Earned Schedule …
an emerging enhancement to EVM

Walt Lipke

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Objective

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

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

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

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

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

\[ \text{PV} \]

\[ \text{BAC} \]

\[ \text{AC} \]

\[ \text{EV} \]

\[ \text{SV} \]

\[ \text{CV} \]

Time

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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 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)**
  
  Number of completed PV time increments EV exceeds + the fraction of the incomplete PV increment

• **ES = C + I** where:
  
  C = number of time increments for EV ≥ PV
  I = (EV – PV₀) / (PV₁ – PV₀)
Interpolation Calculation

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

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

\[
p = EV - PV_C
\]

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

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

• Schedule Variance:

\[ SV(t) = ES - AT \]

• Schedule Performance Index:

\[ SPI(t) = \frac{ES}{AT} \]

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 ≤ 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 Variance Comparison

Early Finish Project

Late Finish Project

SV($)  SV(t)

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Schedule Index Comparison

Early Finish Project

Late Finish Project

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Late Finish Project

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

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)
  – $\text{IEAC}(t) = \frac{PD}{SPI(t)}$
  – $\text{IEAC}(t) = AT + \frac{PD - ES}{PF(t)}$
    where $PF(t)$ is the Performance Factor (time)
  – Analogous to IEAC used to predict final cost

• Independent Estimated Completion Date (IECD)
  – $\text{IECD} = \text{Start Date} + \text{IEAC}(t)$
# Earned Schedule Terminology

<table>
<thead>
<tr>
<th>Metrics</th>
<th>Earned Schedule</th>
<th>ES&lt;sub&gt;cum&lt;/sub&gt;</th>
<th>Actual Time</th>
<th>AT&lt;sub&gt;cum&lt;/sub&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Earned Schedule</td>
<td>ES = C + I number of complete periods (C) plus an incomplete portion (I)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Actual Time</td>
<td>AT = number of periods executed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Predictors</td>
<td>Independent Estimate at Completion (time)</td>
<td>IEAC&lt;sub&gt;t&lt;/sub&gt; = PD / SPI&lt;sub&gt;t&lt;/sub&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Schedule Variance</td>
<td>SV&lt;sub&gt;t&lt;/sub&gt; = ES - AT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Schedule Performance Index</td>
<td>SPI&lt;sub&gt;t&lt;/sub&gt; = ES / AT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>To Complete Schedule Performance Index</td>
<td>TSPI&lt;sub&gt;t&lt;/sub&gt; = (PD – ES) / (PD – AT)</td>
<td></td>
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<td>TSPI&lt;sub&gt;t&lt;/sub&gt; = (PD – ES) / (ED – AT)</td>
<td></td>
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</tbody>
</table>

**Indicators**

- **Schedule Variance**
  \[ SV(t) = ES - AT \]
- **Schedule Performance Index**
  \[ SPI(t) = ES / AT \]
- **To Complete Schedule Performance Index**
  \[ TSPI(t) = (PD – ES) / (PD – AT) \]
  \[ TSPI(t) = (PD – ES) / (ED – AT) \]

**Predictors**

- **Independent Estimate at Completion (time)**
  \[ IEAC(t) = AT + (PD – ES) / PF(t) \]
  \[ IEAC(t) = PD / SPI(t) \]
Independent Confirmation

• 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
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
ES Bridges EVM to the Schedule

\[ \text{Time} \]

\[ \text{PV} \]

\[ \text{BAC} \]

\[ \text{EV} \]

\[ \text{ES} \]

\[ \text{AT} \]

\[ \text{PD} \]

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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!!
Current Usage & Recognition

- EVM Instructors
  - Performance Management Associates, Management Technologies, George Washington University, University of Florida …
- Boeing Dreamliner®, Lockheed Martin, US State Department, Secretary of the Air Force
- Several Countries - Australia, Belgium, United Kingdom, USA …(Japan, Switzerland, Sweden, Spain, Brazil, India, …)
- Applications across weapons programs, construction, software development, …
- Range of project size from very small and short to extremely large and long duration
- Inclusion of Emerging Practice Insert into PMI - EVM Practice Standard (2004)
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
Thank You!

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Thank You from the MetSIG…The Information Highway For the Metrics of the World