Earned Schedule …

something new for EVM and schedule analysis

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Importance of Schedule

“We need to maintain our attention on schedule delivery. Data tells us that since July 2003, real cost increase in projects accounted for less than 3 percent of the total cost growth... Therefore, our problem is not cost, it is SCHEDULE.”

- Dr. Steve Gumley, CEO
Defence Materiel Organization (Australia)

Objective

- Introduce the Earned Schedule Concept
- Develop the Schedule Indicators
- Apply to Project Duration Prediction
- Apply to Schedule Analysis
Earned Value Basics

\[ \text{CPI} = \frac{\text{EV}}{\text{AC}} \]

\[ \text{SPI} = \frac{\text{EV}}{\text{PV}} \]

\[ \text{SV} = \text{EV} - \text{PV} \]

\[ \text{CV} = \text{BAC} - \text{EV} \]

\[ \text{PV} = \text{Planned Value} \]
\[ \text{EV} = \text{Earned Value} \]
\[ \text{AC} = \text{Actual Cost} \]
\[ \text{BAC} = \text{Budget at Completion} \]
\[ \text{PD} = \text{Planned Duration} \]

Something’s wrong!!
EVM Schedule Indicators

- SV & SPI behave erratically for projects behind schedule
  - SPI improves and equals 1.00 at end of project
  - SV improves and concludes at $0 variance
- Schedule indicators lose predictive ability over the last third of the project
EVM Schedule Indicators

- Why does this happen?
  - SV = EV – PV
  - SPI = EV / PV

- At planned completion PV = BAC
- At actual completion EV = BAC
- When actual > planned completion
  - SV = BAC – BAC = $000
  - SPI = BAC / BAC = 1.00

Regardless of lateness!!
The cumulative value of ES is found by using EV to identify in which time period, or increment, of PV the cost value occurs.

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 Metric

• Required measures
  – **Performance Measurement 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**
Earned Schedule Calculation

- **ES (cumulative)** is the:
  Number of completed PV time increments EV exceeds + the fraction of the incomplete PV increment

- **ES = C + I** where:
  \[ C = \text{number of time increments for } EV \geq PV \]
  \[ I = \frac{(EV - PV_C)}{(PV_{C+1} - PV_C)} \]
Interpolation Calculation

\[ I / \text{1 mo} = p / q \]

\[ I = (p / q) \times \text{1 mo} \]

\[ p = EV - PV_C \]

\[ q = PV_{C+1} - PV_C \]

\[ I = \frac{EV - PV_C}{PV_{C+1} - PV_C} \times \text{1mo} \]
Earned Schedule Indicators

- **Schedule Variance:**
  \[ SV(t) = ES - AT \]

- **Schedule Performance Index:**
  \[ SPI(t) = ES / AT \]

where AT is “Actual Time” – the duration from start to time now

- \( SV(t) \) and \( SPI(t) \) are time-based (months, weeks …)
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 \( \leq \) PD, while AT > PD
  – SV(t) will be negative (time behind schedule)
  – SPI(t) will be < 1.00

Reliable Values from Start to Finish!!
Schedule Index Comparison

Early Finish Project

Late Finish Project

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Lipke & Henderson
Late Finish Project

Commercial IT Infrastructure Expansion Project Phase 1
Cost and Schedule Variances
at Project Projection: Week Starting 15th July xx

- CV cum
- SV cum
- Target SV & CV
- SV (t) cum

Stop wk 19
Sched wk 20
Re-start wk 26
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 project management (using EVM with ES)
Schedule Prediction

• Can the project be completed as planned?
  – TSPI = Plan Remaining / Time Remaining
    = (PD – ES) / (PD – AT)
    where PD is the planned duration (time at BAC)
    (PD – ES) = PDWR
    PDWR = Planned Duration for Work Remaining

• …completed as estimated?
  – TSPI = (PD – ES) / (ED – AT)
    where ED = Estimated Duration

<table>
<thead>
<tr>
<th>TSPI Value</th>
<th>Predicted Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 1.00</td>
<td>Achievable</td>
</tr>
<tr>
<td>&gt; 1.10</td>
<td>Not Achievable</td>
</tr>
</tbody>
</table>
Schedule Forecasting

• Long time goal of EVM … *Prediction 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 predict final cost

• Independent Estimated Completion Date (IECD)
  – IECD = Start Date + IEAC(t)
## Earned Schedule Terminology

<table>
<thead>
<tr>
<th>Metrics</th>
<th>Earned Schedule</th>
<th>( ES_{cum} )</th>
<th>( ES = C + I ) number of complete periods (C) plus an incomplete portion (I)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual Time</td>
<td>( AT_{cum} )</td>
<td>( AT = number of periods executed )</td>
<td></td>
</tr>
<tr>
<td>Indicators</td>
<td>Schedule Variance</td>
<td>( SV(t) )</td>
<td>( SV(t) = ES - AT )</td>
</tr>
<tr>
<td>Schedule Performance Index</td>
<td>( SPI(t) )</td>
<td>( SPI(t) = ES / AT )</td>
<td></td>
</tr>
<tr>
<td>To Complete Schedule Performance Index</td>
<td>( TSPI(t) )</td>
<td>( TSPI(t) = (PD – ES) / (PD – AT) )</td>
<td></td>
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<tr>
<td>Predictors</td>
<td>Independent Estimate at Completion (time)</td>
<td>( IEAC(t) )</td>
<td>( IEAC(t) = PD / SPI(t) )</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>( IEAC(t) = AT + (PD – ES) / PF(t) )</td>
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</table>
• SPI(t) & SV(t) do portray the real schedule performance
• At early & middle project stages pre-ES & ES forecasts of project duration produce similar results
• At late project stage ES forecasts outperform all pre-ES forecasts
• The use of the SPI(t) in conjunction with the TSPI(t) has been demonstrated to be useful for managing the schedule

Stephan Vandevoorde – Fabricom Airport Systems, Belgium

• “The results reveal that the earned schedule method outperforms, on the average, all other forecasting methods.”

