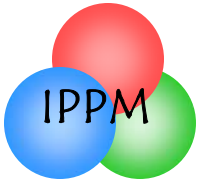

Integrated Project
Performance Management

…….EMERGING PRACTICE…….

Earned Schedule Analysis

A Better Set of Schedule Metrics

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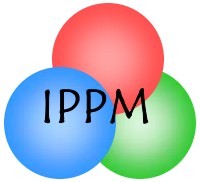
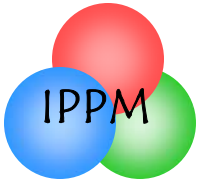


CAUTION

…….EMERGING PRACTICE…….

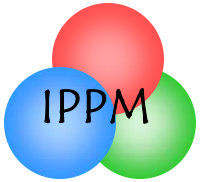
Use with caution until validated by research.

Do not substitute for analysis of integrated master schedule.



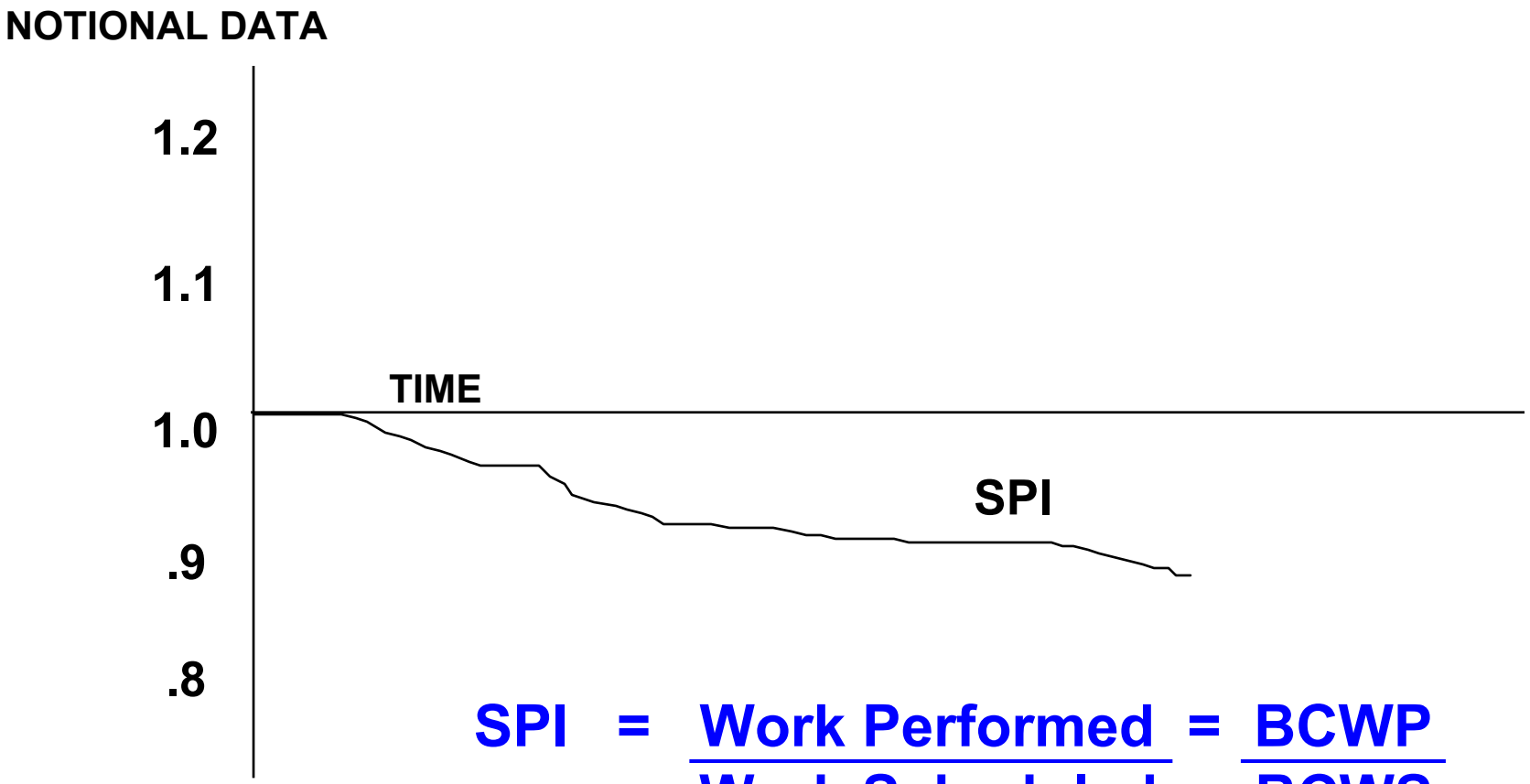
Overview

- How earned schedule was developed
- Basic concepts of earned schedule
- Management uses
- Benefits
- Way ahead



How Earned Schedule was Developed

Traditional Definition
Schedule Performance Index



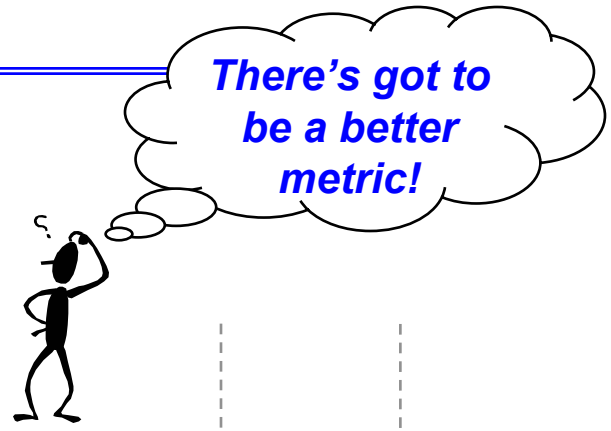
$$SPI = \frac{\text{Work Performed}}{\text{Work Scheduled}} = \frac{BCWP}{BCWS}$$

