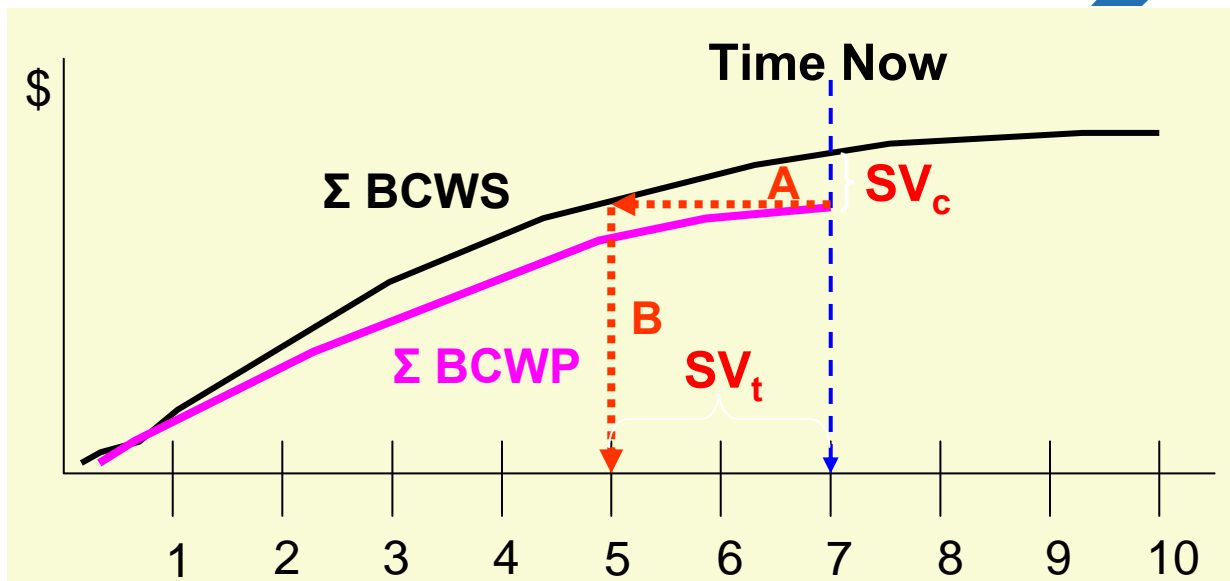


Earned Schedule

New analysis of schedule in Earned Value Management



ASC/Industry Cost & Schedule Workshop 19-20 Sep 2006

Robert Handshuh, CPIM, PMP



- **Background**
 - ***Earned Value Management & Metrics***
 - ***Strengths & Weaknesses***
- **What is Earned Schedule**
- **Sample Calculations**
- **Examples from LM Project Data**
- **Summary / Questions**



- **Earned Value Management (EVM)**
 - *Formalized in the 1960s as C/SCSC*
 - *EVM becomes industry standard with ANSI/EIA 748*
 - *EVM formulas remain the same*

- **The EVM Advantage**
 - *Enforces Project Management discipline*
 - *Predictive capability not just History*
 - *Cost Performance Index (CPI) Validated over many projects*



- **CV= Cost Variance - How much was done minus how much was spent (BCWP-ACWP)**
- **SV= Schedule Variance – What got done minus what was planned (BCWP-BCWS)**
- **CPI= Cost Performance Index – How much was done divided by how much was spent (BCWP / ACWP) “Bang for the buck”**
- **SPI= Schedule Performance Index – How much was done divided by how much was planned (BCWP / BCWS) “Time is money”**



CPI Validated

- **The DoD study in 1977 proved with as little as 15% of the program completed, the Cost Performance Index (CPI) accurately predicted future cost performance.**
 - *DoD study of 400 programs, CPI did not significantly change after 15% complete, Updated study, by Quentin Fleming in 1998, included over 700 programs and showed the same result*

What about SPI ?

- **Studies have shown Schedule Performance Index (SPI) starts losing predictive relevance in the later stages of the program**
 - *Professional Management Associates – EAC Calculations to Project Life Cycle 2004*

Quirks of Schedule Variance

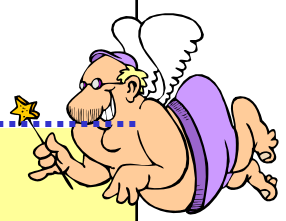


- **Most people think of schedules in time units.**
 - *Is the project ahead or behind in days, weeks or months*
- **Schedule Variance is usually stated in \$.**
 - *A dollar schedule variance is difficult translate to time for many managers.*
- **Schedule Variance returns to “0” at the end of a project, SPI returns to “1”.**
 - *Perfect performance –When it was only (?) months late*

SPI & SV Magical Correction



Month	Σ BCWS	Σ BCWP	SV	SPI
1	100	98	-2	0.98
2	350	325	-25	0.93
3	650	600	-50	0.92
4	1050	960	-90	0.91
5	1500	1360	-140	0.91
6	2000	1830	-170	0.92
7	2500	2260	-240	0.90
8	2950	2665	-285	0.90
9	3350	3075	-275	0.92
10	3650	3350	-300	0.92
11	3900	3575	-325	0.92
12	4000	3725	-275	0.93
13	4000	3800	-200	0.95
14	4000	3875	-125	0.97
15	4000	4000	0	1.00



Example – $\Sigma SPI(c)$



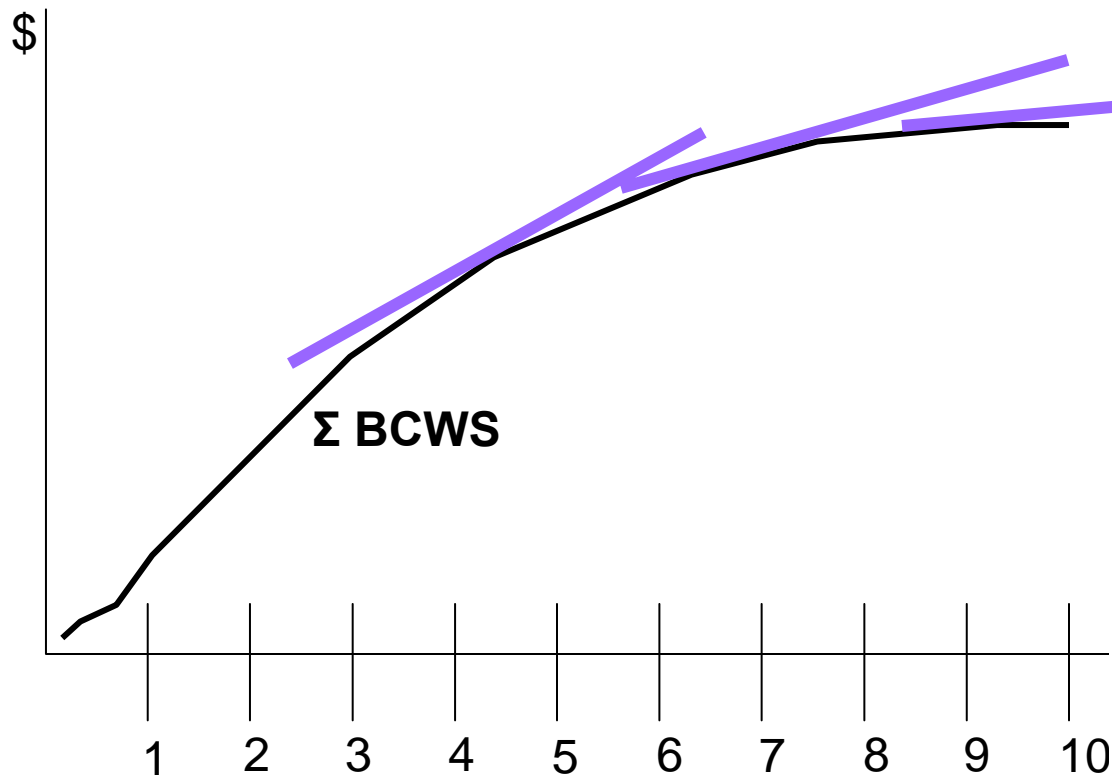
$\$(000)$	Period	Monthly BCWS	Σ BCWS	Σ BCWP	$SPI_{(c)}$
	43	\$2,085	\$257,345	\$231,611	.90
	44	\$ 627	\$257,971	\$231,611	.90
	45	\$ 219	\$258,190	\$231,611	.90
	46	\$ 19	\$258,208	\$231,611	.90
	47	\$ 33	\$258,241	\$231,611	.90
	48	\$ 64	\$258,305	\$231,611	.90

