n}) * AF$
  - $AF_C = \sqrt{((BAC - EV) / (BAC - (EV/n)))}$
  - $AF_S = \sqrt{((PD - ES) / (PD - (ES/n)))}$

- Forecast at Completion
  - $IEAC_{(low\ or\ high)} = BAC / e^{\wedge}(CL_{(\pm)})$
  - $IEAC(t)_{(low\ or\ high)} = PD / e^{\wedge}(CL(t)_{(\pm)})$

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Example Forecast
(90% Confidence – real data)

Project #1 - Cost

Project #1 - Schedule

Example Observations

- Difference between upper & lower CLs becoming smaller as percent complete increases

- CPI is very stable between 50 and 100%

- SPI(t) consistently worsens
  - IEAC(t)H beginning at 30% complete proved to be very close to the eventual final duration

- As a rule, of the three plots, the graph that is most horizontal is the best forecast

The method is generally applicable and encouraged – independent of size or type of project
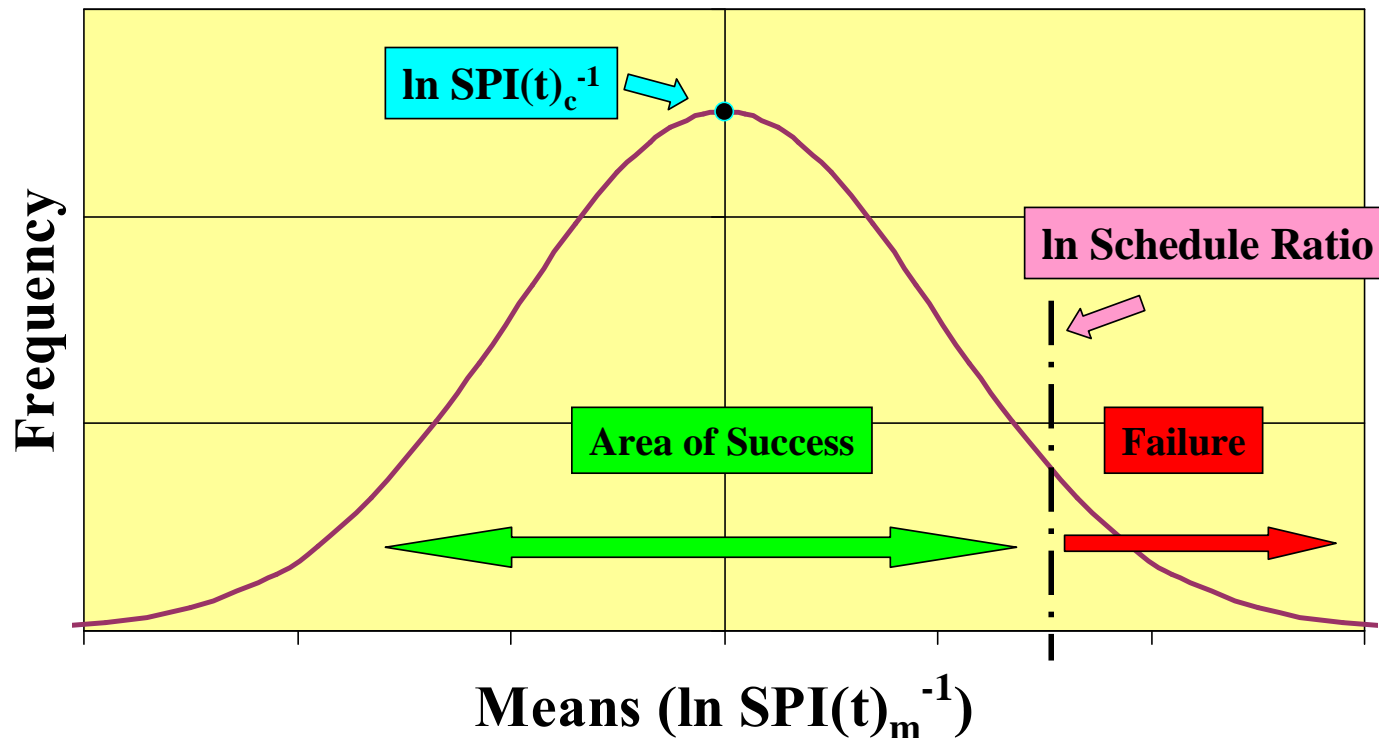
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Statistical Planning

