New Grounds: Time Dimension in Earned Value Management

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Earned Value Management

<table>
<thead>
<tr>
<th>Scope</th>
<th>EV = Earned Value</th>
<th>How much has been done?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost</td>
<td>AC = Actual Cost</td>
<td>How much did the work done cost?</td>
</tr>
<tr>
<td>Time</td>
<td>PV = Planned Value</td>
<td>How much was supposed to be done?</td>
</tr>
</tbody>
</table>

Cost Metrics

CV - CPI

How much will it cost at completion?

COST RESEARCH

Using CPI - metric has been proven usefull in assessing and evaluating final project cost, backed up with lots of research

Schedule Metrics

SV - SPI

How long will it take to finish?

SCHEDULE RESEARCH

No back up research & studies available, to the best of our knowledge
Schedule Variance SV

\[ SV = EV - PV \]  
\(< 0: \text{behind schedule} \quad > 0: \text{ahead of schedule} \]

SV measures a volume of work performed (€)

- difficult to understand

At the end of the project:

- \( EV = PV \) --> \( SV = EV - EV = 0 \)
- showing perfect performance!

SV shows improving trend

Whilst we are slipping further

At a certain point in time, the SV is no more reliable
Schedule Performance Index

SPI = EV / PV  
< 1: behind schedule  
> 1: ahead of schedule

SPI has no dimension
  • using an index is easier to understand

At the end of the project:
  • EV = PV  -->  SPI = EV / EV = 1
  • showing perfect performance!

At a certain point in time, the SPI is no more reliable
Watch Out

- Be careful by using data derived from software tools

Do we really have an improving schedule trend?

- Are we really moving close to the green area?

- Maybe because of the “strange” behavior of the SV & SPI, no research has been done so far.

- However, there is a need to have a schedule metric which behaves correctly during the whole project life, to sanity check schedule expectations.

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>LVL</th>
<th>LL</th>
<th>SV</th>
<th>CV</th>
<th>VAC</th>
<th>VAR</th>
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<tr>
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<td>3</td>
<td>↓</td>
<td>↓</td>
<td>↑</td>
<td>←</td>
<td>←</td>
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<td>←</td>
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<tr>
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<td>↓</td>
<td>↓</td>
<td>↓</td>
<td>←</td>
<td>←</td>
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<tr>
<td>4 SYS ENGINEERING</td>
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<td>↑</td>
<td>←</td>
<td>←</td>
<td>←</td>
<td>←</td>
</tr>
<tr>
<td>5 I &amp; A</td>
<td>3</td>
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<td>↓</td>
<td>←</td>
<td>←</td>
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<tr>
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<td>←</td>
<td>←</td>
<td>←</td>
<td>←</td>
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<tr>
<td>7 FUNC INTEGRA</td>
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<td>↑</td>
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<td>←</td>
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<td>←</td>
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<tr>
<td>8 MANAGEMENT DATA</td>
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<td>↑</td>
<td>↓</td>
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<td>←</td>
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<tr>
<td>9 COMMUNICATIONS</td>
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<td>↑</td>
<td>←</td>
<td>←</td>
<td>←</td>
<td>←</td>
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</tbody>
</table>

Project Management Software Forum
19/01/2006
Stephan Vandevoorde / Mario Vanhoucke
Extending Earned Value

Scope  EV = Earned Value  How much has been done?
Cost   AC = Actual Cost   How much did the work done cost?
Time  PV = Planned Value  How much was supposed to be done?

Cost Metrics
CV - CPI

Schedule Metrics
SV - SPI

Earned Schedule
SV(t) - SPI(t)

How much will it cost at completion?

COST RESEARCH
Using CPI - metric has been proven useful in assessing and evaluating final project cost, backed up with lots of research

How long will it take to finish?