Once 80% complete, monthly gains only have marginal effect on ΣSPI . Smoothing effect is increased by lower monthly budgets typically established in the final phase program

If the project had Σ BCWP of \$231,611 in month 43 then
 $SPI = 0.90$
($\$231,611 / \$257,345$)

If **NOTHING** was done for the next 6 months SPI would still equal 0.90 (rounded)
($\$231,611 / \$258,305$)

SPIC Historical Smoothing



Slope of the curve is Diminishing. BCWS is less each month while time is constant

Even at perfect SPIC (1.0) each monthly gain is a smaller and smaller fraction of total budget

More dramatic effect on large dollar programs



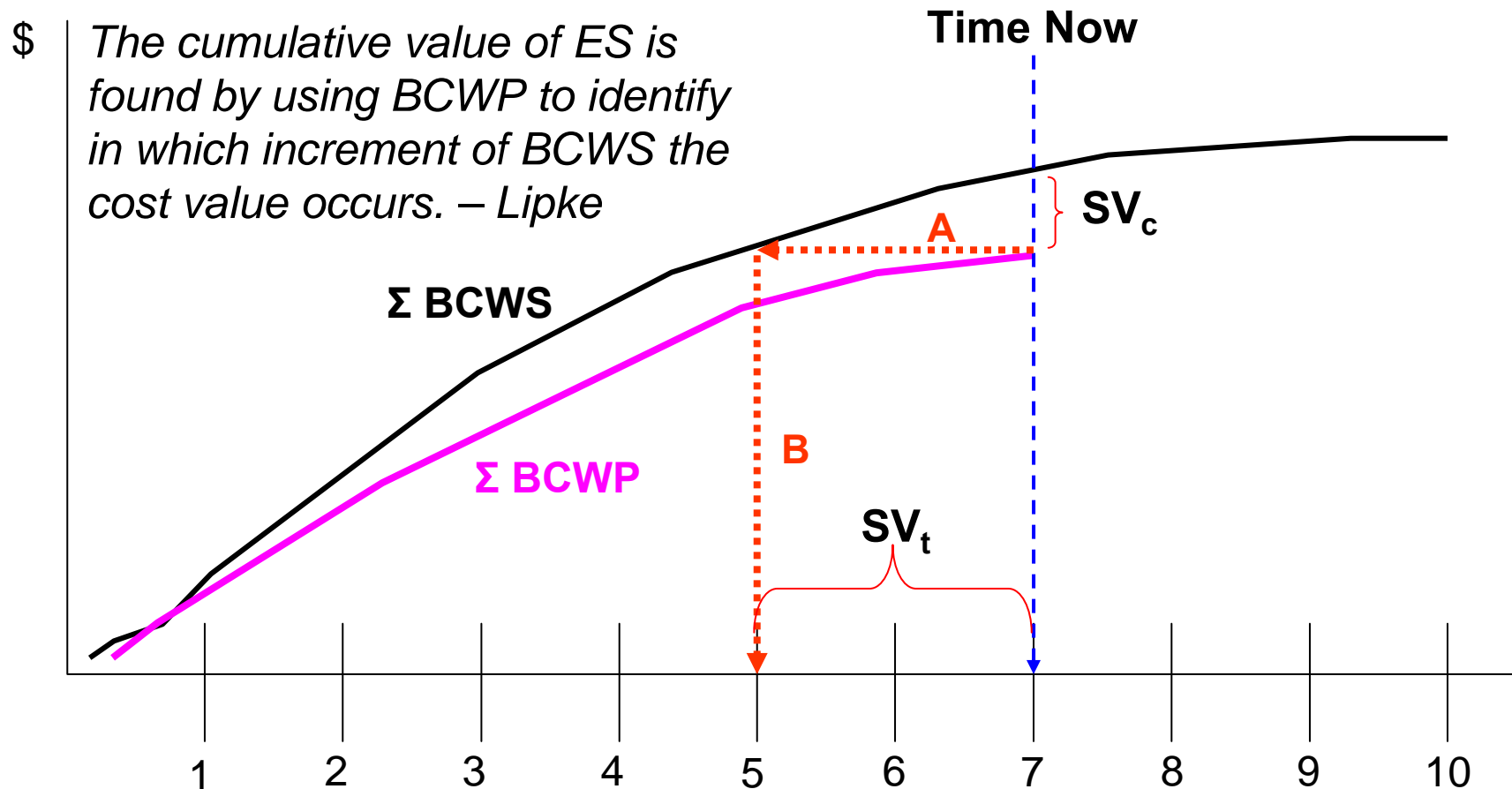
- **Earned Schedule (ES)**
 - *Proposed in 2003 by Walter Lipke*
 - *New formulas for Schedule Variance and Schedule Performance Index based on time*
 - *Validation currently in progress*
- **Earned Schedule Advantages**
 - *Expressed in time units*
 - *Does not revert back to 1.0 at the end of a project*
 - *Predictive capability*

Earned Schedule – It's About Time



- **Earned Schedule is done by projecting BCWP on to BCWS and then measuring the time units**
 - ***Better understanding of project status***
 - ***Closer relation to CV and CPI metrics***
- **Earned Schedule does not return to 1.0**
 - ***Usable through out project life cycle***
 - ***Historical reference for future projects***
 - ***Predictive capability under research & evaluation***
- **Earned Schedule is based on Σ BCWP and Σ BCWS**
 - ***EVM data points you are already collecting***
 - ***No new software; No Salesman will call***

