Earned Schedule in Action

PMI Oklahoma City Chapter
13th July 2007

Kym Henderson
Immediate Past Education Director
PMI Sydney Australia Chapter
Kym.Henderson@froggy.com.au
Commonwealth of Australia

- European settlement started on 26th Jan 1788
  - British penal colony
- Federation of 6 colonies on 1st Jan 1901
  - US style Federation
  - Federal Parliament has
    - House of Representatives
    - Senate (12 Senators per State)
  - Federal Constitution
    - Defines powers between Federal and State Governments
    - No Bill of Rights
- BUT use British Westminster system of Parliamentary democracy
  - Majority Leader in House of Representatives becomes “Prime Minister”
- Population
  - Reached 21 million this year
- Land mass
  - Similar size to contiguous US 48 states
### Earned Value Basics

The Earned Value framework is a project management technique that measures progress and performance of a project by comparing the budgeted cost of work performed (BCWP), the earned value (EV), and the budgeted cost of work scheduled (BCWS). The key metrics are:

- **PV (Planned Value)**: The budgeted cost of work planned for a given time period.
- **EV (Earned Value)**: The budgeted cost of work actually completed.
- **AC (Actual Cost)**: The actual cost of work performed.
- **BAC (Budget at Completion)**: The total budget for the project.
- **CV (Cost Variance)**: The difference between EV and AC.
- **SV (Schedule Variance)**: The difference between EV and PV.

#### Formulas:

- **SPI (Schedule Performance Index)**: \[ \text{SPI} = \frac{\text{EV}}{\text{PV}} \]
- **CPI (Cost Performance Index)**: \[ \text{CPI} = \frac{\text{EV}}{\text{AC}} \]

#### Key Points:

- **SV = EV – PV**
- **CV = EV – AC**
- **SV < 0** indicates the project is behind schedule.
- **CV < 0** indicates the project is over budget.

---

**Something’s wrong!!**

- **PV** = Planned Value
- **EV** = Earned Value
- **AC** = Actual Cost
- **BAC** = Budget at Completion
- **PD** = Planned Duration
- **AT** = Actual Time
EVM Schedule Indicators

- SV & SPI behave erratically for projects behind schedule
  - SPI improves and concludes at 1.00 at end of project
  - SV improves and concludes at $0 variance at end of project
- Schedule indicators lose predictive ability nominally 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 completion > planned completion
  - $SV = BAC - BAC = $000$
  - $SPI = BAC / BAC = 1.00$

**Regardless of lateness !!**
Introduction to Earned Schedule
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)

Earned Schedule: The Concept
Seminal paper published in 2003 (Lipke)

1. Project EV onto PV curve
2. Use the X (time) axis to measure schedule performance
3. Use the formula to calculate “Earned Schedule”

\[
\text{SPI}($) = \frac{\text{EV}}{\text{PV}}
\]

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

\[
\text{SV}($) = \text{EV} - \text{PV}
\]

\[
\text{SV}(t) = \text{ES} - \text{AT}
\]

\[
\text{ES} = 5.5 \\
\text{AT} = 7 \\
\text{SV}(t) = 5.5 - 7 = (1.5) \\
\text{SPI}(t) = 5.5/7 = .79
\]

\[
\text{ES} = \text{All of May } + \text{Portion of June} \\
\text{ES} = 5 + \frac{\text{EV($) - PV(May)}}{\text{PV(June)} - \text{PV(May)}} \\
\text{AT} = 7
\]
Earned Schedule Metrics

- Required measures
  - Performance Management 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 statused
- All measures available from existing EVM data
Earned Schedule Metrics