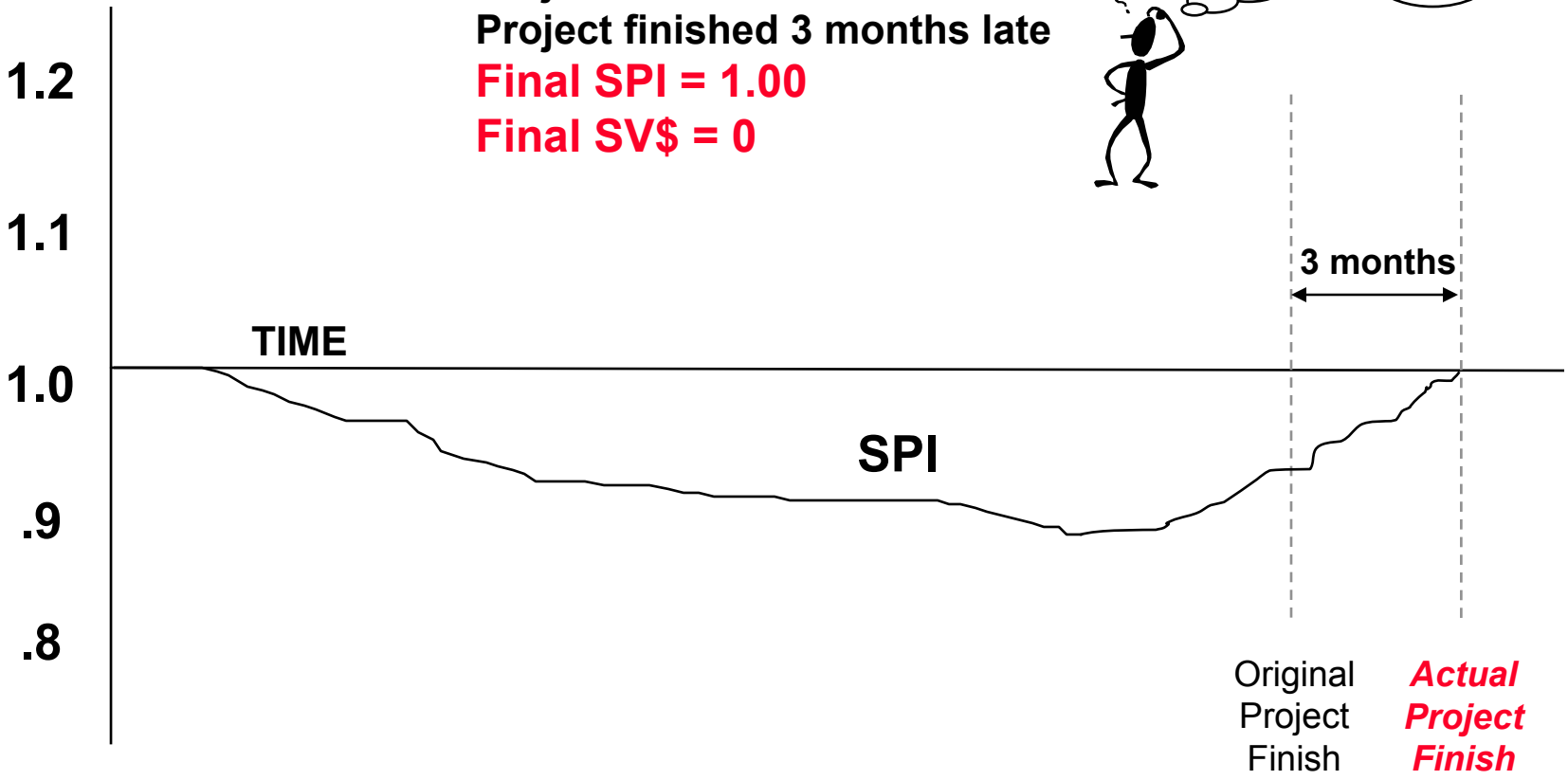
calculated from budgeted cost

SPI at the End of the Project

NOTIONAL DATA

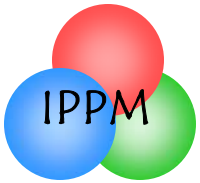
Project status:
Project finished 3 months late
Final SPI = 1.00
Final SV$ = 0





The Problem with Traditional EVM Schedule Metrics

- 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
  - Eventually, all "budget" will be earned as the work is completed, ***no matter how late you finish***
    - SPI improves and ends up at 1.00 at end of project
    - SV improves and ends up at $0 variance
    - 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!



The Beginning of Earned Schedule

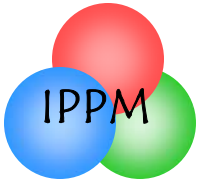
- Seeking a statistical application to software management
  - **A growing trend in the software industry**
  - **Had become a requirement for SEI CMM Level 4**
- Chose CPI & SPI instead of a quality metric (e.g., defects / LOC)
  - **More meaningful application …the system vice a component**
- Vision …the application could provide …
  - **Greater process understanding**
  - **Improved planning …a probabilistic treatment of Risk**
  - **Better outcome prediction …the probability of success**
  - **Long term process improvement indicators**
- **Inherent failure of SPI …statistics must have reliable numbers**
  - **Experiment …schedule accomplishment of PMB resolves EVM flaw**
- Published result in Spring 2003 *The Measurable News*
  - **Kym Henderson phoned from Australia … "It works!!"**
  - **IPMC 2003 & CPM 2004 …Eleanor has been a strong advocate**

References

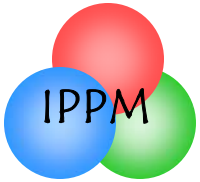
- Lipke, Walt, Schedule is Different, Measurable News, College of Performance Management, March 2003 (reprinted Summer 2003)

- Henderson, Kym, Earned Schedule: A Breakthrough Extension to Earned Value Theory? A Retrospective Analysis of Real Project Data, Measurable News, College of Performance Management, Summer 2003

- Henderson, Kym, Further Developments in Earned Schedule, Measurable News, College of Performance Management, Spring 2004



Basic Concepts of Earned Schedule



Earned Schedule Concepts

- Analogous to Earned Value
  - **Based on time-phased earned value data (BCWS, BCWP)**
- However, schedule performance is determined with **time based** metrics, not **cost**
  - **Key concept: how much schedule did I earn on the BCWS curve?**
  - **Resulting metrics and variances are expressed in time units**
  - **Works for both conditions (ahead or behind schedule)**
- Bridge between traditional EVM and integrated scheduling
  - **Correlation requires certain data from integrated master schedule (IMS)**
  - ***Does not replace need to maintain and analyze IMS***

What Data do I Need?

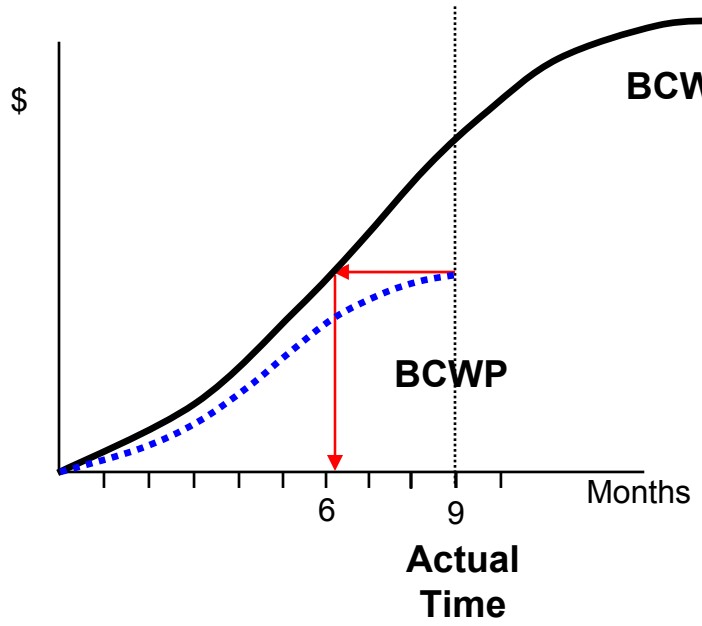
- EVM data
  - BCWP cum to date
  - BCWS cum to date (from beginning to time now)
- Integrated Master Schedule data
  - Start date
  - Planned completion date (baseline)
  - Planned duration (without total float)
  - Total schedule float (days)
  - Estimated completion date
  - Optional:
    - Unconstrained completion date

Determining Earned Schedule

How Much Schedule Did I Earn?