Earned Schedule : How it Works

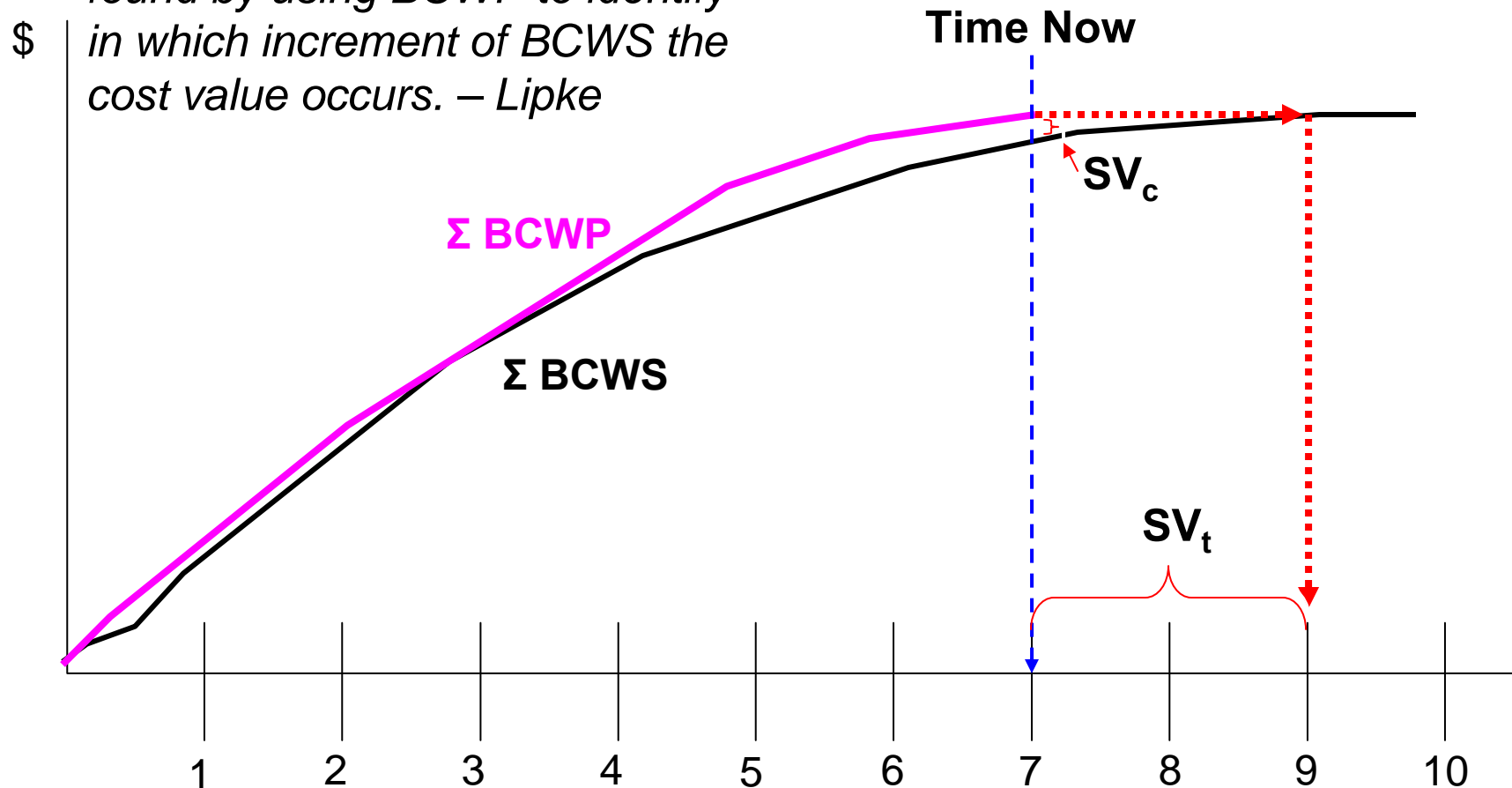


**7 months gone by, but the project only has “Earned Schedule” to Month 5
Which SV “Answers the mail?” \$ behind or 2 months behind schedule?**

Earned Schedule : How it Works



The cumulative value of ES is found by using BCWP to identify in which increment of BCWS the cost value occurs. – Lipke



**7 months gone by, but now project has “Earned Schedule” to Month 9
As a program manager how would define this project? \$ or 2 mo. ahead**



Earned Schedule Suggested Acronyms

Earned Schedule = ES (Similar to EV Cost)

Schedule Variance (time) = SV_t (Similar to CV)

Schedule Performance Index (time) = SPI_t (Similar to CPI)

Actual Time = AT (Latest Status Date)

Planned Duration = PD (Project Duration)

Independent Estimate at Compete, Time = $IEAC_t$ (Similar to IEAC)



Earned Schedule Formulas

Earned Schedule =

Whole months completed were $\Sigma BCWP \geq \Sigma BCWS$ + fractional month completed

= Month (X) + $[(\Sigma BCWP_t - \Sigma BCWS_x) \div (\Sigma BCWS_y - \Sigma BCWS_x)]$

(X = whole month earned; Y = month following X; T = Actual Time)

Schedule Variance (time) = Earned Schedule - Actual Time

(ES - AT = SV_t)

Schedule Performance Index (time) = Earned Schedule \div Actual Time

(ES \div AT = SPI_t)

Independent Time Estimate at Compete (time) =

Planned Duration \div Schedule Performance Index (time)

(PD \div SPI_t = IEAC_t)

Don't Panic – It's not that hard!



Earned Schedule =

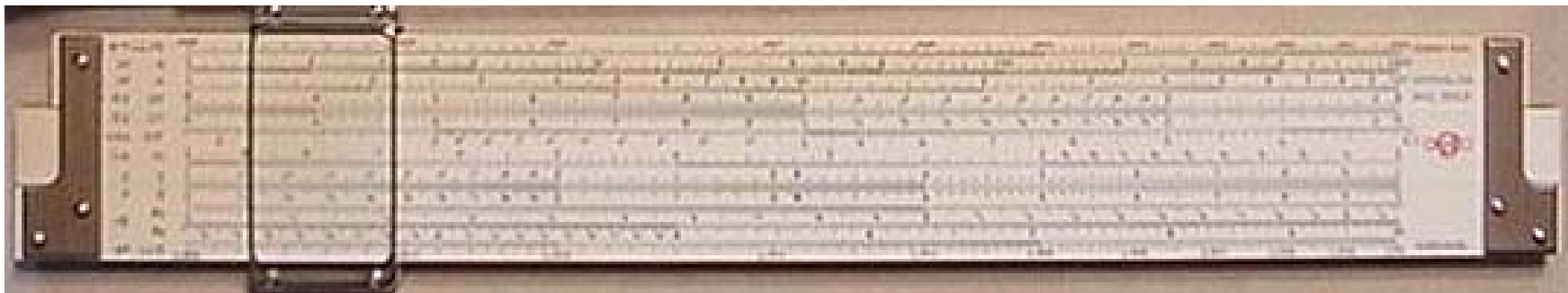
**Whole months completed were $\Sigma BCWP \geq \Sigma BCWS$ +
fractional month completed**

= Month (X) + $[(\Sigma BCWP_t - \Sigma BCWS_x) \div (\Sigma BCWS_y - \Sigma BCWS_x)]$

x = whole month earned

y = month following X

t = Actual Time (Time Now)



Calculating ES -

Extrapolation Between the points - (Time Now - Month 7)



$$\text{Month (X)} + [(\Sigma \text{BCWP}_t - \Sigma \text{BCWS}_x) \div (\Sigma \text{BCWS}_y - \Sigma \text{BCWS}_x)]$$

x = whole month earned; y = month following x; t = Actual Time (Time Now)

- Find X - BCWP to BCWS

- $2260 \geq 2000 \quad X = 6$

- $\text{BCWP}_t - \text{BCWS}_x =$

- $(2260 - 2000)$

- $\text{BCWS}_y - \text{BCWS}_x =$

- $(2500 - 2000)$

- $\text{ES} = 6 + (2260 - 2000) \div (2500 - 2000)$

- $\text{ES} = 6 + (260 \div 500) = 6.52$

- We are in month 7 but only Earned 6.52 months of Schedule

Month	Σ BCWS	Σ BCWP
5	1500	1360
6	2000	1830
7	2500	2260
8	2950	
9	3350	

A blue arrow points from the text "(2260 - 2000)" to the BCWP value of 2260 in the table. A line connects the 2260 value to the calculation in the text "(2260 - 2000)".