- $\text{ES}_{\text{cum}}$ is the:
  - Number of completed PV time increments EV exceeds + the fraction of the incomplete PV increment
- $\text{ES}_{\text{cum}} = C + I$ where:
  - $C =$ number of time increments for $EV \geq PV$
  - $I = (EV - PV_C) / (EV_{C+1} - PV_C)$
- $\text{ES}_{\text{period}(n)} = \text{ES}_{\text{cum}(n)} - \text{ES}_{\text{cum}(n-1)} = \Delta \text{ES}_{\text{cum}}$
- $\text{AT}_{\text{cum}}$
  - $AT =$ Actual Time (time now)
- $\text{AT}_{\text{period}(n)} = \text{AT}_{\text{cum}(n)} - \text{AT}_{\text{cum}(n-1)} = \Delta \text{AT}_{\text{cum}}$
  - $\Delta \text{AT}_{\text{cum}}$ is normally equal to 1
Earned Schedule Indicators

- **Schedule Variance: SV(t)**
  - Cumulative: \( SV(t) = ES_{cum} - AT_{cum} \)
  - Period: \( \Delta SV(t) = \Delta ES_{cum} - \Delta AT_{cum} \)

- **Schedule Performance Index: SPI(t)**
  - Cumulative: \( SPI(t) = ES_{cum} / AT_{cum} \)
  - Period: \( \Delta SPI(t) = \Delta ES_{cum} / \Delta AT_{cum} \)
**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 !!**
Earned Schedule Predictors

- Long time goal of EVM and project management … *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 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 Management
  - (Using EVM with ES)
Critical Path Study
Critical Path Study Outline

- The Scheduling Challenge

- Case Study Project
  - The project
  - The EVM, Earned Schedule and Network Schedule approach

- Earned Schedule vs Critical Path predictors

- **Real** Schedule Management with Earned Schedule
  - Initial experience and observations

- Conclusion and Final Thoughts
The Scheduling Challenge

- A realistic project schedule is dependent on multiple, often complex factors including accurate:
  - Estimation of the tasks required,
  - Estimates of the task durations
  - Resources required to complete the identified tasks
- **Identification and modeling of dependencies impacting the execution of the project**
  - Task dependencies (e.g. F-S process flows)
  - “Dependent” Milestones (internal and external)
  - “Other logic”
The Scheduling Challenge

- From small projects into large projects and programs, scheduling requirements becomes exponentially more complex

- **Integration**
  - Of schedules between “master” and “subordinate” schedules
  - Often across multiple tiers of
    - Activities and
    - Organisations
  - contributing to the overall program of work

- **Essential for producing a useful integrated master schedule**
To further compound schedule complexity

- Once an initial schedule baseline has been established, progress monitoring *inevitably* results in changes:
  - Task and activity durations change because “actual performance” does not conform to plan.
  - Additional *unforeseen* activities may need to be added.
  - Logic changes as a result of corrective actions to contain slippages; and
  - Improved understanding of the work being undertaken.
  - Other “planned changes” (Change Requests) also contribute to schedule modifications over time.
Wouldn’t it be nice …. 

- To be able to explicitly declare “Schedule Reserve” in the project “schedule of record”
  - Protect committed key milestone delivery dates

- To have schedule macro level indicators and predictors
  - Ideally, derived separately from the network schedule!
  - Provides a means for comparison and validation of the measures and predictors provided by the network schedule
  - An independent predictor of project duration would be a particularly useful metric
    - “On time” completion of projects usually considered important

- Just like EVM practitioners have for cost …. 
  - The potential offered by Earned Schedule
Case Study Project

- 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
The EVM and ES Approach

- **Microsoft Project 2002 schedule**
  - Resource loaded for time phased effort and cost estimation
  - Control Account – Work Package views developed in the schedule
  - Actual Costs captured in SAP time recording system
    - Limited (actual) cost – schedule integration
  - Contingency (Management Reserve) managed outside the schedule

- **Top level Planned Values cum “copied and pasted” into Excel EVM and ES template**
  - High level of cost – schedule integration achieved
## Baseline Schedule: CAP and WP View (Excluding Risk)