Statistical Planning

- Risk mitigation $\Rightarrow$ *Cost/Schedule Reserve*

- Data needed
  - Performance variation from similar historical project [Standard Deviation = σ_H] -or- qualitative estimate of Risk
  - Planned Duration of new project [provides the number of performance observations (n)]
  - Variation of Means (ln $xPI(t)_m^{-1}$) = $\sigma_H / \sqrt{n} = \sigma_m$
  - Probability of Success Desired (PS)

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Probability of Success

○ Below is a graphic example using schedule measures

The chart shows a bell curve with:
- **ln SPI(t)$_c^{-1}$** labeled at the peak
- **ln Schedule Ratio** labeled at a vertical dashed line on the right
- **Area of Success** (green, left/center region)
- **Failure** (red, right region)
- Y-axis: **Frequency**
- X-axis: **Means (ln SPI(t)$_m^{-1}$)**

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Planning Data & Calculation

- Calculation

  PS $\Rightarrow$ Z (use Normal Distribution Tables or Excel)

  $Z = (\ln xR - \ln xPI(t)_c^{-1}) / \sigma_m$

  where $xPI(t)_c^{-1} = 1.0$ for plan

  $xR = \text{antilog} (Z * \sigma_m)$

  Cost: CR = TAB/BAC $\Rightarrow$ TAB = CR $*$ BAC

  Management Reserve = (CR – 1) $*$ BAC

  Schedule: SR = TAD/PD $\Rightarrow$ TAD = SR $*$ PD

  Schedule Reserve = (SR – 1) $*$ PD

Example Calculation

- Data: σ_H = 0.4, BAC = $1M, n = 36, PS = 90%
- Calculation:

  σ_m = 0.4 / $\sqrt{36}$ = 0.0667

  PS = 90% $\Rightarrow$ Z = 1.2816

  Cost Ratio = antilog (1.2816 $*$ 0.0667)

  = 1.0892

  Management Reserve = (1.0892 – 1) $*$ $1M
  = $89,200

- Does this amount of reserve cause the bid to be non-competitive? …Can we accept more risk with a lower probability of success?

Planning Comments

- Simple statistical methods link probability of success to reserves …to bid competitiveness …and management decisions

- Makes use of historical data …and creates need for repository containing valid data

- Creates an awareness during planning of the connection between risk and competitiveness

- Separates risk resource planning from task estimates for both cost and duration

Wrap-Up

Earned Schedule Summary

- Managing schedule may be more difficult than cost and has more repercussions

- ES is derived from the PMB and EV accrued

- ES makes possible - reliable schedule performance indicators, forecasting, prediction

- ES facilitates - identifying process impediments, assessing actions taken & minimizing rework

- ES amplifies ability to control project using EVM data

- Application aids are available and coming

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Supplemental Remarks

- Data for analysis comes from EVM …no new data is required

- Provides top down approach to assessing schedule performance

- Equally usable for re-planned projects, and small projects having stop work and down-time conditions

Supplemental Remarks

○ ES methodology is growing
- ES website is receiving $\cong$ 45K hits per month
- Project management and EVM books now include ES
- Included in university coursework & research
- Evidence of use is global
- Usage is occurring in several industries
- Included in PMI® EVM Practice Standard (Oct 2011)

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Supplemental Remarks

- ES has had its share of detractors …and proponents, as well
- British philosopher, John Stuart Mill, once made this observation that new ideas pass through three phases of denial:

  First – *They are wrong*

  Second – *They are against religion*

  Third – *They are old news, trivial, common sense, and we all would have thought of them if we had had the time, money, and interest*

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Application Help

- Explore the Earned Schedule website
  - www.earnedschedule.com
  - Papers, Presentations, Calculators, Terminology
- Read two articles …to begin
  - "Schedule is Different"
  - "Further Developments in Earned Schedule"
- Scan the Calculators …experiment with them
  - ES Calculator (v1a & vs1b)
  - P-Factor Calculator
  - Statistical Prediction Calculator
  - SA Index & Rework Calculator

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Available Resources

- Earned Schedule Website
  http://www.earnedschedule.com/

- PMI® *Practice Standard for Earned Value Management*, 2nd Edition

- *Earned Schedule* book (English, Japanese, Spanish)
  - Print
  - ePub (Nook & iPad)
  - Kindle
  - PDF

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Contact Information

Walt Lipke		Kym Henderson
waltlipke@cox.net	Email	kym.henderson@gmail.com
+1 405 364 1594	Phone	+61 414 428 537