SCHEDULE RESEARCH
1st research in its kind by Prof. Vanhoucke, Ghent University
Earned Schedule Concept

\[ ES = N + \frac{(EV - PV_N)}{(PV_{N+1} - PV_N)} \]

Created by Walt Lipke, *Schedule is Different, The Measurable News, Summer 2003*
Schedule Variance $SV(t)$

$SV(t) = ES - AD < 0$: behind schedule $> 0$: ahead of schedule

$SV(t)$ measures in time units
  - easy to understand

At the end of the project:
  - $SV(t)$ shows real deviation from plan

At all time, the $SV(t)$ is reliable

$SV(t)$ shows the real performance
Schedule Performance SPI(t)

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

- SPI(t) has no dimension
  - easier to understand

At the end of the project:
  - SPI(t) shows real schedule performance

At all time, the SPI(t) is reliable
PD/SPI: forecasting capability only at early & middle project stage
PD/SPI(t): forecasting capability during the whole project life
What Next

- **Emperical evidence:**
  - Vandevenoorde St., Vanhoucke M., A Comparison of different project duration forecasting methods using earned value metrics, Ghent University, working paper 2005/312, June 2005
  - to appear in International Journal of Project Management
  - State of the Art Report on Forecasting Duration Methods

  - **Earned Schedule provide schedule metrics which behave correctly during the whole project life,**
  - **Earned Schedule forecasting is more reliable, and useful to sanity check schedule expectations**

- **But can these findings be generalised? So we started a research project.**
  - Vanhoucke M., Vandevenoorde St., A simulation and evaluation of earned value metrics to forecast the project duration, Ghent University, working paper 2005/317, July 2005
  - paper under submission for publishing in international journal
Research Methodology

Network indicators (SP, AD, LA, TF) → Project network
Generate project networks
With a pre-defined structure

Project schedule
Construct an earliest start schedule (ESS) using forward calculations

Planned Value (PV) → Actual Cost (AC)

9 simulation scenarios → Project execution
Monte-Carlo simulation for each activity’s duration and cost

Earned Value (EV)

Project monitoring
Measure the forecasting accuracy at each review period
Network Generation

- So far: ES adopted to a small set of real life project data
- But: we need a very large dataset, which is not available
- Create a database of networks with a controlled topological structure by the using a network generator
- So we guarantee we have a very large set of networks than can and might occur in practice
- To control the design of the generated networks 4 indicators are used:
  - Network indicator: Serial or parallel network (SP)
  - Activity indicator: Activity distribution (AD):
  - Precedence relations indicator: Length of arcs (LA):
  - Float indicator: Topological float (TF)
Execution scenarios

- We measure a project ahead of schedule and it’s true
  (critical and non-critical activities are ahead)

- We measure a project ahead of schedule and there is none
  (critical activities are on plan and non-critical activities are ahead)

- We measure a project ahead of schedule and it’s false
  (critical activities are delayed and non-critical activities are ahead)

- We measure a project delay and it’s true
  (critical activities are delayed, non-critical activities are on plan)

- We measure a project delay there is none
  (critical activities are on plan, non-critical activities are delayed)

- We measure a project delay and it’s true
  (critical and non-critical activities are delayed)
Research Analysis

1. Forecast Accuracy for each Scenario
   - We measure the overall forecast accuracy of all methods for each scenario by using the MAPE
   - Comparison between scenarios is of little value, as simulations have been forced to reflect the respective scenario

2. Influence of the network structure
   - We measure the influence of the network structure as defined by the network indicators of the forecast accuracy of all methods for each scenario by using the MPE

3. Forecast Accuracy along project stage
   - We measure the overall forecast accuracy of all methods along the project stage (early, middle, late) by using the MPE for early and late finish projects
Forecast Accuracy / Scenario