<table>
<thead>
<tr>
<th>Task Name</th>
<th>Baseline Work</th>
<th>Baseline Cost</th>
<th>Duration</th>
<th>Details</th>
<th>July</th>
<th>August</th>
<th>September</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project: ES Example #1 Initial Baseline Schedule</td>
<td>1,675 hrs</td>
<td>$167,857</td>
<td>87 days</td>
<td>Cost</td>
<td>$74,084</td>
<td>$57,310</td>
<td></td>
</tr>
<tr>
<td>CAP 1 PROJECT MANAGEMENT</td>
<td>297 hrs</td>
<td>$38,610</td>
<td>44 days</td>
<td>Cum. Cost</td>
<td>$75,852</td>
<td>$133,162</td>
<td>$133,162</td>
</tr>
<tr>
<td>CAP 5 BUSINESS REQUIREMENTS</td>
<td>192 hrs</td>
<td>$0</td>
<td>34 days</td>
<td>Cost</td>
<td>$14,139</td>
<td>$17,680</td>
<td></td>
</tr>
<tr>
<td>CAP 7 SOLUTION DESIGN</td>
<td>160 hrs</td>
<td>$16,567</td>
<td>9.5 days</td>
<td>Cum. Cost</td>
<td>$15,907</td>
<td>$33,587</td>
<td>$33,587</td>
</tr>
<tr>
<td>CAP 8 BUILD &amp; UNIT TEST</td>
<td>720 hrs</td>
<td>$77,760</td>
<td>30.25 days</td>
<td>Cost</td>
<td>$45,128</td>
<td>$13,760</td>
<td></td>
</tr>
<tr>
<td>01 Mainframe Stream 1</td>
<td>192 hrs</td>
<td>$24,960</td>
<td>19.38 days</td>
<td>Cum. Cost</td>
<td>$45,128</td>
<td>$58,888</td>
<td>$58,888</td>
</tr>
<tr>
<td>02 Mainframe Stream 2</td>
<td>64 hrs</td>
<td>$6,400</td>
<td>10 days</td>
<td>Cost</td>
<td>$4,240</td>
<td>$4,240</td>
<td>$4,240</td>
</tr>
<tr>
<td>03 Frontend</td>
<td>104 hrs</td>
<td>$10,400</td>
<td>19 days</td>
<td>Cum. Cost</td>
<td>$7,920</td>
<td>$9,360</td>
<td>$9,360</td>
</tr>
<tr>
<td>04 Connect</td>
<td>40 hrs</td>
<td>$4,000</td>
<td>6.25 days</td>
<td>Cost</td>
<td>$4,000</td>
<td>$4,000</td>
<td>$4,000</td>
</tr>
<tr>
<td>05 Database</td>
<td>8 hrs</td>
<td>$800</td>
<td>1.25 days</td>
<td>Cum. Cost</td>
<td>$800</td>
<td>$800</td>
<td>$800</td>
</tr>
<tr>
<td>06 Middle Tier</td>
<td>208 hrs</td>
<td>$20,800</td>
<td>25 days</td>
<td>Cost</td>
<td>$12,320</td>
<td>$6,880</td>
<td></td>
</tr>
<tr>
<td>07 Reporting</td>
<td>104 hrs</td>
<td>$10,400</td>
<td>21.5 days</td>
<td>Cum. Cost</td>
<td>$12,320</td>
<td>$19,200</td>
<td>$19,200</td>
</tr>
<tr>
<td>CAP 9 SYSTEM TEST</td>
<td>104 hrs</td>
<td>$13,520</td>
<td>29.06 days</td>
<td>Cost</td>
<td>$3,680</td>
<td>$5,440</td>
<td></td>
</tr>
<tr>
<td>CAP 10 UAT</td>
<td>45 hrs</td>
<td>$5,040</td>
<td>3.75 days</td>
<td>Cum. Cost</td>
<td>$3,680</td>
<td>$9,120</td>
<td>$9,120</td>
</tr>
<tr>
<td>CAP 11 PRODUCTION IMPLEMENTATION</td>
<td>96 hrs</td>
<td>$10,260</td>
<td>11.81 days</td>
<td>Cost</td>
<td>$8,450</td>
<td>$5,040</td>
<td></td>
</tr>
</tbody>
</table>