Completing the ES Analysis

(Time Now - Month 7)



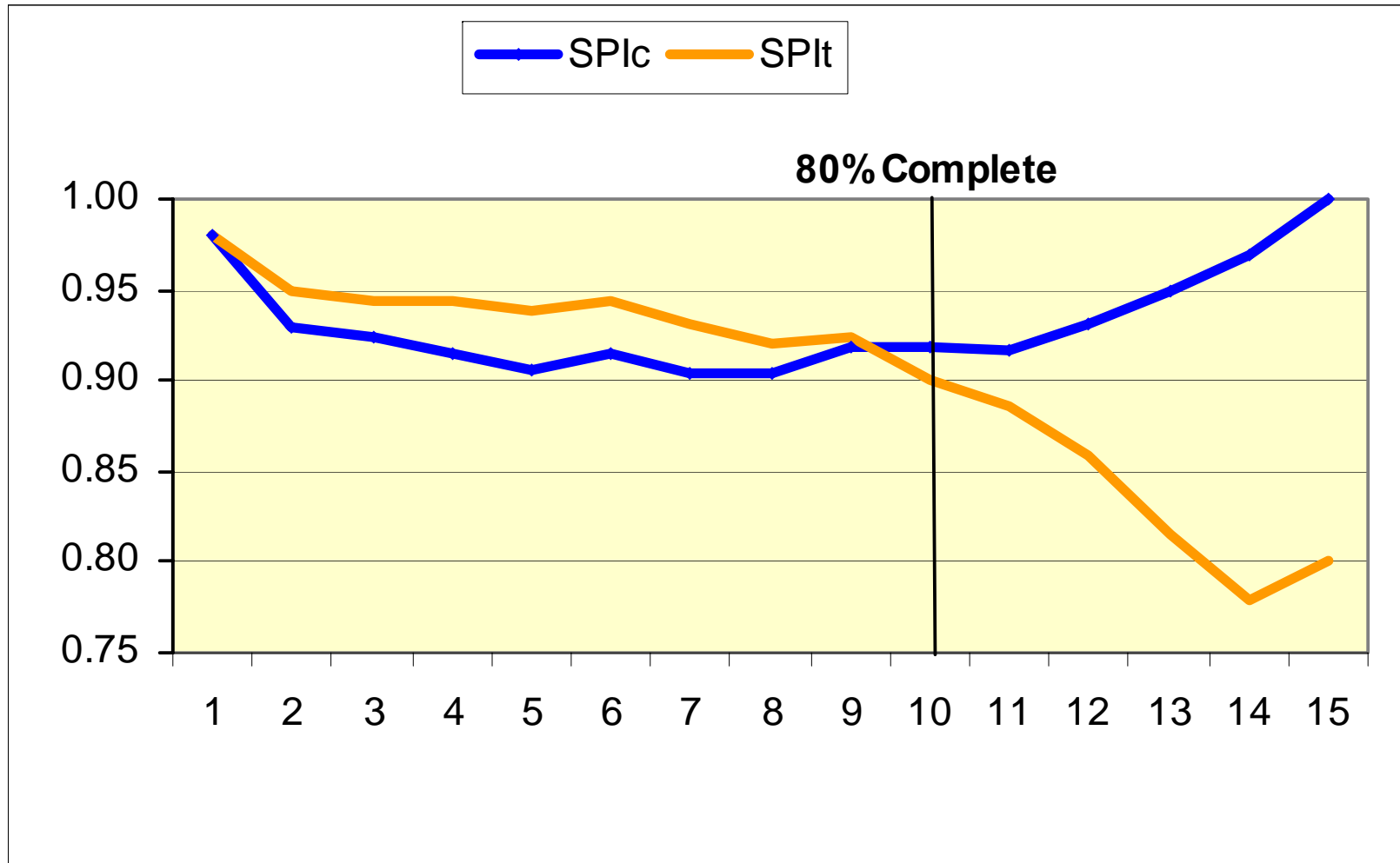
- Schedule Variance (time) = Earned Schedule - Actual Time
($ES - AT = SVt$) = $6.52 - 7 = - .48$ Months Behind
- Schedule Performance Index (time) = Earned Schedule \div Actual Time
($ES \div AT = SPIt$) = $6.52 \div 7 = .93$ Earning Schedule at 93% efficiency (in months)
- Independent Time Estimate at Compete = Planned Duration \div Schedule Performance Index (time)
($PD \div SPIt = IEACT$) = $12 \div .93 = 12.90$ Time to Complete

Filling in the rest of the data -



Month	Σ BCWS	Σ BCWP	SV_c	SPI_c	SV_t	SPI_t
1	100	98	-2	0.98	-0.02	0.98
2	350	325	-25	0.93	-0.10	0.95
3	650	600	-50	0.92	-0.17	0.94
4	1050	960	-90	0.91	-0.23	0.94
5	1500	1360	-140	0.91	-0.31	0.94
6	2000	1830	-170	0.92	-0.34	0.94
7	2500	2260	-240	0.90	-0.48	0.93
8	2950	2665	-285	0.90	-0.63	0.92
9	3350	3075	-275	0.92	-0.69	0.92
10	3650	3350	-300	0.92	-1.00	0.90
11	3900	3575	-325	0.92	-1.25	0.89
12	4000	3725	-275	0.93	-1.70	0.86
13		3800	-200	0.95	-2.40	0.82
14		3875	-125	0.97	-3.10	0.78
15		4000	0	1.00	-3.00	0.80

SPI_{cost} vs. SPI_{time} Graphically



{Notional Data from Slide 19}

ES – EZ Method



- Do ES by hand? (Who has time?)
- Use a spreadsheet

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	BCWPcum	BCWScum	# Pc=>Sc	Numerator	Denominator	InterpVal	EScum	ESmo	SPI(t)mo	SPI(t)cum	AT	SV(t)mo	SV(t)cum
2	0	0									0		
3	98	100	0	98	100	0.9800	0.9800	0.9800	0.9800	0.9800	1	-0.0200	-0.0200
4	325	350	1	225	250	0.9000	1.9000	0.9200	0.9200	0.9500	2	-0.0800	-0.1000
5	600	650	2	250	300	0.8333	2.8333	0.9333	0.9333	0.9444	3	-0.0667	-0.1667
6	960	1050	3	310	400	0.7750	3.7750	0.9417	0.9417	0.9438	4	-0.0583	-0.2250
7	1360	1500	4	310	450	0.6889	4.6889	0.9139	0.9139	0.9378	5	-0.0861	-0.3111
8	1830	2000	5	330	500	0.6600	5.6600	0.9711	0.9711	0.9433	6	-0.0289	-0.3400
9	2260	2500	6	260	500	0.5200	6.5200	0.8600	0.8600	0.9314	7	-0.1400	-0.4800
10	2665	2950	7	165	450	0.3667	7.3667	0.8467	0.8467	0.9208	8	-0.1533	-0.6333
11	3075	3350	8	125	400	0.3125	8.3125	0.9458	0.9458	0.9236	9	-0.0542	-0.6875
12	3350	3650	9	0	300	0.0000	9.0000	0.6875	0.6875	0.9000	10	-0.3125	-1.0000
13	3575	3900	9	225	300	0.7500	9.7500	0.7500	0.7500	0.8864	11	-0.2500	-1.2500
14	3725	4000	10	75	250	0.3000	10.3000	0.5500	0.5500	0.8583	12	-0.4500	-1.7000
15	3800		10	150	250	0.6000	10.6000	0.3000	0.3000	0.8154	13	-0.7000	-2.4000
16	3875		10	225	250	0.9000	10.9000	0.3000	0.3000	0.7786	14	-0.7000	-3.1000
17	4000		12	0	-4000	0.0000	12.0000	1.1000	1.1000	0.8000	15	0.1000	-3.0000
18			Pc=>Sc	NUM	DENOM	InterpVal	EScum	ESmo	SPI(t)mo	SPI(t)cum	AT	SV(t)mo	SV(t)cum
19			Pc=>Sc	NUM	DENOM	InterpVal	EScum	ESmo	SPI(t)mo	SPI(t)cum	AT	SV(t)mo	SV(t)cum
20			Pc=>Sc	NUM	DENOM	InterpVal	EScum	ESmo	SPI(t)mo	SPI(t)cum	AT	SV(t)mo	SV(t)cum
21			Pc=>Sc	NUM	DENOM	InterpVal	EScum	ESmo	SPI(t)mo	SPI(t)cum	AT	SV(t)mo	SV(t)cum