- **Earned Schedule** = cumulative **earned value** in **time units** as established by the value of cumulative BCWP on the BCWS curve
  - Partial units of time are calculated
- Can be calculated graphically or with tabular data

EARNED SCHEDULE = ~6.1 months



- **Actual time is 9 months**
- **The earned schedule is 6.1 months**

Earned Schedule Metrics

SV(t) = Schedule Variance (time)

= Earned Schedule – Actual Time

= 6.1 months – 9 months

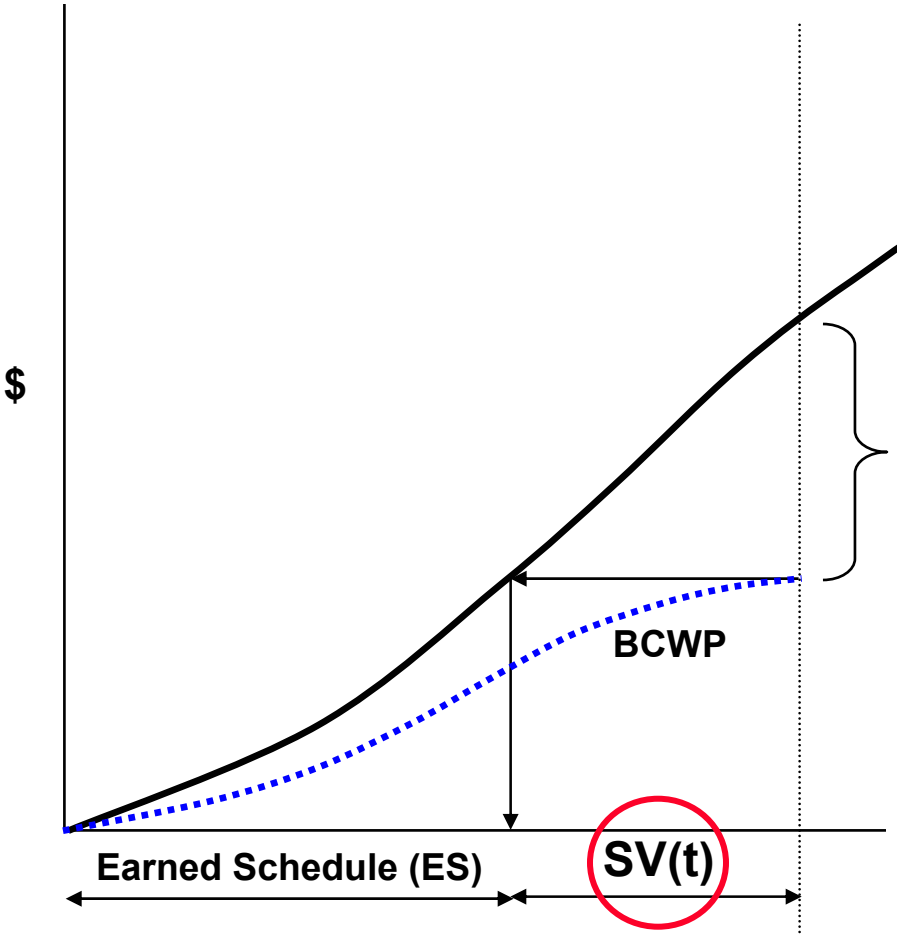
= **-2.9 months**

I should have earned 9 months, but have only earned 6.1 months

SPI(t) = Schedule Performance Index (time)

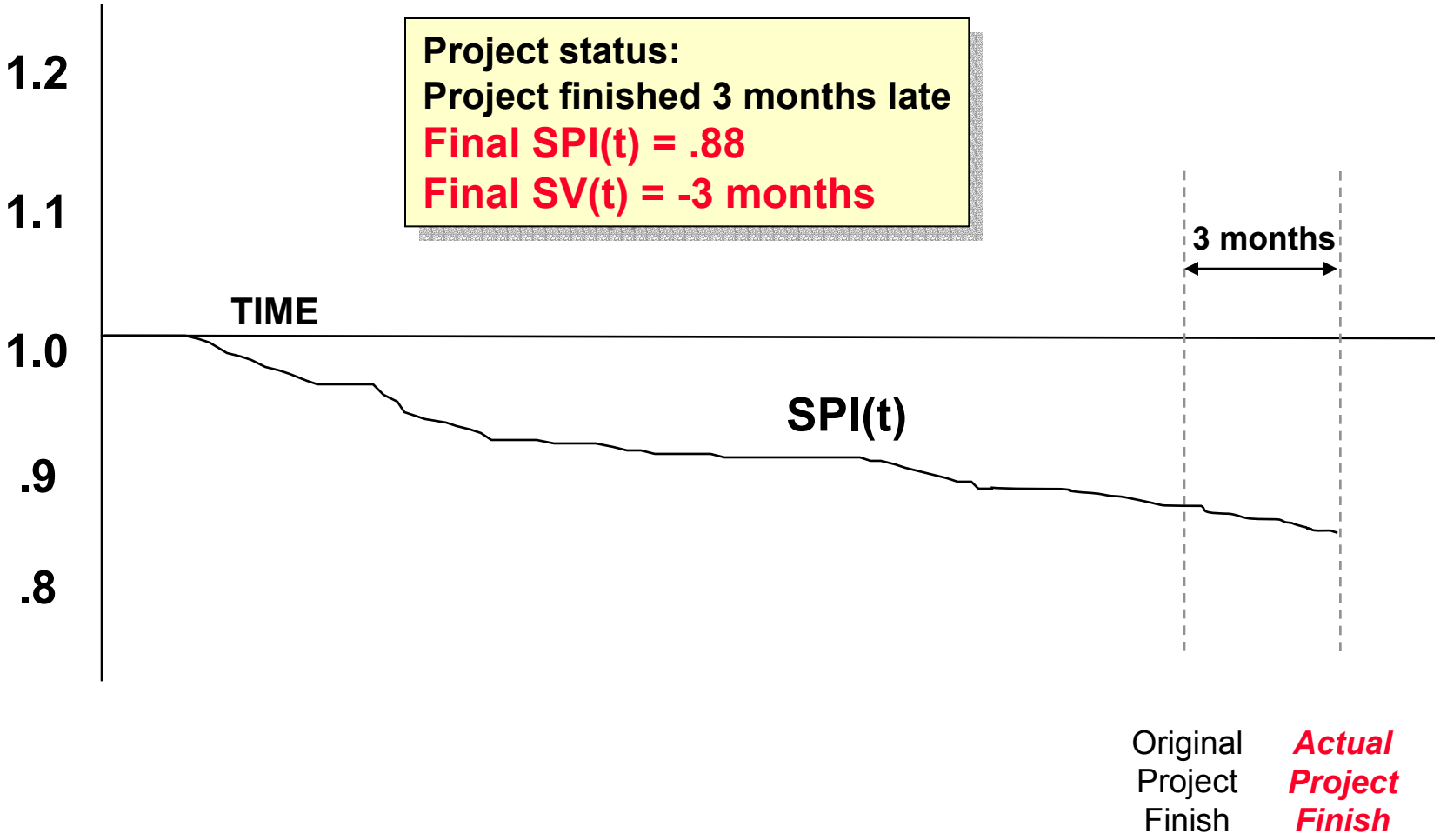
$$= \frac{\text{Earned Schedule}}{\text{Actual Time}} = \frac{6.1}{9} = \mathbf{.68}$$