Earned Schedule In Action PMI OKC July 2007 v1
Schedule Management

- **Weekly schedule updates from week 3 focusing on:**
  - Accurate task level percentage work completion updates
  - The project level percentage work completion (cumulative) calculated by Microsoft Project
    - Percentage work complete transferred to the EVM and ES template to derive the progressive Earned Value (cumulative) measures
- **Schedule review focusing on critical path analysis**
  - Schedule updates occurred as needed with
  - Revised estimates of task duration and
  - Changes to network schedule logic
    particularly when needed to facilitate schedule based corrective action
- **Actual costs entered into the EVM template as they became available (~ weekly)**
An Integrated Schedule Analysis Chart
Critical Path, IECD, SPI(t) and SPI($) on one page
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
    - e.g. 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
The 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
  - Cannot directly take into account critical path information
  - BUT does calibrate the prediction based on historic schedule performance as reflected in the SPI(t)
Further Observations

- Much has been written about the consequences of not achieving work at the EVM rate planned
  - At very least, incomplete work needs to be rescheduled …
  - Immediate critical vs non critical path implication requires detailed analysis of the network schedule
  - Sustained improvement in schedule performance is a difficult challenge
    - SPI(t) remained in the .7 to .8 band for the entire project!
    - In spite of the corrective action and recovery effort
  - Any task delayed eventually becomes critical path if not completed!
- SPI(t) a very useful indicator of schedule performance
  - Especially later in the project when SPI($) resolving to 1.0
Questions of Scale

- We know that ES is scalable as is EVM
  - Issues of scale did not arise due to small size of the project

- Detailed analysis of the ES metrics is required
  - The same as EVM for cost
  - The “masking” or “washout” effect of negative and positive ES variances at the detailed level can be an issue
  - The same as EVM for cost

- Apply Earned Schedule to the Control Accounts and Work Packages on the critical path
  - And “near” critical path activities

- Earned Schedule augments network schedule analysis – it doesn’t replace it
  - Just as EVM doesn't replace a bottom up ETC and EAC
Real Schedule Management with Earned Schedule

- ES is of considerable benefit in analysing and managing schedule performance
- The “time critical” dichotomy of working to “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
Final Thoughts

◆ ES is expected be of considerable value to the schedule management for large scale projects and programs
  ● Exponential increase in the network scheduling complexities which is both
  ● Unavoidable and essential on those programs which means
  ● The need and benefits of independent techniques to sanity check schedules of such complexity is much greater

◆ ES is anticipated to become the “bridge” between EVM and the Network Schedule
Available Resources
Publications


Click “Education,” then “Presentations and Papers” for .pdf copies

http://www.earnedschedule.com
Presentations

1. Earned Schedule – An Emerging Practice, 16th IIPM Conference, November 2004 [Walt Lipke, Kym Henderson]
4. Forecasting Project Schedule Completion by Using Earned Value Metrics, EVM Training at Ghent University (Belgium), January 2005 [Stephan Vandevoorde]
6. Forecasting Project Schedule Completion by Using Earned Value Metrics, Early Warning Signals Congress (Belgium), June 2005 [Stephan Vandevoorde, Dr. Mario Vanhoucke]

Click “Education,” then “Presentations and Papers” for .pdf copies

http://www.earnschedule.com
Calculator & Analysis Tools

- Freely provided upon email request
  - Application assistance if needed
- Please respect copyright ©
- Feedback requested
  - Improvement / Enhancement suggestions
  - Your assessment of value to Project Managers
  - Disclosure of application and results (with organization permission and/or anonymously)
## Contact Information

<table>
<thead>
<tr>
<th>Walt Lipke</th>
<th>Kym Henderson</th>
</tr>
</thead>
<tbody>
<tr>
<td><a href="mailto:waltlipke@cox.net">waltlipke@cox.net</a></td>
<td><a href="mailto:kym.henderson@froggy.com.au">kym.henderson@froggy.com.au</a></td>
</tr>
<tr>
<td>(405) 364-1594</td>
<td>61 414 428 537</td>
</tr>
</tbody>
</table>
Appendix: ES and Re-Baselining
ES and Re-Baselining