Spreadsheet developed by Walter Lipke, available on the Internet



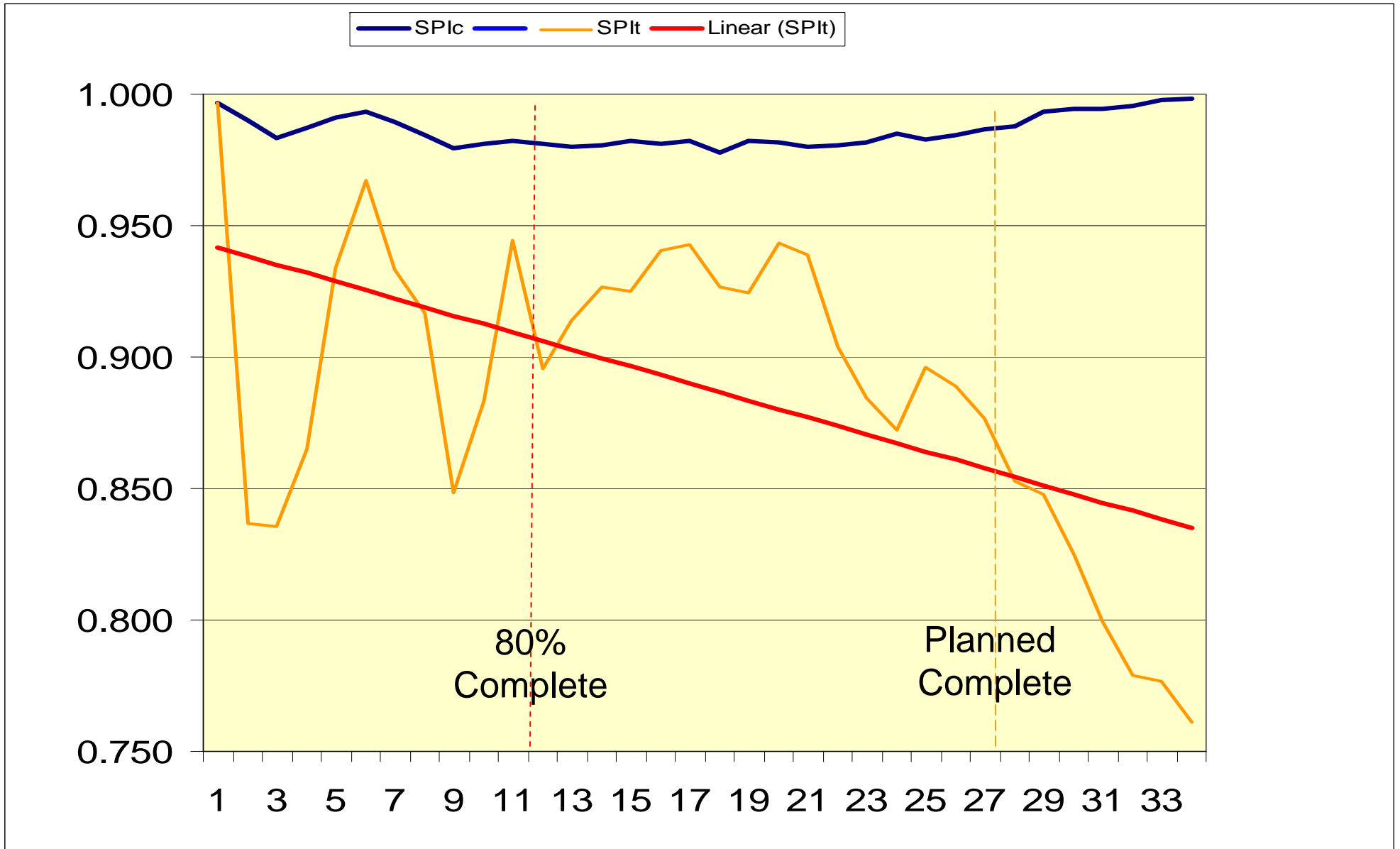
- **Earned Schedule – Validation Checks**
 - *SPI(t) Does not revert back to 1.0 like SPI(c)*
 - *Independent Time Estimate At Complete (ITEAC) based on SPI(t) may be used to estimate time to complete*
- **Earned Schedule applied to three unique programs**
 - *Evaluate SPI(t) vs SPI(c)*
 - *Evaluate ITEAC vs Completion dates*