Mario Vanhoucke & Stephan Vandevoorde
“A Simulation and Evaluation of Earned Value Metrics to Forecast Project Duration”
*Journal of the Operational Research Society* (September 2006)
Schedule Analysis with EVM?

• Most practitioners analyze schedule from the bottom up using the network schedule, independent from EVM
  ....“It is the only way possible.”
  – Analysis of the Schedule is overwhelming
  – Critical Path is used to shorten analysis
    (CP is longest path of the schedule)
• Duration prediction using Earned Schedule provides a macro-method similar to the method for estimating Cost
  – A significant advance in practice

But, there’s more that ES facilitates ....
Facilitates Drill-Down Analysis

- ES can be applied to any level of the WBS, to include task groupings such as the Critical Path (CP)
  - Requires creating PMB for the area of interest
  - EV for the area of interest is used to determine its ES
- Enables comparison of forecasts, total project (TP) to CP
  - Desired result: forecasts are equal
  - When TP forecast > CP forecast, CP has changed
  - When CP > TP, possibility of future problems
Critical Path Case Study

• Commercial sector software development and enhancement project
  – Small scale: 10 week Planned Duration
  – Time critical: Needed to support launch of revenue generating marketing campaign
  – Cost budget: 100% labour costs

• Mixture of:
  – 3 tier client server development
    • Mainframe, Middleware, Workstation
  – 2 tier client server development
    • Mainframe to Workstation direct
Case Study Schedule Analysis

- Initial expectation
  - The critical path predicted completion date would be more pessimistic than the IECD

- In fact
  - The ES IECD trend line depicted a “late finish” project with improving schedule performance
  - The critical path predicted completion dates showed an “early finish project” with deteriorating schedule performance

- Became the “critical question” in Week 8
  - ES IECD improvement trend reversed
  - Continued deterioration in the critical path predicted completion dates
Schedule Analysis Result

- **IECD the more credible predictor in this circumstance**
  - Work was not being accomplished at the rate planned
  - No adverse contribution by critical path factors
    - Externally imposed delays caused by “dependent milestone”
- **Two weeks schedule delay communicated to management**
  - Very late delay of schedule slippage a very sensitive issue
- **Corrective action was immediately implemented**
  - Resulted in two weeks progress in one week based on IECD improvement in week 9
  - Project substantively delivered to the revised delivery date
IECD vs Critical Path Predictors

• Network schedule updates do not usually factor past (critical path) task performance into the future
  – Generally concentrate on the current time window
    • Task updates
    • Corrective action to try and contain slippages
  – Critical path predicted completion date is not usually calibrated by past actual schedule performance

• The ES IECD
  – Does not directly take into account critical path information – for this study
  – BUT does calibrate the prediction based on historic schedule performance as reflected in the SPI(t)
Schedule Management with ES

- The “time critical” dichotomy of reporting “optimistic” predicted task completions and setting and reporting realistic completion dates was avoided
  - ES metrics provided an independent means of sanity checking the critical path predicted completion date
  - Prior to communicating overall schedule status to management
- ES focused much more attention onto the network schedule than using EVM alone
ES Bridges EVM to the Schedule
How Can This Be Used?

- **Tasks behind** – possibility of impediments or constraints can be identified
- **Tasks ahead** – a likelihood of future rework can be identified
- The identification is independent from schedule efficiency
- The identification can be automated

PMs can now have a schedule analysis tool connected to the EVM Data!!
EVM instruction including ES
- Performance Management Associates, Management Technologies, George Washington University, University of Florida …
- Boeing, Lockheed Martin, US State Department, Secretary of the Air Force
- Several Countries - Australia, Belgium, United Kingdom, USA ....(Spain, Brazil, Serbia, Sweden, Canada, India, …)
- Applications across weapons programs, construction, software development, …
- Range of project size from very small and short to extremely large and long duration
Current Usage & Recognition

- Inclusion of Emerging Practice Insert into PMI - EVM Practice Standard (2004)
- Described and included in *The Earned Value Management Maturity Model* by Ray Stratton
- Earned Schedule macro for MS Project 2003
  - Created by Diego Navarro
dnavarro@armell.com
  - Spanish version
http://www.armell.com/excel/earned_schedule_es.zip
  - English version being tested
Current Usage & Recognition

- Freely available add on tool for the Deltek Cobra product
- Requires registration to Earned Value Forums
- Contact: Mike Boulton
  WST Pacific
  mboulton@wstpacific.com.au
  +61 8 8150 5500

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
- Application is growing in both small and large projects
- Practice recognized as “Emerging Practice”
- Facilitates bridging EVM analysis to include the Schedule
Available Resources

  - Repository for ES Papers and Presentations

- **Earned Schedule Website**  [http://www.earnerschedule.com/](http://www.earnerschedule.com/)
  - Established February 2006
  - Contains News, Papers, Presentations, ES Terminology, ES Calculators
  - Identifies Contacts to assist with application

# Contact Information

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