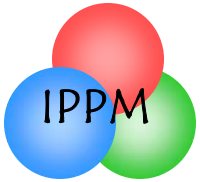
SV($) versus SV(t)



- Earned schedule metrics relate work performed to actual time, not work scheduled
- Retain utility over time
  - never return to 0 or 1.00

SPI(t) at the End of the Project

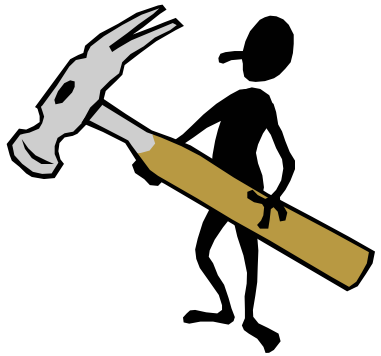




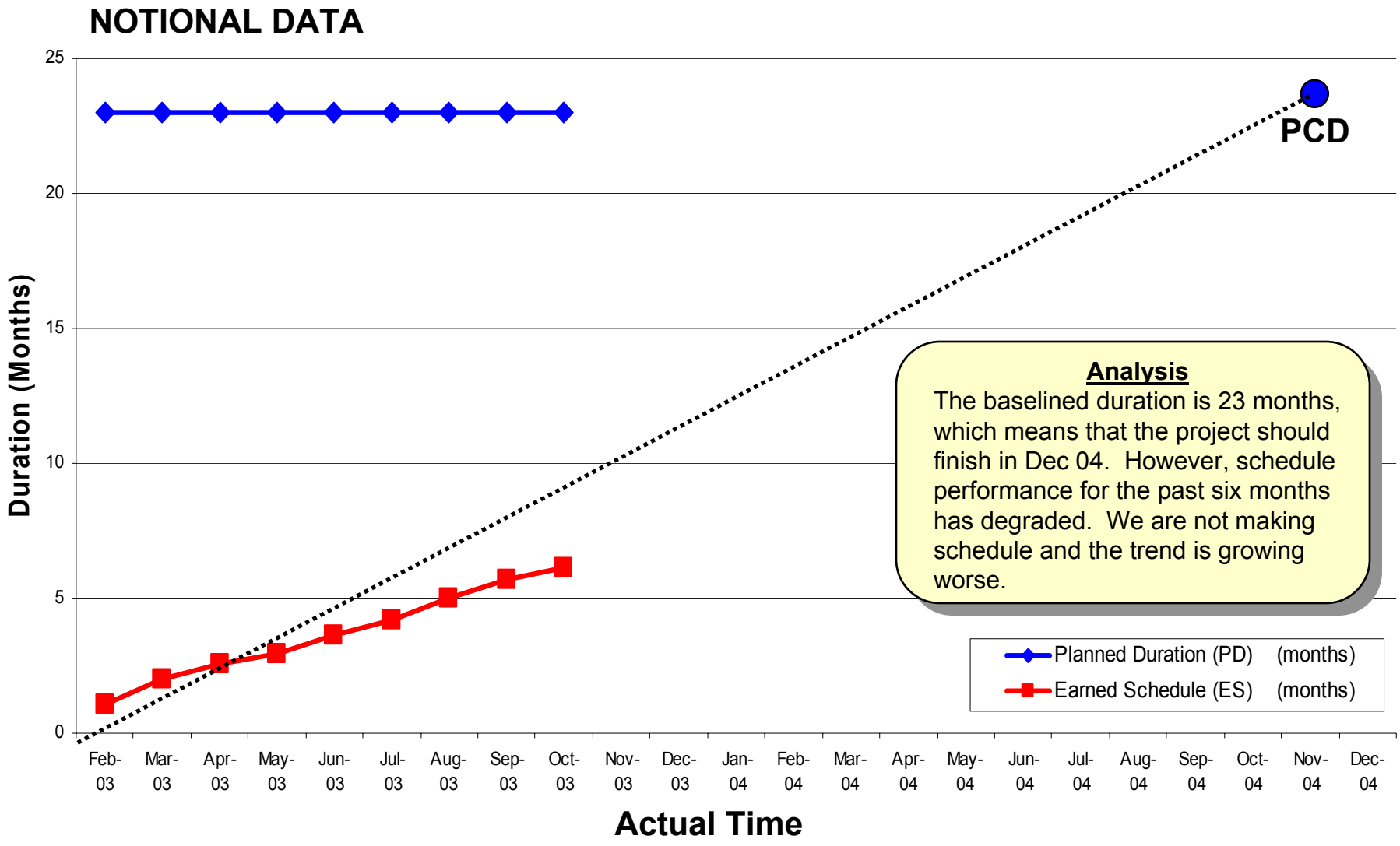
Management Uses

How to Gain the Attention of the Project Manager

- Evaluate and show trends against baseline schedule
- Predict a range of durations
- Evaluate realism of contractor's schedule estimate
- Show a range of completion dates
- Compare ES trends to integrated master schedule



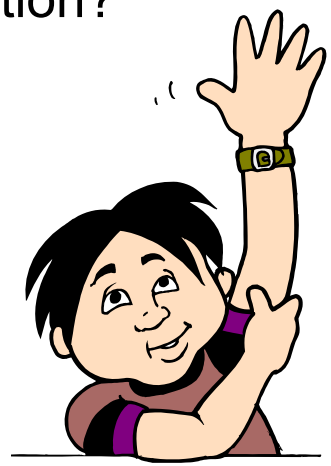
Earned Schedule vs. Planned Duration



NOTE: the dashed line is a straight line, as it represents that we should be earning one month of schedule for each elapsed month. This is not a BCWS curve.

Predicting Durations?

- EVM
  - CPI has proven to be stable metric
    - Used to predict estimated final costs
  - SPI($) rarely used to predict duration
- Earned Schedule
  - Early work by Kym Henderson indicates stability of SPI(t)
  - How can SPI(t) be used to predict duration?