ES in the “Real World” Example 1



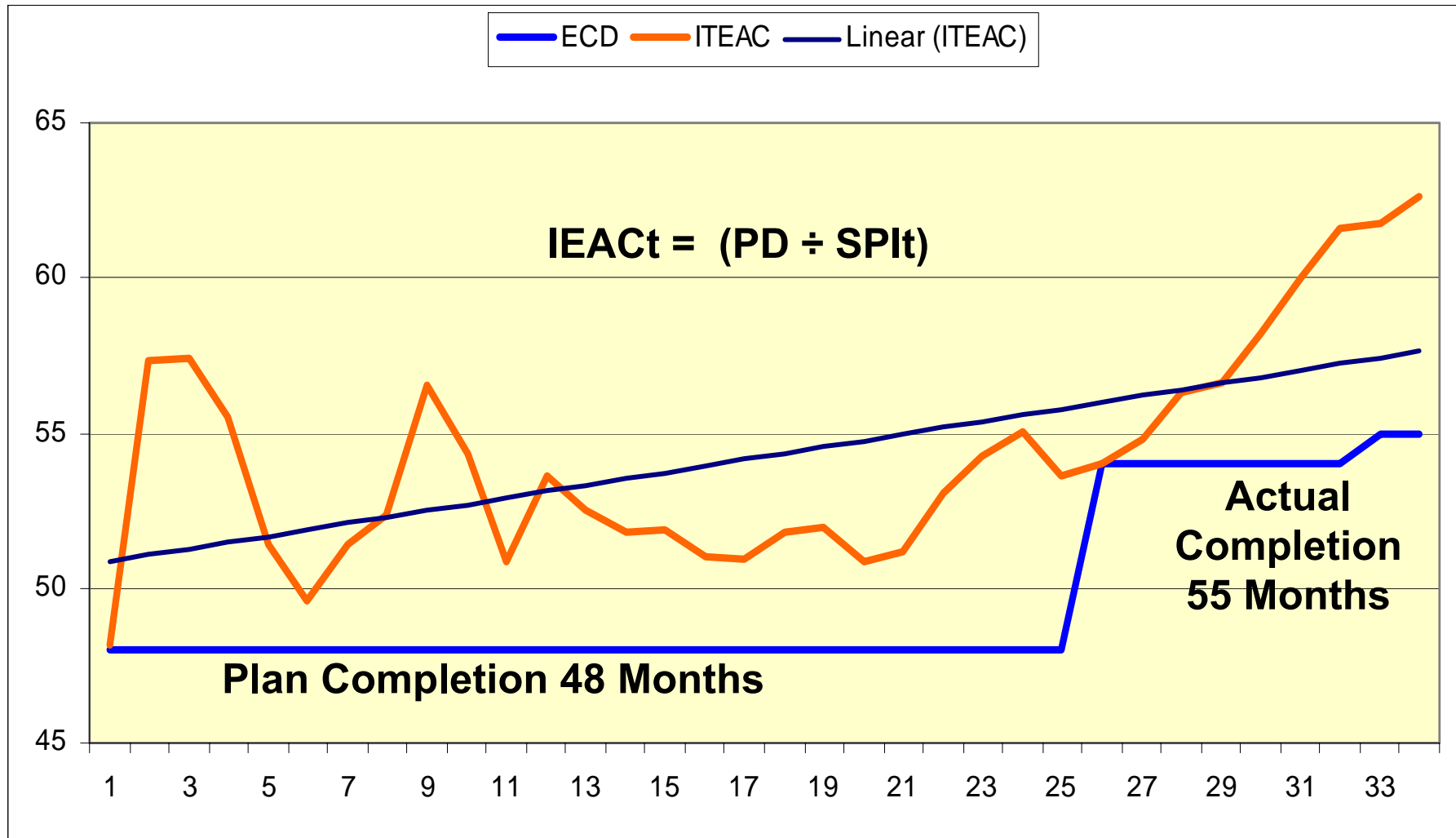
- **The Project**
 - *Reporting 99.9% complete as of July 2005*
- **~ \$260 million dollar contract (CPIF)**
 - *Original 48 month duration*
 - *Planned End Date - Dec 2004*
 - *Actual Completion July 2005 - 7 month Slip*
- **Earned Schedule Calculations**
 - *Data points for the last 34 months*
 - *SPI_c and SPI_t*
 - *$IEAC_t$ ($PD \div SPI_t$)*

ES SPI_c vs. SPI_t Tracking



ES for Schedule Completion

Independent Time Estimate At Complete (ITEAC)

