Earned Schedule in Action

Achieving RISK LEADERSHIP IN COMPLEX PROJECT MANAGEMENT

Learning Network Solutions

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EVM Schedule Indicators

- **CPI** = \( \frac{BCWP}{ACWP} \)
- **SPI** = \( \frac{BCWP}{BCWS} \)

Where:
- **BCWP** (Budgeted Cost of Work Performed)
- **ACWP** (Actual Cost of Work Performed)
- **BCWS** (Budgeted Cost of Work Scheduled)
- **BAC** (Budget at Completion)

**SV** (Sv Chi-squared) and **CV** (Cost Variance) are also shown in the diagram.
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 = BCWP – BCWS
  - SPI = BCWP / BCWS

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

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

\[ \text{SPI}($) = \frac{\text{BCWP}}{\text{BCWS}} \]

\[ \text{SV}($) = \text{BCWP} - \text{BCWS} \]

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

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

Projection of BCWP onto BCWS

\[ \text{ES} = \text{All of May} + \text{Portion of June} \]

\[ \text{ES} = 5 + \frac{\text{BCWP}($) - \text{BCWS(May)}}{\text{BCWS(June)} - \text{BCWS(May)}} \]

\[ \text{AT} = 7 \]
Earned Schedule Metrics

- Required measures
  - **Performance Management Baseline** (PMB) – the time phased planned values (BCWS) from project start to completion
  - **Earned Value** (BCWP) – 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 existing EVM data
Earned Schedule Metrics

- **$ES_{cum}$** is the:
  
  Number of completed BCWS time increments BCWP exceeds + the fraction of the incomplete BCWS increment

- **$ES_{cum} = C + I$** where:
  
  $C = \text{number of time increments for } BCWP \geq BCWS$
  $I = (BCWP - BCWS_C) / (BCWS_{C+1} - BCWS_C)$

- **$ES_{period(n)} = ES_{cum}(n) - ES_{cum}(n-1) = \Delta ES_{cum}$**

- **$AT_{cum}$**
  
  $AT = \text{Actual Time (time now)}$

- **$AT_{period(n)} = AT_{cum}(n) - AT_{cum}(n-1) = \Delta AT_{cum}$**
  
  $\Delta AT_{cum}$ 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 (BCWS = 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 … *Prediction of total project duration from present schedule status*

- Independent Estimate at Completion (time)
  - \( \text{IEAC}(t) = \frac{\text{PD}}{\text{SPI}(t)} \)
  - \( \text{IEAC}(t) = \text{AT} + \frac{(\text{PD} - \text{ES})}{\text{PF}(t)} \)
    where \( \text{PF}(t) \) 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 BCWS 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>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Project: ES Example #1 Initial Baseline Schedule</strong></td>
<td>1,675 hrs</td>
<td>$167,857</td>
<td>87 days</td>
<td></td>
</tr>
<tr>
<td>CAP 1 PROJECT MANAGEMENT</td>
<td>297 hrs</td>
<td>$38,610</td>
<td>44 days</td>
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<tr>
<td>CAP 5 BUSINESS REQUIREMENTS</td>
<td>192 hrs</td>
<td>$0</td>
<td>34 days</td>
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<tr>
<td>CAP 7 SOLUTION DESIGN</td>
<td>160 hrs</td>
<td>$16,567</td>
<td>9.5 days</td>
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<tr>
<td>CAP 8 BUILD &amp; UNIT TEST</td>
<td>720 hrs</td>
<td>$77,760</td>
<td>30.25 days</td>
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<tr>
<td>01 Mainframe Stream 1</td>
<td>192 hrs</td>
<td>$24,960</td>
<td>19.38 days</td>
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</tr>
<tr>
<td>02 Mainframe Stream 2</td>
<td>64 hrs</td>
<td>$6,400</td>
<td>10 days</td>
<td></td>
</tr>
<tr>
<td>03 Frontend</td>
<td>104 hrs</td>
<td>$10,400</td>
<td>19 days</td>
<td></td>
</tr>
<tr>
<td>04 Connect</td>
<td>40 hrs</td>
<td>$4,000</td>
<td>6.25 days</td>
<td></td>
</tr>
<tr>
<td>05 Database</td>
<td>8 hrs</td>
<td>$800</td>
<td>1.25 days</td>
<td></td>
</tr>
<tr>
<td>06 Middle Tier</td>
<td>208 hrs</td>
<td>$20,800</td>
<td>25 days</td>
<td></td>
</tr>
<tr>
<td>07 Reporting</td>
<td>104 hrs</td>
<td>$10,400</td>
<td>21.5 days</td>
<td></td>
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<td>CAP 9 SYSTEM TEST</td>
<td>104 hrs</td>
<td>$13,520</td>
<td>29.06 days</td>
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<tr>
<td>CAP 10 UAT</td>
<td>45 hrs</td>
<td>$5,040</td>
<td>3.75 days</td>
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<tr>
<td>CAP 11 PRODUCTION IMPLEMENTATION</td>
<td>96 hrs</td>
<td>$10,260</td>
<td>11.81 days</td>
<td></td>
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</tbody>
</table>
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

![Graph showing Earned Schedule Example Project #1](image)
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 to 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
Earned Value, Earned Schedule & TPM

An integrated solution for managing project uncertainty
Available Resources
Publications


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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]

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Presentations


6. Forecasting Project Schedule Completion by Using Earned Value Metrics, Early Warning Signals Congress (Belgium), June 2005 [Stephan Vandevoorde, Dr. Mario Vanhoucke]

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- 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

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</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

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

2. Schedule delay

3. Re-baseline effect

<table>
<thead>
<tr>
<th>Actual Time (weeks)</th>
<th>0.00</th>
<th>4.00</th>
<th>8.00</th>
<th>12.00</th>
<th>17.00</th>
<th>21.00</th>
<th>25.00</th>
<th>26.00</th>
<th>30.00</th>
<th>34.00</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>33.00</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>
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<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>
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<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>
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</table>
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) | 01 Jan | 29 Jan | 26 Feb | 26 Mar | 30 Apr | 28 May | 25 Jun | 02 Jul | 30 Jul | 27 Aug
---|---|---|---|---|---|---|---|---|---|---
CV cum | 0.00 | (12.14) | (23.70) | (42.92) | (87.31) | (108.61) | (121.43) | 6.96 | 11.09 | (2.30)
SV($) cum | 0.00 | (0.41) | 6.65 | 6.73 | (1.42) | (22.07) | (46.48) | (8.60) | (5.22) | 0.00
Target CV and SV | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00
SV(t) cum | 0.00 | (0.16) | 0.60 | 0.56 | (0.13) | (3.55) | (7.41) | (0.09) | (1.30) | (1.00)

Dollars,000