Predicting the Duration

IEAC(t) = Independent Estimate at Completion (Time)

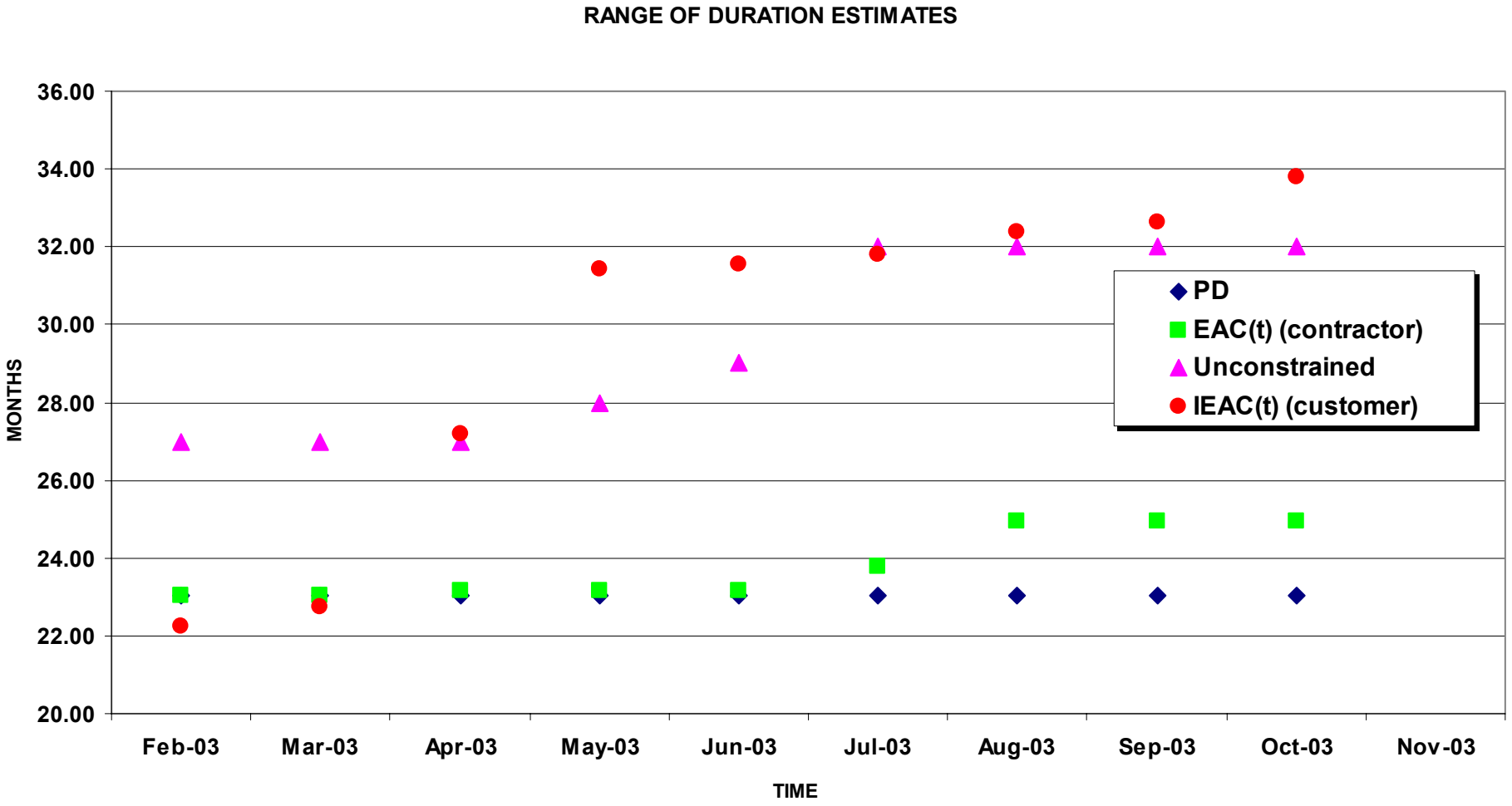
$$= \frac{\text{Planned Duration}}{\text{SPI(t)}} = \frac{23 \text{ months}}{.68}$$

$$= 33.8 \text{ months}$$

Parallels EAC formula based on CPI

Assumes schedule performance will remain at same efficiency

Use this as crosscheck against baseline or revised estimate of schedule



Analysis

Even though the contractor has provided an updated schedule estimate, it appears that it is unachievable. The independent calculation by the customer results in an estimated duration of just under 34 months, compared to the contractor's estimate of 25 months.

Recommend calculation of a range of durations

Evaluate Realism of Contractor's Schedule

Compare Past to Future Efficiency

Past Schedule Efficiency = SPI(t)

$$= \frac{\text{Earned Schedule}}{\text{Actual Time}}$$

.68

COMPARE

Future Schedule Efficiency = To complete Schedule Performance Index (time)