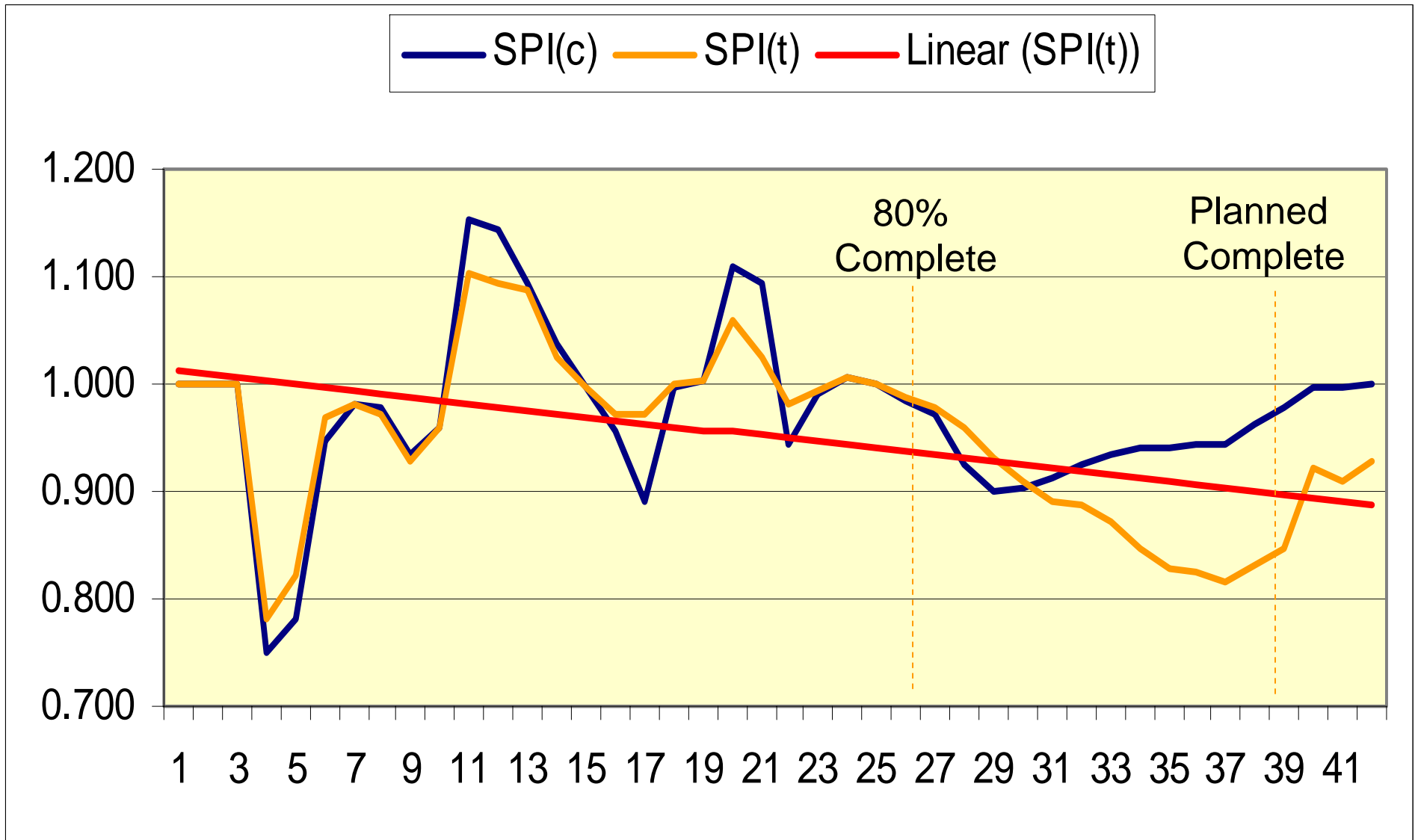


ES in the “Real World” Example 2



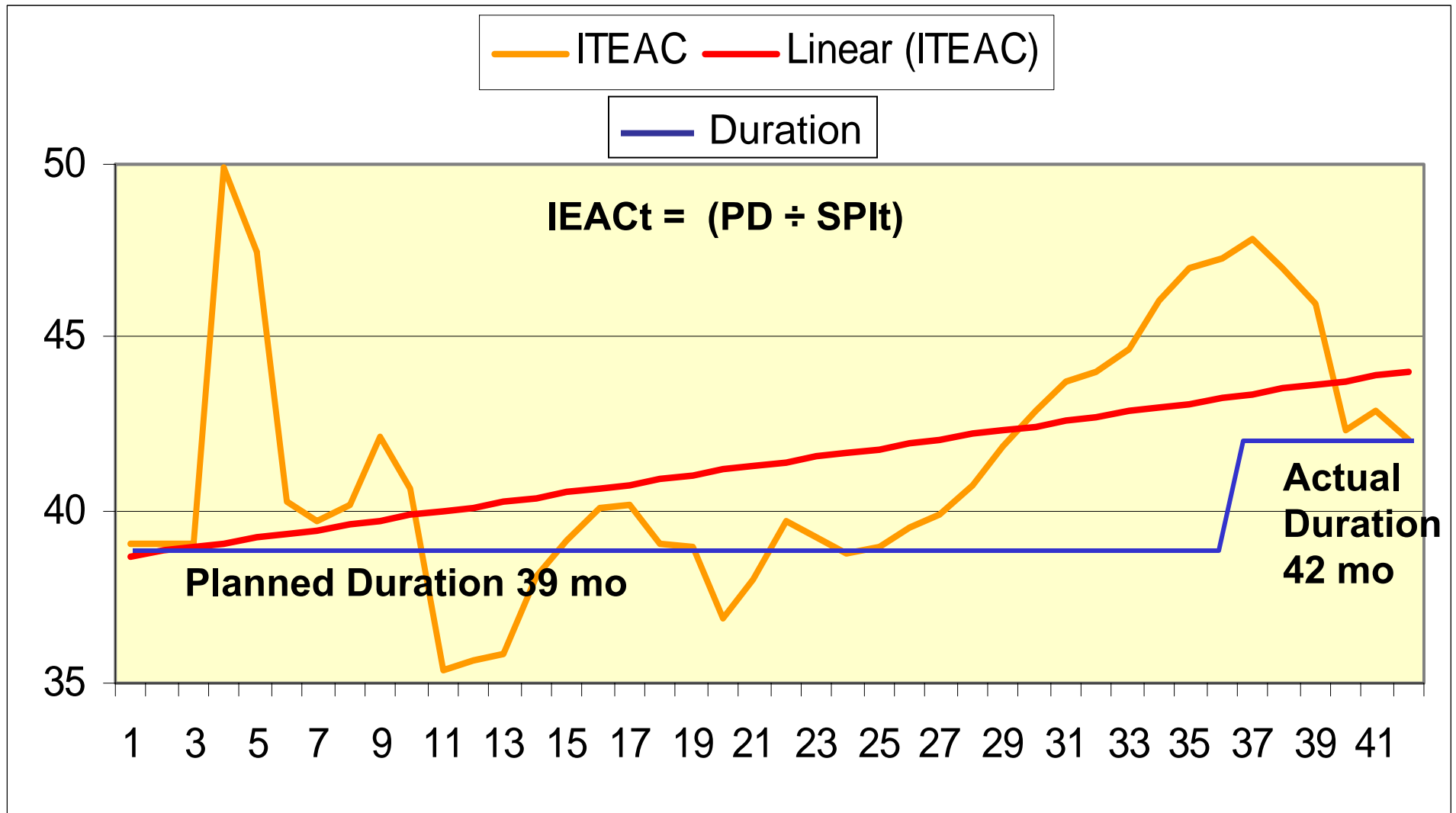
- **The Project**
 - *Reporting 100% complete as of March 05*
- **~ \$4.60 million dollar contract**
 - *39 month duration*
 - *Planned End Date - Dec 2004*
 - *Completion - Mar 05 (3 month Slip)*
- **Earned Schedule Calculations**
 - *SPI_c and SPI_t*
 - *ITEAC (Planned Duration \div SPI_t)*

ES SPI_c vs. SPI_t Tracking



ES for Schedule Completion

Independent Time Estimate At Complete (ITEAC)