Table 5. The forecast accuracy (MAPE) of the three methods for the 9 scenarios

<table>
<thead>
<tr>
<th>Scenario</th>
<th>PV1</th>
<th>PV2</th>
<th>PV3</th>
<th>ED1</th>
<th>ED2</th>
<th>ED3</th>
<th>ES1</th>
<th>ES2</th>
<th>ES3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.106</td>
<td>0.128</td>
<td>0.481</td>
<td>0.112</td>
<td>0.128</td>
<td>0.249</td>
<td>0.076</td>
<td>0.099</td>
<td>0.270</td>
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<tr>
<td>2</td>
<td>0.114</td>
<td>0.095</td>
<td>0.101</td>
<td>0.121</td>
<td>0.095</td>
<td>0.087</td>
<td>0.094</td>
<td>0.036</td>
<td>0.054</td>
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<tr>
<td>3</td>
<td>0.067</td>
<td>0.080</td>
<td>0.254</td>
<td>0.066</td>
<td>0.080</td>
<td>0.175</td>
<td>0.055</td>
<td>0.064</td>
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<tr>
<td>4</td>
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<td>0.071</td>
<td>0.426</td>
<td>0.023</td>
<td>0.071</td>
<td>0.229</td>
<td>0.033</td>
<td>0.092</td>
<td>0.237</td>
</tr>
<tr>
<td>5</td>
<td>0.000</td>
<td>0.000</td>
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<td>0.000</td>
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<td>0.000</td>
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<tr>
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<td>0.416</td>
<td>0.021</td>
<td>0.051</td>
<td>0.242</td>
<td>0.019</td>
<td>0.063</td>
<td>0.273</td>
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<tr>
<td>7</td>
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<td>0.077</td>
<td>0.409</td>
<td>0.032</td>
<td>0.077</td>
<td>0.222</td>
<td>0.034</td>
<td>0.093</td>
<td>0.227</td>
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<tr>
<td>8</td>
<td>0.100</td>
<td>0.090</td>
<td>0.119</td>
<td>0.102</td>
<td>0.090</td>
<td>0.102</td>
<td>0.076</td>
<td>0.031</td>
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<tr>
<td>9</td>
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<td>0.064</td>
<td>0.232</td>
<td>0.064</td>
<td>0.064</td>
<td>0.132</td>
<td>0.046</td>
<td>0.032</td>
<td>0.142</td>
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</tbody>
</table>
Influence of SP - Indicator
### Execution scenarios

#### Table 9. The mean percentage error (MPE) for project with RD > PD (project delay)

<table>
<thead>
<tr>
<th></th>
<th>Early</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>Late</th>
<th></th>
<th></th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>0-20</td>
<td>0-30</td>
<td>0-40</td>
<td>20-60</td>
<td>20-70</td>
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<td>30-70</td>
<td>30-80</td>
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<td>40-70</td>
<td>40-80</td>
<td>60-100</td>
<td>70-100</td>
</tr>
<tr>
<td>PV1</td>
<td>0.11</td>
<td>0.10</td>
<td>0.09</td>
<td>0.07</td>
<td>0.07</td>
<td>0.07</td>
<td>0.06</td>
<td>0.06</td>
<td>0.06</td>
<td>0.06</td>
<td>0.06</td>
<td>0.06</td>
<td>0.07</td>
<td>0.07</td>
</tr>
<tr>
<td>PV2</td>
<td>-0.03</td>
<td>-0.03</td>
<td>-0.02</td>
<td>-0.01</td>
<td>-0.01</td>
<td>-0.01</td>
<td>-0.01</td>
<td>-0.01</td>
<td>-0.01</td>
<td>-0.01</td>
<td>-0.01</td>
<td>-0.01</td>
<td>-0.05</td>
<td>-0.06</td>
</tr>
<tr>
<td>PV3</td>
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<td>-0.24</td>
<td>-0.22</td>
<td>-0.16</td>
<td>-0.15</td>
<td>-0.14</td>
<td>-0.13</td>
<td>-0.12</td>
<td>-0.13</td>
<td>-0.13</td>
<td>-0.13</td>
<td>-0.12</td>
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<td>-0.06</td>
</tr>
<tr>
<td>ED1</td>
<td>0.11</td>
<td>0.11</td>
<td>0.10</td>
<td>0.08</td>
<td>0.08</td>
<td>0.08</td>
<td>0.08</td>
<td>0.08</td>
<td>0.08</td>
<td>0.08</td>
<td>0.08</td>
<td>0.08</td>
<td>0.07</td>
<td>0.07</td>
</tr>
<tr>
<td>ED2</td>
<td>-0.03</td>
<td>-0.03</td>
<td>-0.02</td>
<td>-0.01</td>
<td>-0.01</td>
<td>-0.01</td>
<td>-0.01</td>
<td>-0.01</td>
<td>-0.01</td>
<td>-0.01</td>
<td>-0.01</td>
<td>-0.01</td>
<td>0.05</td>
<td>0.06</td>
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<tr>
<td>ED3</td>
<td>-0.24</td>
<td>-0.22</td>
<td>-0.19</td>
<td>-0.12</td>
<td>-0.10</td>
<td>-0.08</td>
<td>-0.08</td>
<td>-0.06</td>
<td>-0.06</td>
<td>-0.07</td>
<td>-0.07</td>
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<td>0.04</td>
</tr>
<tr>
<td>ES1</td>
<td>0.11</td>
<td>0.10</td>
<td>0.10</td>
<td>0.08</td>
<td>0.07</td>
<td>0.07</td>
<td>0.07</td>
<td>0.07</td>
<td>0.06</td>
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<td>0.07</td>
<td>0.06</td>
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<tr>
<td>ES2</td>
<td>-0.04</td>
<td>-0.05</td>
<td>-0.04</td>
<td>-0.03</td>
<td>-0.03</td>
<td>-0.02</td>
<td>-0.02</td>
<td>-0.01</td>
<td>-0.01</td>
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<td>-0.01</td>
<td>-0.01</td>
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<tr>
<td>ES3</td>
<td>-0.26</td>
<td>-0.24</td>
<td>-0.22</td>
<td>-0.14</td>
<td>-0.13</td>
<td>-0.11</td>
<td>-0.12</td>
<td>-0.10</td>
<td>-0.09</td>
<td>-0.09</td>
<td>-0.09</td>
<td>-0.08</td>
<td>-0.03</td>
<td>-0.02</td>
</tr>
</tbody>
</table>