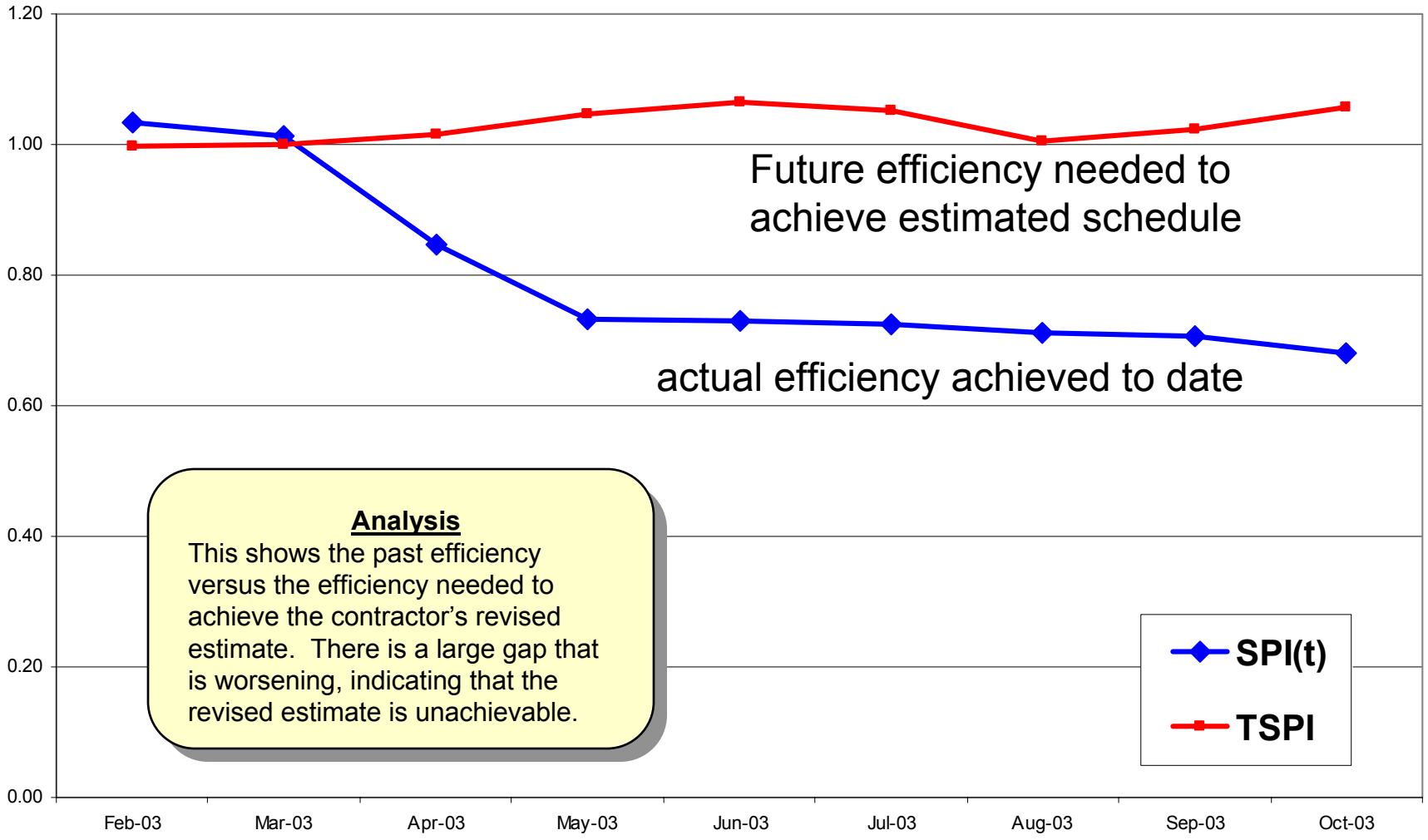
= TSPI

1.06

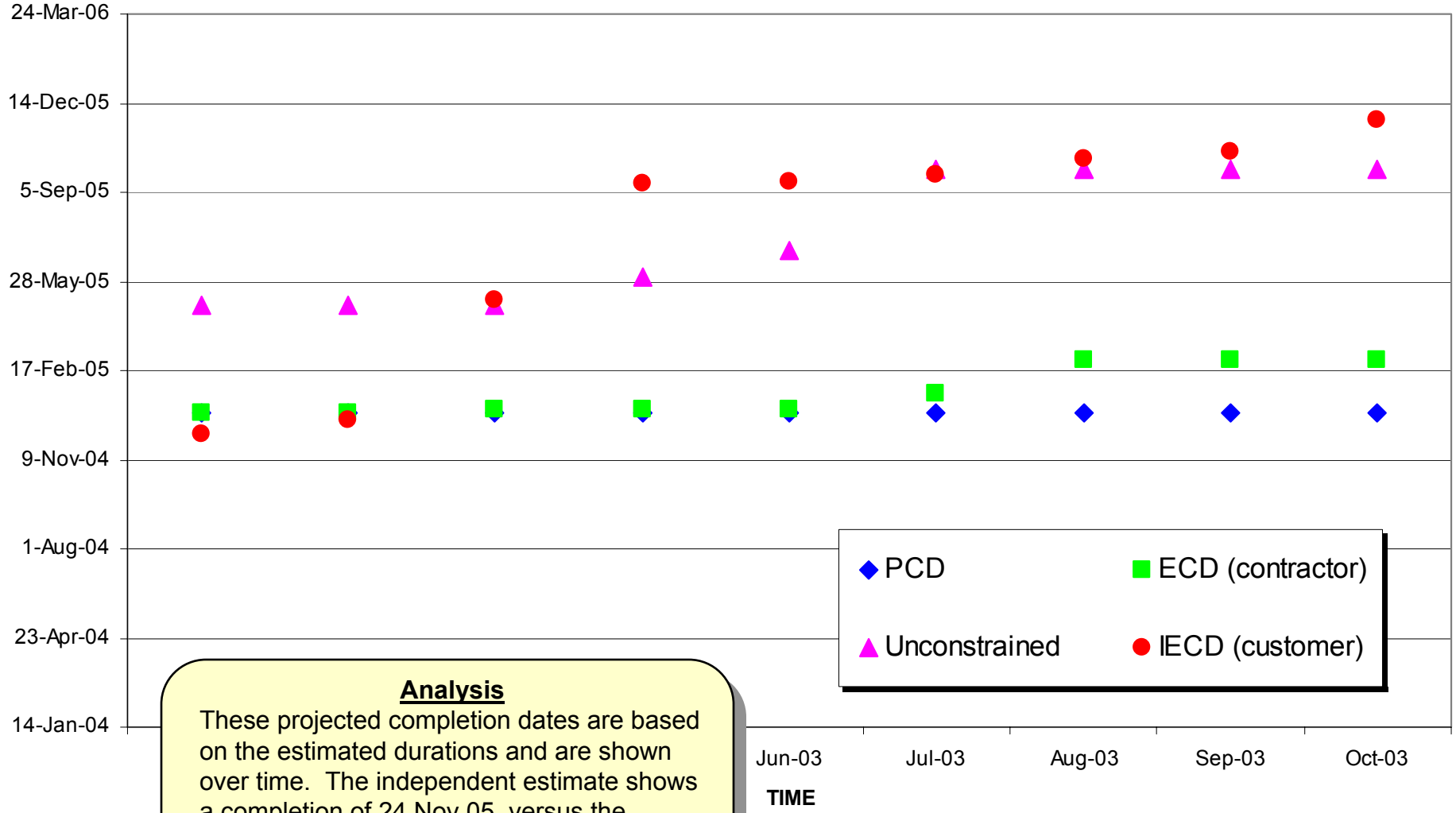
$$= \frac{\textbf{Planned Duration for Work Remaining}}{\textbf{Time Estimate to Complete}}$$

Future efficiency needed to achieve contractor's revised estimate of duration

SPI(t) versus TSPI(t)



