Earned Value

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Where did Earned Value Management come from?

• In 1967 the Department of Defense (DoD) established the Cost/Schedule Control Systems Criteria (C/SCSC) to standardize contractor requirements for reporting cost and schedule performance on major contracts.

• A basic tenet of C/SCSC is the concept of Earned Value Management.
What is Earned Value Management (EVM)?

• EVM is an incremental methodology for measuring project performance by determining cost and schedule performance of a project by comparing "planned" work with "accomplished" work in terms of the dollar value assigned to the work, and determining the need to recommend corrective actions.

• EVM results from an earned value analysis to indicate potential deviation of the project from cost and schedule baselines.

• Earned value is a Management Tool
  – Provides a snapshot of project performance at a point in time.
  – Compares where the project is now with: (1) previous work accomplished and (2) where the project was planned to be.
  – Serves as an early warning system to detect deficient or endangered progress.

• EVM is a significant tool in the Project Manager's "toolbox" for gaining valuable insight into project performance and is the tool that integrates technical, cost, schedule and risk management. In addition, EVM provides valuable quantifiable performance metrics for forecasting at-completion cost and schedule for their project.
Why use Earned Value Management (EVM)?

- When you manage project performance by just comparing planned to actual results, you could easily be on time but overspend according to your plan.
- Using EVM is a better method because it integrates cost, time and the work done (scope) and can be used to forecast future performance and project completion dates and costs.
- Earned value analysis results should be a major part of project reporting.
- EVM is the basis for course correction and will lead to new forecasted completion costs, change requests and other items that will need to be communicated.
- EVM provides an accurate picture of contract status and supports mutual goals of contractor and customer.
- The major objectives of applying earned value to a contract are to encourage contractors to use effective internal technical, cost and schedule management control systems, and to permit the customer to rely on timely data produced by those systems, for better management insight to bring project in on schedule and cost.
- This data is in turn used for determining product-oriented contract status, and projecting future performance based on trends to date.
Why use Earned Value Management?

• EVM allows better and more effective management decision making to minimize adverse impacts to the project.
• Earned value provides an objective measurement of how much work has been accomplished on a project.
• EVM ensures a clear definition of work prior to beginning that work
• EVM presents a logical plan for accomplishing the work
• EVM provides early and accurate identification of trends and potential problems, and serves as a key element of a project's risk management process.
• To measure progress, there must be a standard against which the movement may be compared. EVM establishes that standard as the “Performance Measurement Baseline” and measures progress against that baseline.
• Unless you are tracking earned value, you really have no idea what is going on with your project!
Key questions that Earned Value Management answers

We analyze past performance……..

PAST          PRESENT          FUTURE

The Two Key Questions

1. Did we get what we wanted for what we spent?

2. At the end of the project, is it likely that the cost will be less than or equal to the original estimate?
What do we measure progress against?

• Performance measurement baseline
  – budget is spread over . . .
  – time, to accomplish the scope of
  – work against which progress can be measured

• Earned Value is a key concept
  – how much progress did I make against my original plan?
  – expressed in dollars or hours
Ways of earning value

• Should be a quantitative and discrete whenever possible
  • Discrete = tangible end product
  • e.g. delivery of a specification, vendor parts contract awarded, foundation completed

• Should be integrated with success criteria or technical measures
  • e.g., successful completion of clean-up, a specific test, reliability growth curve
The Work Breakdown Structure (WBS) and Earned Value

- The WBS has been an integral part of the earned value concept.
- The WBS is a graphic portrayal of the project, exploding it in a level-by-level fashion, down to the degree of detail needed for effective planning and control. It must include all deliverable end items, and include the major functional activities that must be performed.
- A project consists of the sum total of all the elements of the WBS. Conversely, an element that is not contained in the WBS is not a part of the project. Any work that cannot be identified in the WBS requires authorization to proceed, either as a recognized omission or as an approved change order.
- The lowest levels of the WBS are significant because each defines a discrete element of work or task to be performed against which resources can be assigned and cost and schedule measured.
- These lowest level activities or tasks in the WBS, when assigned a schedule and cost, together with required resources (people and material) and the individual responsible for its accomplishment, define a work package, which can be rolled up to a “control account” via a process called “cost aggregation”.
- The control account is a critical point for performance measurement to occur, for this is where the integration of scope, schedule, and resources will take place and where the project will measure its performance throughout the duration of the project.
- Definition of the work package is critical to effective Earned Value Management and the use of earned value in risk management.
- Perhaps most critical to the use of earned value in risk management is the tenet that work packages either be limited in size to be accomplishable in a relatively short period of time, or that they include discrete milestones against which work performance can be measured.
Cost Budgeting

• A budget is merely a compilation of the individual costs estimates.
• Activity costs are rolled up to work package costs.
• Work package costs are rolled up to control account costs.
• Control account costs are rolled up to project costs.
• Contingency reserve is for the risks remaining after risk response planning.
• The cost baseline is made up of the contingency reserve plus project costs.
• Management reserve is any extra amount of funds to be set aside to cover unforeseen risks or changes to the project.
• The cost budget will include the management reserve and the cost baseline.
How does Earned Value work?