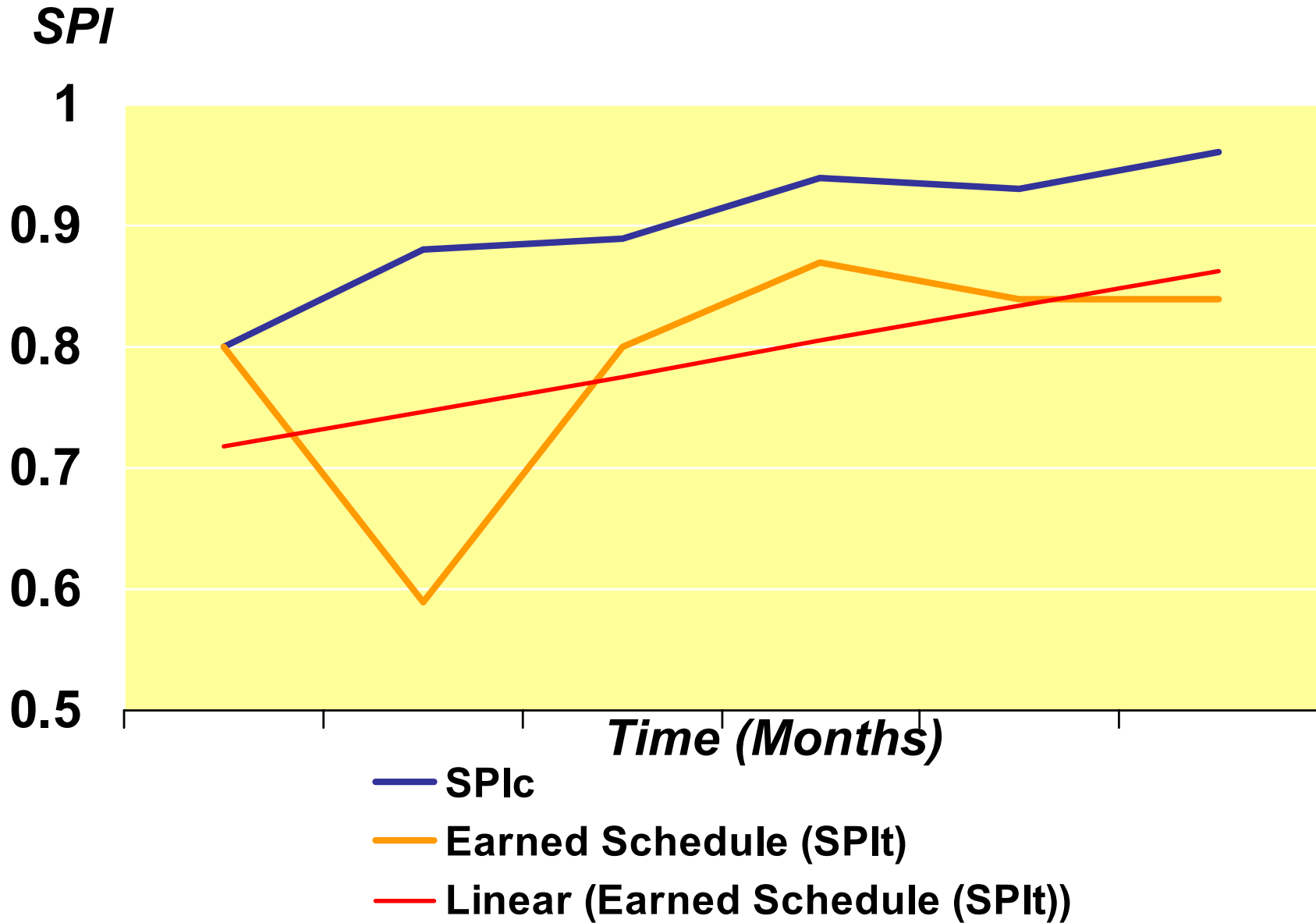


ES in the “Real World” Example 3

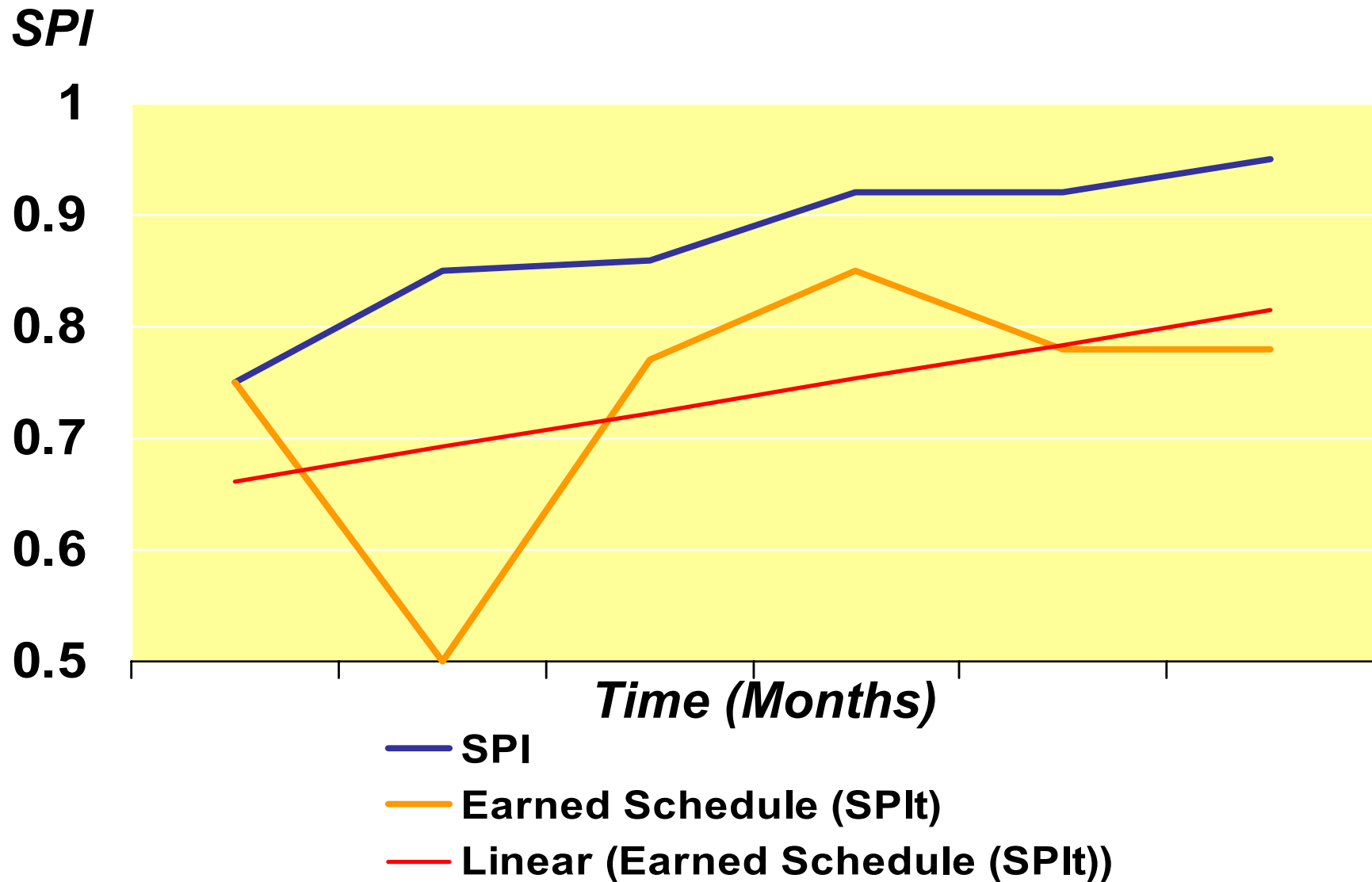


- **The Project**
 - ***Software Development***
 - ***6 months into 14 month project***
 - ***Project needs new baseline, projecting 6 month slip***
- **Program Manager comment -**
 - ***EVM did not provide early warning of projected slip***
 - ***New Planned End Date – Month 23***
- **Earned Schedule Calculations**
 - ***SPI_c and SPI_t***
 - ***ITEAC (Planned Duration \div SPI_t)***

Total Program



Program Excluding LOE





ES Independent Time Estimate At Complete

Calculated on 14 month planned duration

- **Total Program**
 - **14 ÷ Average ES
(SPI_{time})**
 - **14 ÷ .79 = 17.7 months
(3.7 month Slip)**
- **Program w/o LOE**
 - **14 ÷ Average ES
(SPI_{time})**
 - **14 ÷ .737 = 19 months
(5 month Slip)**



- **ES is based on incremental gains against BCWS**
 - ***Observing incremental schedule gains with $SPT(t)$ will lead to more volatility of data points like monthly CPI***
 - ***Reacts faster to schedule issues than SPIc***
 - ***Potential for Duration forecasting***
 - ***May require several months data to establish actual trend***
 - ***Trend lines may be used to smooth data***
 - ***Check and balance for current metrics***



- **New & Emerging Concept**
 - ***Academic Research and Proof of Concept***
 - Air Force Studying Concept
 - PMI Australia and Belgium (Academic Studies)
 - Boeing in Seattle on the 787 DreamLiner
 - UK MoD on Nimrod and Type 47 Destroyer Projects
- **ES requires a firm baseline / sound EVM practices – ES will not cure -**
 - ***PMF (Performance Measurement Flexline)***
 - ***EV “Gaming”***
 - Non Critical Completions; Front Loading
 - ***Does not replace Critical Path Schedule Analysis***



- **Moving Forward**
 - *Adoption of ES in EVM and PM Practice*
 - *Education and Training*
 - *Incorporation of ES formulas in EVM / PM software*
 - *Used in conjunction with current validated metrics for project measurement and analysis*
- **Bottom Line –**
 - *Appears to be a better way to analyze EVMS schedule performance*
 - *First new concept in Earned Value theory & practice since C/SCSC established in the '60's*



www.earnedschedule.com

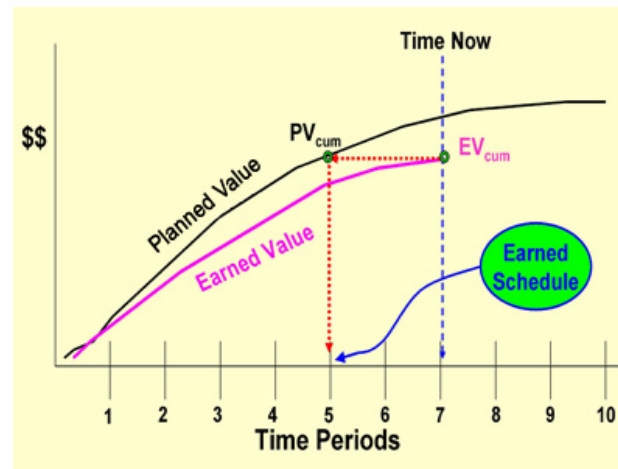


Earned Schedule
An extension to Earned Value Management

[home](#) [news](#) [papers](#) [presentations](#) [es terminology](#) [es calculator](#)

Earned Value Management (EVM) is a wonderful management system, integrating in a very intriguing way, cost ... schedule ... and technical performance. It is a system, however, that causes difficulty to those just being introduced to its concepts. EVM measures schedule performance not in units of time, but rather in cost, i.e. dollars. After overcoming this mental obstacle, we later discover another quirk of EVM: at the completion of a project which is behind schedule, Schedule Variance (SV) is equal to zero, and the Schedule Performance Index (SPI) equals unity. We know the project completed late, yet the indicator values say the project has ...perfect schedule performance!!

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[Sites of Interest](#)



Questions ?