- **ES indicators are affected by re-baselining**
  - Behaviour of SV(t) and SPI(t) is analogous to CV and CPI
    - See examples

- **PMB change affects schedule prediction similarly to cost**

- **Earned Schedule brings attention to the potential schedule impact of a declared “cost only” change**
Earned Schedule – Re-Baseline Example

Real project data – nominal re-baseline

<table>
<thead>
<tr>
<th>Actual Time (weeks)</th>
<th>01 Jan</th>
<th>29 Jan</th>
<th>26 Feb</th>
<th>26 Mar</th>
<th>30 Apr</th>
<th>28 May</th>
<th>25 Jun</th>
<th>02 Jul</th>
<th>30 Jul</th>
<th>27 Aug</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planned Schedule ReBline #1</td>
<td>0.00</td>
<td>4.00</td>
<td>8.00</td>
<td>12.00</td>
<td>17.00</td>
<td>21.00</td>
<td>25.00</td>
<td>26.00</td>
<td>30.00</td>
<td>34.00</td>
</tr>
<tr>
<td>Planned Schedule cum CBB</td>
<td>0.00</td>
<td>4.00</td>
<td>8.00</td>
<td>12.00</td>
<td>17.00</td>
<td>20.00</td>
<td>20.00</td>
<td>20.00</td>
<td>20.00</td>
<td>20.00</td>
</tr>
<tr>
<td>Earned Schedule cum</td>
<td>0.00</td>
<td>3.84</td>
<td>8.60</td>
<td>12.56</td>
<td>16.87</td>
<td>17.45</td>
<td>17.59</td>
<td>25.91</td>
<td>28.70</td>
<td>33.00</td>
</tr>
<tr>
<td>IEAC(t) SPI(t)</td>
<td>20.85</td>
<td>18.60</td>
<td>19.11</td>
<td>20.15</td>
<td>24.07</td>
<td>28.42</td>
<td>33.12</td>
<td>34.50</td>
<td>34.00</td>
<td></td>
</tr>
</tbody>
</table>

1. Nominal Re-plan 02 July Cost and schedule overrun
2. Schedule delay
3. Re-baseline effect
**Earned Schedule – Re-Baseline Example**

*CV, SV($) and SV(t)*

**1. Nominal Re-plan 02 July**
Cost and schedule overrun

**2. Cost Overrun**

**3. Schedule delay**

**4. “Sawtooth” effect of re-baselining (CV, SV($) and SV(t)**

**5. 1 week completion delay on re-baselined PMB**

---

**Actual Time (weeks)**

<table>
<thead>
<tr>
<th>Actual Time (weeks)</th>
<th>01 Jan</th>
<th>29 Jan</th>
<th>26 Feb</th>
<th>26 Mar</th>
<th>30 Apr</th>
<th>28 May</th>
<th>25 Jun</th>
<th>02 Jul</th>
<th>30 Jul</th>
<th>27 Aug</th>
</tr>
</thead>
<tbody>
<tr>
<td>CV cum</td>
<td>0.00</td>
<td>(12.14)</td>
<td>(23.70)</td>
<td>(42.92)</td>
<td>(87.31)</td>
<td>(108.61)</td>
<td>(121.43)</td>
<td>6.96</td>
<td>11.09</td>
<td>(2.30)</td>
</tr>
<tr>
<td>SV($) cum</td>
<td>0.00</td>
<td>(0.41)</td>
<td>6.65</td>
<td>6.73</td>
<td>(1.42)</td>
<td>(22.07)</td>
<td>(46.48)</td>
<td>(8.60)</td>
<td>(5.22)</td>
<td>0.00</td>
</tr>
<tr>
<td>Target CV and SV</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>SV(t) cum</td>
<td>0.00</td>
<td>(0.16)</td>
<td>0.60</td>
<td>0.56</td>
<td>(0.13)</td>
<td>(3.55)</td>
<td>(7.41)</td>
<td>(0.09)</td>
<td>(1.30)</td>
<td>(1.00)</td>
</tr>
</tbody>
</table>