- Work is planned, budgeted and scheduled in time-phased increments utilizing a Work Breakdown Structure (WBS) to define activities and to assign costs to those activities.
- As work is accomplished, value is "earned" on the same basis it was planned.
- Comparison of this earned value with the planned value for a specific time period provides an indication of activity progress- if more value is planned than is earned for a specified period, then the project is in danger of not meeting its required schedule, unless action is taken to recapture the unaccomplished work.
- Similarly, comparison of the earned value for a task or group of tasks with the "actual" costs required to accomplish the same activities provides an indication of task cost performance- if actual costs are greater than planned costs for the accomplished activities, then the project is experiencing a cost overrun situation.
- Therefore, EVM requires that the project’s scope be fully defined, and then a bottoms-up baseline plan be put in place that integrates the scope with the authorized resources, all set within a specific time frame for performance with detailed measurement taken against the project plan, and a periodic forecast of the final expected results based on the actual performance results.
Earned value and your project

Define the Work

Plan the Work

Work the Plan

Collect Results

Measure Performance

Analyze Deviations

Take Corrective Action

Change Control

External Changes

Not for duplication nor distribution
# Earned Value Terminology

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Term</th>
<th>Interpretation (as of today…)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PV</td>
<td>Planned Value</td>
<td>What is the estimated value of the work planned to be done?</td>
</tr>
<tr>
<td>EV</td>
<td>Earned Value</td>
<td>What is the estimated value of the work actually accomplished?</td>
</tr>
<tr>
<td>AC</td>
<td>Actual Cost</td>
<td>What is the actual cost incurred for the work accomplished?</td>
</tr>
<tr>
<td>BAC</td>
<td>Budget at completion</td>
<td>How much did we BUDGET for the TOTAL project effort?</td>
</tr>
<tr>
<td>EAC</td>
<td>Estimate at Completion</td>
<td>What do we currently expect the TOTAL project to cost?</td>
</tr>
<tr>
<td>ETC</td>
<td>Estimate to Complete</td>
<td>From this point on, how much MORE do we expect it to cost to finish the project?</td>
</tr>
<tr>
<td>VAC</td>
<td>Variance at Completion</td>
<td>How much over or under budget do we expect to be at the end of the project?</td>
</tr>
</tbody>
</table>
# Earned Value Formulas

<table>
<thead>
<tr>
<th>Name</th>
<th>Formula</th>
<th>Interpretation (as of today…)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost Variance (CV)</td>
<td>EV - AC</td>
<td>NEGATIVE is over budget, POSITIVE is under budget.</td>
</tr>
<tr>
<td>Schedule Variance (SV)</td>
<td>EV – PV</td>
<td>NEGATIVE is behind schedule, POSTIVE is ahead of schedule.</td>
</tr>
<tr>
<td>Cost Performance Index (CPI)</td>
<td>EV / AC</td>
<td>We are getting $____ worth of work out of every $1 spent. Funds are or are not being used efficiently.</td>
</tr>
<tr>
<td>Schedule Performance Index (SPI)</td>
<td>EV / PV</td>
<td>We are (only) progressing at ___ percent of the rate originally planned.</td>
</tr>
<tr>
<td>Estimate to Complete (ETC)</td>
<td>EAC – AC</td>
<td>How much more will the project cost?</td>
</tr>
<tr>
<td>Variance at Completion (VAC)</td>
<td>BAC – EAC</td>
<td>How much over or under budget will we be at the end of the project?</td>
</tr>
</tbody>
</table>
# Earned Value Formulas

| Estimate At Completion (EAC) | BAC / CPI  
| Note: there are many ways to calculate EAC, depending on the assumptions made. | AC + ETC  
| | AC + (BAC - EV)  
| | AC + (BAC - EV) / CPI  
| As of now, how much do we expect the total project to cost?  
| • Used if no variances from the BAC have occurred or you will continue at the same rate of spending.  
| • Actual plus a new estimate for remaining work. Used when original estimate was fundamentally flawed.  
| • Actual to date plus remaining budget. Used when current variances are thought to be atypical of the future. AC plus the remaining value of work to perform.  
| • Actual to date plus remaining budget modified by performance. Used when current variances are thought to be typical of the future. |
Earned Value in action
**Earned Value Analysis example**