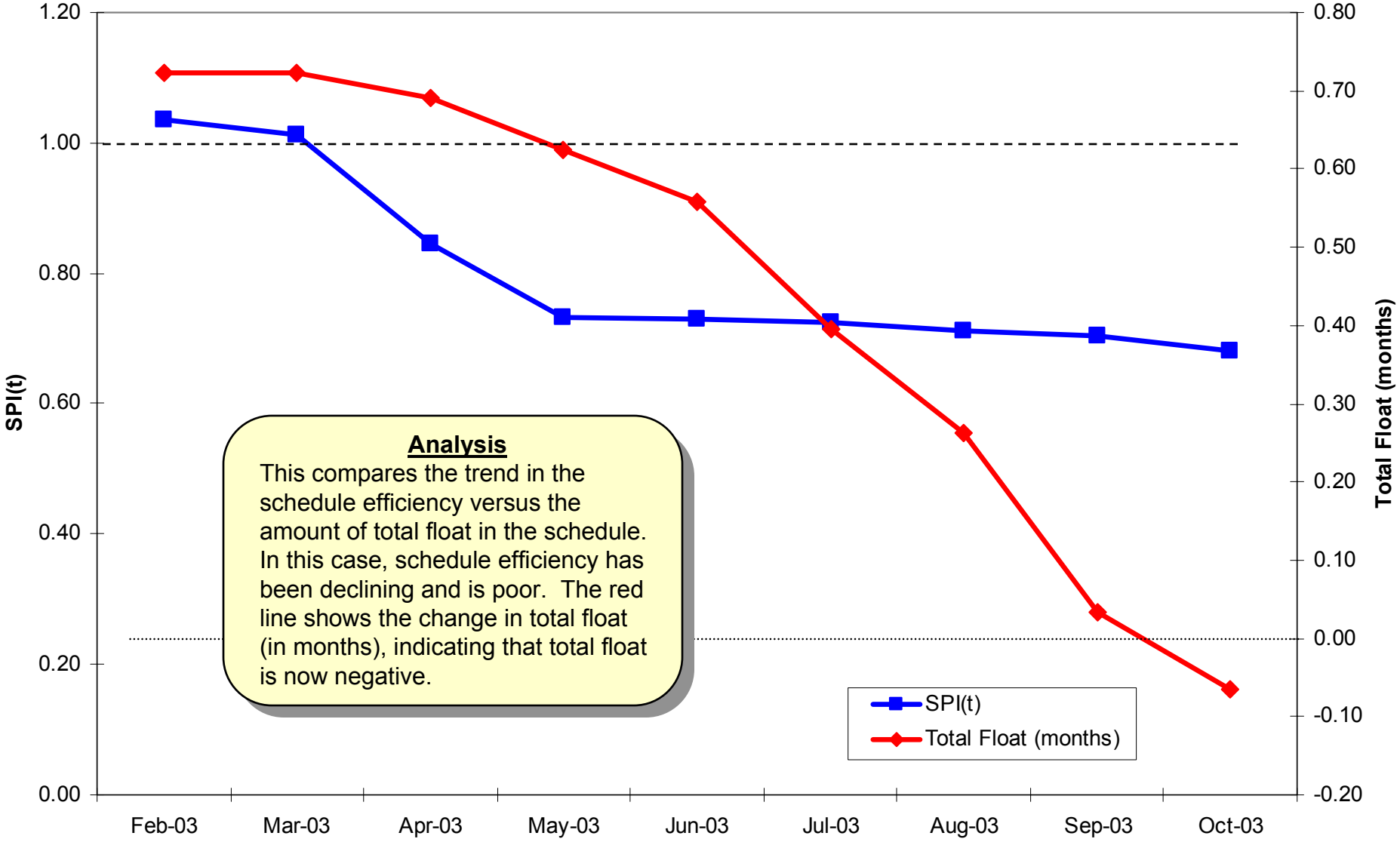
COMPLETION DATES



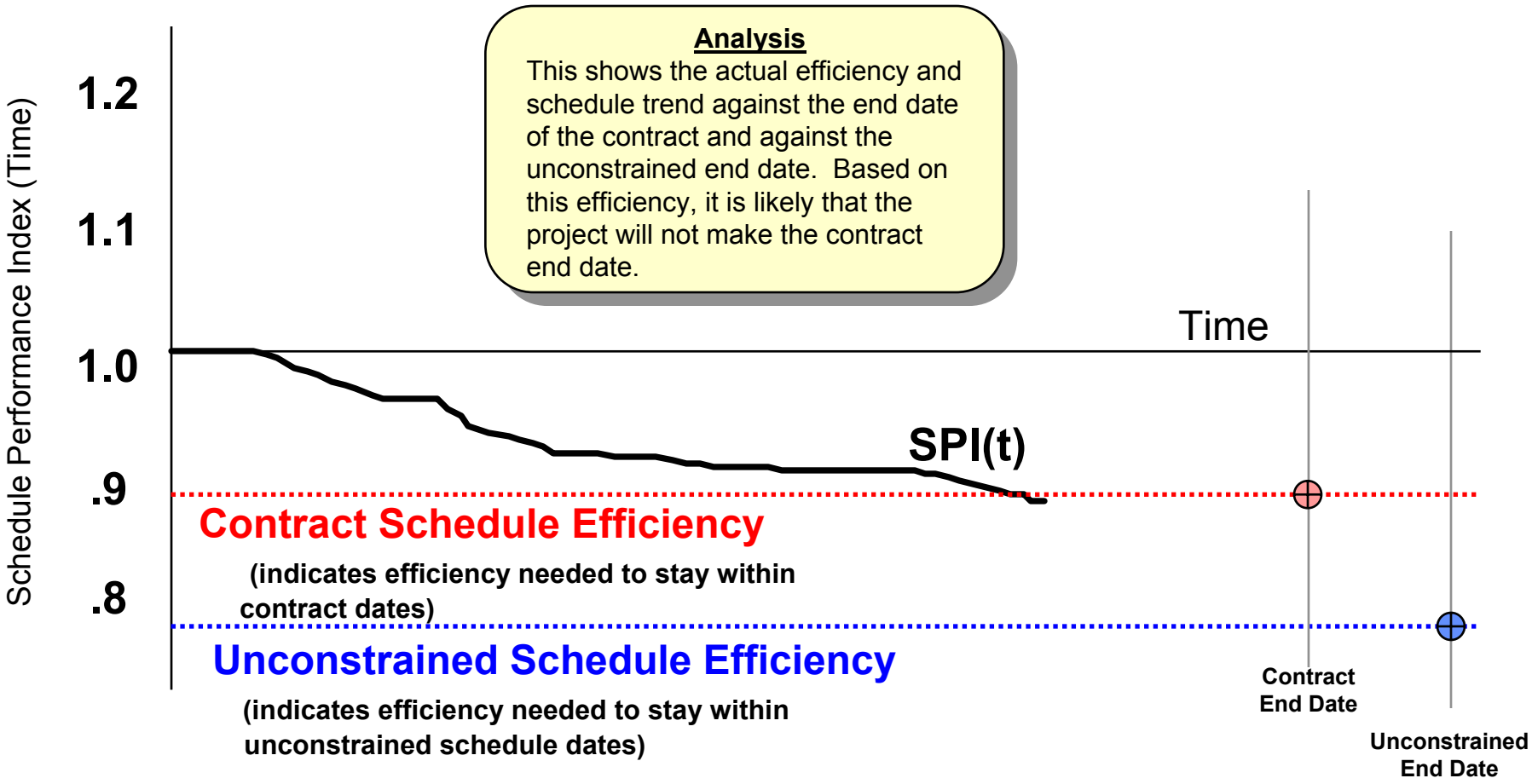
Analysis

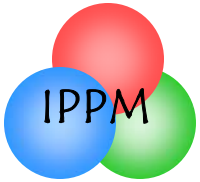
These projected completion dates are based on the estimated durations and are shown over time. The independent estimate shows a completion of 24 Nov 05, versus the baselined date of 31 Dec 04, a slip of 11 months. Contractor's schedule appears unachievable.

SPI(t) versus Total Float



Efficiencies vs. Completion Dates





Help!

I’m a little overwhelmed…

New Terminology Parallels EVM Terminology

	EVMS	Earned Schedule
Status	Earned Value (EV)	Earned Schedule (ES)
	Actual Costs (AC)	Actual Time (AT)
	SV($)	SV(t)
	SPI($)	SPI(t)
Future Work	Budgeted Cost for Work Remaining (BCWR)	Planned Duration for Work Remaining (PDWR)
	Estimate to Complete (ETC)	Estimate to Complete (time) ETC(t)
Final Status	Variance at Completion (VAC)	Variance at Completion (time) VAC(t)
	Estimate at Completion (EAC) (contractor)	Estimate at Completion (time) EAC(t) (contractor)
	Independent EAC (IEAC) (customer)	Independent Estimate at Completion (time) IEAC(t) (customer)