#### Table 7. The mean percentage error (MPE) for project with RD < PD (ahead of schedule)

|       | Early |       |       |       |       |       |       |       |       | Middle |       |       |       |       |       | Late |       |       |       |       |       |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|       | 0-20  | 0-30  | 0-40  | 20-60 | 20-70 | 20-80 | 30-60 | 30-70 | 30-80 | 40-60| 40-70 | 40-80 | 60-100| 70-100| 80-100|       |       |       |       |       |
| PV1   | -0.89 | -0.83 | -0.78 | -0.64 | -0.60 | -0.56 | -0.60 | -0.56 | -0.52 | -0.56 | -0.56 | -0.47 | -0.29 | -0.25 | -0.21 |       |       |       |       |       |
| PV2   | -0.16 | -0.15 | -0.16 | -0.14 | -0.15 | -0.15 | -0.14 | -0.15 | -0.15 | -0.14 | -0.14 | -0.14 | -0.14 |       |       |       |       |       |       |       |
| PV3   | 0.35  | 0.37  | 0.37  | 0.37  | 0.37  | 0.37  | 0.37  | 0.37  | 0.37  | 0.37 | 0.37  | 0.37  | 0.38  | 0.39  | 0.39  |       |       |       |       |       |       |
| ED1   | -0.94 | -0.89 | -0.84 | -0.72 | -0.68 | -0.64 | -0.68 | -0.64 | -0.64 | -0.60 | -0.60 | -0.55 | -0.35 | -0.31 | -0.27 |       |       |       |       |       |       |
| ED2   | -0.16 | -0.15 | -0.16 | -0.14 | -0.15 | -0.15 | -0.14 | -0.15 | -0.15 | -0.14 | -0.14 | -0.14 | -0.14 |       |       |       |       |       |       |       |
| ED3   | 0.32  | 0.31  | 0.29  | 0.24  | 0.21  | 0.19  | 0.22  | 0.19  | 0.17  | 0.19  | 0.17 | 0.15  | 0.04  | 0.01  | -0.01 |       |       |       |       |       |       |
| ES1   | -0.91 | -0.86 | -0.80 | -0.67 | -0.62 | -0.57 | -0.63 | -0.58 | -0.53 | -0.58 | -0.53 | -0.48 | -0.23 | -0.18 | -0.13 |       |       |       |       |       |       |
| ES2   | 0.05  | 0.05  | 0.04  | 0.03  | 0.02  | 0.02  | 0.02  | 0.01  | 0.02  | 0.01 | 0.01  | 0.01  | 0.00  | 0.00  | 0.00  |       |       |       |       |       |       |
| ES3   | 0.44  | 0.42  | 0.40  | 0.33  | 0.30  | 0.28  | 0.30  | 0.28  | 0.25  | 0.28 | 0.26  | 0.23  | 0.11  | 0.09  | 0.07  |       |       |       |       |       |       |
Conclusions/Future Research

1. Forecast Accuracy (continued)
   - Accuracy of time and cost metrics
   - Need for new software package?
   - Real-life data available?

2. Project complexity?
   - What if the project is not yet defined?
     - Rework / Uncertainty / Dynamic planning / …

3. Early warning or corrective action?
   - What do we do with more accurate metrics?
     - Corrective actions (re-active) or management reserve (pro-active)?
Questions

Coming Soon:

Management Jaarboek 2006

“Waar zit het tijdsaspect in een “earned value” meetsysteem?”