Earned Schedule

New analysis of schedule in Earned Value Management

ASC/Industry Cost & Schedule Workshop  19-20 Sep 2006
Robert Handshuh, CPIM, PMP
Agenda

• 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
BASIC EV METRICS

- 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

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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)
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 throughout project life cycle
  - Historical reference for future projects
  - Predictive capability under research & evaluation

- Earned Schedule is based on $\Sigma$ BCWP and $\Sigma$ BCWS
  - EVM data points you are already collecting
  - No new software; No Salesman will call
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 the project only has “Earned Schedule” to Month 5. Which SV “Answers the mail?” $ behind or 2 months behind schedule?
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

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

($X =$ 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 Complete (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 $\Sigma \text{BCWP} \geq \Sigma \text{BCWS} +$ fractional month completed

= $\text{Month (X)} + [\frac{(\Sigma \text{BCWP}_{t} - \Sigma \text{BCWS}_{x})}{(\Sigma \text{BCWS}_{y} - \Sigma \text{BCWS}_{x})}]$

$x = \text{whole month earned}$

$y = \text{month following X}$

$t = \text{Actual Time (Time Now)}$
Calculating ES -
Extrapolation Between the points - (Time Now - Month 7)

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

\[ x = \text{whole month earned}; \quad y = \text{month following } x; \quad t = \text{Actual Time (Time Now)} \]

- Find X - BCWP to BCWS
- \(2260 \geq 2000 \quad X = 6\)
- \(\text{BCWP}_t - \text{BCWS}_x =\)
- \((2260 - 2000)\)
- \(\text{BCWS}_y - \text{BCWS}_x =\)
- \((2500 - 2000)\)
- \(\text{ES} = 6 + (2260 - 2000) ÷ (2500-2000)\)
- \(\text{ES} = 6 + (260 ÷ 500) = 6.52\)
- We are in month 7 but only Earned 6.52 months of Schedule
Completing the ES Analysis
(Time Now - Month 7)

- Schedule Variance (time) = Earned Schedule - Actual Time
  \[(ES - AT = SV_t) = 6.52 - 7 = -0.48\] Months Behind

- Schedule Performance Index (time) = Earned Schedule ÷ Actual Time
  \[(ES ÷ AT = SPI_t) = 6.52 ÷ 7 = 0.93\] Earning Schedule at 93% efficiency (in months)

- Independent Time Estimate at Complete = Planned Duration ÷ Schedule Performance Index (time)
  \[(PD ÷ SPI_t = IEAC_t) = 12 ÷ 0.93 = 12.90\] Time to Complete
## Filling in the rest of the data -

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SPI\textsubscript{cost} vs. SPI\textsubscript{time} Graphically

80\% Complete

{Notional Data from Slide 19}
**ES – EZ Method**

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

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Spreadsheet developed by Walter Lipke, available on the Internet
Earned Schedule as EVM Analytical Tool

- 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 ÷ $SPI_t$)
ES $SPI_c$ vs. $SPI_t$ Tracking
IEACt = (PD ÷ SPIt)

Plan Completion 48 Months

Actual Completion 55 Months

ECD  ITEAC  Linear (ITEAC)
• 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 ÷ SPI_t)*
ES $\text{SPI}_c$ vs. $\text{SPI}_t$ Tracking

The graph shows the comparison of $\text{SPI}_c$ (blue line), $\text{SPI}_t$ (orange line), and a linear trend (red line) from week 1 to week 41. The graph indicates that the tracking is close to the planned values, with a completion of 80% as of week 27. The planned completion is marked for week 39.
ES for Schedule Completion
Independent Time Estimate At Complete (ITEAC)

\[ IEAC_t = \frac{PD}{SPI_t} \]

**ITEAC**

- **Planned Duration:** 39 mo
- **Actual Duration:** 42 mo

**Linear (ITEAC)**

Graph showing the comparison between planned and actual durations.
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 \( (\text{Planned Duration} \div SPI_t) \)
Total Program

- SPIc
- Earned Schedule (SPIt)
- Linear (Earned Schedule (SPIt))
Program Excluding LOE
ES Independent Time Estimate At Complete

Calculated on 14 month planned duration

- Total Program
  - $14 \div \text{Average ES (SPI}_{\text{time}}$)
  - $14 \div .79 = 17.7$ months (3.7 month Slip)

- Program w/o LOE
  - $14 \div \text{Average ES (SPI}_{\text{time}}$
  - $14 \div .737 = 19$ months (5 month Slip)
Observation - ES on actual projects

- 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*
ES Summary -

- **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*
ES Summary

• 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
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!