Earned Schedule Excel worksheet

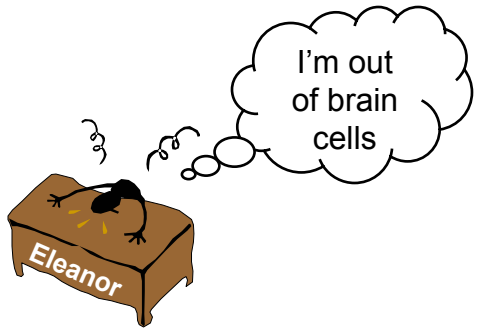
Contains logic, formulas, generates charts

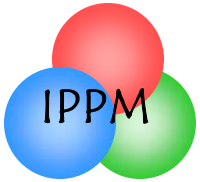
Month	Feb-03	Mar-03	Apr-03	May-03	Jun-03	Jul-03	Aug-03	Sep-03	Oct-03
BCWScum ($)	782	1,411	1,923	2,510	3,215	4,127	5,122	6,229	7,279
BCWPcum ($)	804	1,423	1,687	1,886	2,304	2,751	3,198	3,801	4,257
Status to Date									
Actual Time (AT) (months)	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00
Earned Schedule (ES) (months)	1.03	2.02	2.54	2.93	3.65	4.34	4.98	5.64	6.13
Planned Duration for Work Remaining (PDWR)	21.98	20.99	20.47	20.09	19.36	18.67	18.04	17.37	16.88
SV(t) (months)	0.03	0.02	-0.46	-1.07	-1.35	-1.66	-2.02	-2.36	-2.87
SV(t) %	3%	1%	-15%	-27%	-27%	-28%	-29%	-29%	-32%
SPI(t)	1.03	1.01	0.85	0.73	0.73	0.72	0.71	0.71	0.68
At Completion	BLUE FONT INDICATES DATA ENTRY CELLS								
Project Start	1-Feb-03								
Planned Completion Date (PCD)	31-Dec-04	31-Dec-04	31-Dec-04	31-Dec-04	31-Dec-04	31-Dec-04	31-Dec-04	31-Dec-04	31-Dec-04
Estimated Completion Date (ECD)	31-Dec-04	31-Dec-04	5-Jan-05	5-Jan-05	5-Jan-05	23-Jan-05	28-Feb-05	28-Feb-05	28-Feb-05
Contract Completion Date	22-Jan-05	22-Jan-05	22-Jan-05	22-Jan-05	22-Jan-05	22-Jan-05	22-Jan-05	22-Jan-05	22-Jan-05
Total Float (days)	22	22	21	19	17	12	8	1	-2
Total Float (months)	0.72	0.72	0.69	0.62	0.56	0.39	0.26	0.03	-0.07
Unconstrained Duration (months)	27.00	27.00	27.00	28.00	29.00	32.00	32.00	32.00	32.00
Unconstrained Schedule Efficiency (USE)	0.85	0.85	0.85	0.82	0.79	0.72	0.72	0.72	0.72
Unconstrained Completion Date	2-May-05	2-May-05	2-May-05	1-Jun-05	2-Jul-05	1-Oct-05	1-Oct-05	1-Oct-05	1-Oct-05
Planned Duration (PD) (months)	23.01	23.01	23.01	23.01	23.01				
Estimate at Completion (time) EAC(t) (months)	23.01	23.01	23.18	23.18	23.18				
Estimate to Completion (time) ETC(t) (months)	22.01	21.01	20.18	19.18	18.18				
Variance at Completion (time) VAC(t) (months)	0.00	0.00	-0.16	-0.16	-0.16				
Independent Estimate at Completion (time) IEAC(t)									
AT + PDWR	22.98	22.99	23.47	24.09	24.36				
AT + PDWR + Total Float	23.70	23.71	24.17	24.71	24.92				
PD / SPI(t)	22.24	22.75	27.19	31.44	31.53				
PD / SPI(t) + Total Float	22.96	23.47	27.88	32.07	32.09				
(PD + TF) / SPI(t)	22.93	23.46	28.01	32.30	32.30				
AT + (PDWR / USE)	26.79	26.63	27.02	28.44	29.40	31.96	32.08	32.15	32.48
Independent Estimated Completion Date (using SPI(t))	8-Dec-04	23-Dec-04	8-May-05	14-Sep-05	17-Sep-05	25-Sep-05	12-Oct-05	20-Oct-05	24-Nov-05
Comparison of Indices									
SPI(t)	1.03	1.01	0.85	0.73	0.73	0.72	0.71	0.71	0.68
TSPI	1.00	1.00	1.01	1.05	1.07	1.05	1.00	1.02	1.06
Projected Final SPI(t)	1.00	1.00	0.99	0.99	0.99	0.97	0.92	0.92	0.92
Contract Efficiencies									
Contract Duration	23.74	23.74	23.74	23.74	23.74	23.74	23.74	23.74	23.74
Contract Schedule Efficiency	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97
Unconstrained Schedule Efficiency	0.85	0.85	0.85	0.82	0.79	0.72	0.72	0.72	0.72
SPI(t)	1.03	1.01	0.85	0.73	0.73	0.72	0.71	0.71	0.68

NOTIONAL DATA

available upon request for use or evaluation

EARNED SCHEDULE
= (HLOOKUP(J5,$B$3:$X$5,2))+(J5-(HLOOKUP(J5,$B$3:$X$5,1)))/((HLOOKUP(((HLOOKUP(J5,$B$3:$X$5,2))+1),$B$7:$X$8,2)-(HLOOKUP(J5,$B$3:$X$5,1))))

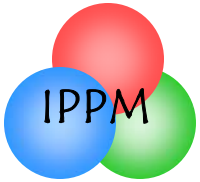




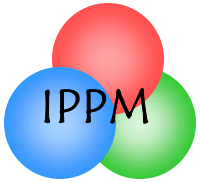
Benefits

Benefits of Earned Schedule

- **Makes common sense!**
- **Easier concept to grasp**
  - **Schedule variance metrics in terms of time rather than $**
- **More stable metric**
  - **Retains trend until end of project**
  - **Retains predictive utility**
    - **Use to predict duration**
    - **Can be used to improve EAC predictions**
  - **Check of contractor's schedule realism**
- **Bridge between EVM and the integrated master schedule**



The Way Ahead



Research Topics

- Determine if SPI(t) is a valid predictor of final duration (ongoing graduate thesis)
- Validate use of SPI(t) in EAC formulas
- Determine if earned schedule metrics are better at portraying schedule performance than traditional EVM metrics
  - Demonstrated on pilot projects
  - Need demonstration on broader scope of projects
- Compare predicted IEAC(t) durations against predicted critical path

Impact to EAC Formulas

- Performance based EAC formulas
  - Two formulas rely on SPI($)
    - But, predictive ability is lost during late stage of project
  - Need to determine applicability of using SPI(t) in EAC formulas
    - Weighted performance factor: .5*CPI + .5*SPI(t)
    - Composite performance factor: CPI*SPI(t)
  - Analysts should use with caution until research confirms utility

- "Burn rate" analysis
  - Use average burn rates (actual cost per month) against estimates of duration
  - Should improve EAC projections

Conclusions

- ***Earned Schedule***
  - a powerful new dimension to Integrated Project Performance Management (IPPM)
  - should replace traditional EVM schedule metrics
  - a breakthrough in theory and application

the first scheduling system