You have a project to build a new fence. The fence is four sided. Each side is to take one day to build and is budgeted for $1,000 per side. The sides are planned to be completed one after the other. Today is the end of day three.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Day 1</th>
<th>Day 2</th>
<th>Day 3</th>
<th>Day 4</th>
<th>Status End of Day 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Side 1</td>
<td>S-------------F</td>
<td></td>
<td></td>
<td></td>
<td>Complete, spent $1,000</td>
</tr>
<tr>
<td>Side 2</td>
<td>S-------------PF</td>
<td>----F</td>
<td></td>
<td></td>
<td>Complete, spent $1,200</td>
</tr>
<tr>
<td>Side 3</td>
<td>PS---S----PF</td>
<td></td>
<td></td>
<td></td>
<td>50% done, spent $600</td>
</tr>
<tr>
<td>Side 4</td>
<td></td>
<td></td>
<td>PS---------PF</td>
<td>Not yet started</td>
<td></td>
</tr>
</tbody>
</table>

Key  S = Actual Start, F = Actual Finish, PS = Planned Start, and PF = Planned Finish
<table>
<thead>
<tr>
<th>What is?</th>
<th>Calculation</th>
<th>Answer</th>
<th>Interpretation of answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>PV</td>
<td>1,000 + 1,000 + 1,000</td>
<td>3,000</td>
<td>We should have done $3,000 worth of work.</td>
</tr>
<tr>
<td>EV</td>
<td>complete, complete, half done or 1,000 + 1,000 + 500</td>
<td>2,500</td>
<td>We have actually completed $2,500 worth of work.</td>
</tr>
<tr>
<td>AC</td>
<td>1,000 + 1,200 + 600</td>
<td>2,800</td>
<td>We have actually spent $2,800.</td>
</tr>
<tr>
<td>BAC</td>
<td>1,000 + 1,000 + 1,000 + 1,000</td>
<td>4,000</td>
<td>Our project budget is $4,000.</td>
</tr>
<tr>
<td>CV</td>
<td>2,500 – 2,800</td>
<td>-300</td>
<td>We are over budget by $300.</td>
</tr>
<tr>
<td>CPI</td>
<td>2,500 / 2,800</td>
<td>.893</td>
<td>We are only getting 89 cents out of every dollar we put into the project.</td>
</tr>
<tr>
<td>SV</td>
<td>2,500 – 3,000</td>
<td>-500</td>
<td>We are behind schedule.</td>
</tr>
<tr>
<td>SPI</td>
<td>2,500 / 3,000</td>
<td>.833</td>
<td>We are only progressing at 83 percent of the rate planned.</td>
</tr>
<tr>
<td>EAC</td>
<td>4,000 / .893</td>
<td>4,479</td>
<td>We currently estimate that the total project will cost $4,479.</td>
</tr>
<tr>
<td>ETC</td>
<td>4,479 – 2,800</td>
<td>1,679</td>
<td>We need to spend $1,679 to finish the project.</td>
</tr>
<tr>
<td>VAC</td>
<td>4,000 – 4,479</td>
<td>-479</td>
<td>We currently expect to be $479 over budget when the project is completed.</td>
</tr>
</tbody>
</table>
Using performance measurements for decision making

- **Behind Schedule**
  - How critical is schedule?
  - Can I afford to work overtime to recover?
  - Can I do tasks concurrently?
  - Are there technical innovations which could speed up the process?
  - Am I “gold plating” instead of just meeting requirements?
  - Should I do a schedule risk assessment to project impact to program?

- **Over Cost**
  - Can I reschedule tasks? (Time phasing)
  - Is there a less costly facility I can use?
  - Are there tasks which can be deleted?
  - Should the element be added to my risk management profile?
Earned Value Analysis techniques

• Sort on significant variances
  – eliminate almost complete, just starting, etc.
• Graph and analyze trends
• Look at comparative data
  – e.g. cumulative performance vs. projected performance
• Examine written analysis by contractor
  – does it answer why?
  – adequacy of corrective action plans
• Analysis of schedule trends, critical path
• Analysis of Estimate At Completion (EAC) realism

what are the drivers?
what can we do about them?
Cost variance chart
Schedule variance chart

$K

250

200

150

100

50

4 8 12 16 20 24

Month

Work Plan Scale

Work Accomplished Scale

Schedule Variance

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What is a significant variance?

• % variance (e.g., >10%)
• $ variance (e.g., >$50,000 at the control account level)
• critical path element
• risk/complexity
• impact to other elements
• Top 10, Top 20, etc.
• contractor defined
EVM Performance Reporting
Cost and schedule performance chart.

Graphing the cost and schedule variance of Projects A, B, C, and D quickly identifies which needs the most immediate attention. Earned value reporting uses cost data to give more accurate cost and schedule reports. It does this by combining cost and schedule status to provide a complete picture of the project. Project cost can also be graphed versus time.
References

• Use of Earned Value Management to Mitigate Software Development Risk, by Paul E. Young.
• Earned Value Management, by James R. Chapman.
• Earned Value Management, by U.S.A. Government NASA
• Earned Value Project Management, 2nd Edition, by Quentin W. Fleming and Joel M. Koppelman