An introduction to

Earned Value Analysis

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Abstract

Earned value analysis is a method of performance measurement. Many project managers manage their project performance by comparing planned to actual results. With this method, one could easily be on time but overspend according to the plan. A better method is earned value because it integrates cost, schedule and scope and can be used to forecast future performance and project completion dates. It is an "early warning" program/project management tool that enables managers to identify and control problems before they become insurmountable. It allows projects to be managed better – on time, on budget.

Earned Value

Earned Value analysis is a method of performance measurement. Earned Value is a program management technique that uses "work in progress" to indicate what will happen to work in the future. Earned Value is an enhancement over traditional accounting progress measures. Traditional methods focus on planned accomplishment (expenditure) and actual costs. Earned Value goes one step further and examines actual accomplishment. This gives managers greater insight into potential risk areas. With clearer picture, managers can create risk mitigation plans based on actual cost, schedule and technical progress of the work. It is an "early warning" program/project management tool that enables managers to identify and control problems before they become insurmountable. It allows projects to be managed better – on time, on budget. Earned Value Management System is not a specific system or tool set, but rather, a set of guidelines that guide a company's management control system.

Introduction to the Earned-Value Concept

The earned-value measurement concept was first introduced to the American defense contracting community when the government issued the Department of Defense (DoD) and NASA Guide to PERT/Cost in 1963, which provided a simple definition of earned value. In 1967 the DoD established the Cost/Schedule Control Systems Criteria (C/SCSC) to standardize contractor requirements for reporting cost and schedule performance on major contracts. The effect of the C/SCSC mandate was to require a formal version of the "Earned Value" concept of cost and schedule management on selected new projects. The C/SCSC concept has been consistently applied for over 30

years and has set the standard for major government systems acquisitions. Other government agencies in United States and in other nations such as Australia, Canada and Sweden have adopted similar earned-value criteria in management of their major system acquisitions.

Although some people consider the C/SCSC standards ideal for all private firms to emulate, many within private industry have had difficulty employing the rigid criteria on all their projects – particularly commercial projects. Their perception is that there are too many nonvalue-added requirements in the formalized C/SCSC for them to be universally employed on all their commercial projects. This is unfortunate since earned value performance measurement provides a sound project management tool. When properly employed, it can give the project manager an early warning signal that the project is heading for a cost overrun unless immediate steps are taken to change the spending plan.

In 1995, private industry as represented by the National Security Industrial Association (NSIA) was allowed to assess the utility of the earned-value criteria. After a long study, NSIA subcommittee came up with its version of the criteria, reworked significantly to be more palatable to the project management community. The industry standard was called the Earned Value Management System (EVMS). The DoD endorsed this major development in December 1996.

Description of Earned Value Management terms

Three quantities form the basis for cost performance measurement using Earned Value Management. They are Budgeted Cost of Work Scheduled (BCWS) or Planned Value (PV), Budgeted Cost of Work Performed (BCWP) or Earned Value (EV) and Actual Cost of Work Performed (ACWP) or Actual Cost (AC).

The above quantities are defined below.

- Budgeted Cost of Work Scheduled (BCWS) or Planned Value (PV) – The sum of budgets for all work packages scheduled to be accomplished within a given time period.
- Budgeted Cost of Work Performed (BCWP) or Earned Value (EV) – The sum of budgets for completed work packages and completed portions of open work packages.
- Actual Cost of Work Performed (ACWP) or Actual Cost (AC) – The actual cost incurred in accomplishing the work performed within a given time period. For equitable comparison, ACWP is only recorded for the work performed to date against tasks for which a BCWP is also reported.

From these three quantities we can determine our total program budget as well as make a determination of schedule and cost performance and provide an estimated cost of the project at its completion. Additional terms are defined to record cost and schedule performance and program budget:

- Performance Measurement Baseline (PMB) – The sum of all work packages Budgeted Cost of Work Scheduled (BCWS) for each time period, calculated for the

total program duration. The PMB forms the time-phased budget plan against which project performance is measured.

- Budget At Completion (BAC) – The sum of all the budgets allocated to a program. In addition to the PMB, there generally is an amount of management reserve, which is a portion of the total program budget not allocated to specific work packages and withheld for management control processes. The BAC consists of the PMB plus all management reserve.
- Schedule Variance (SV) – The difference between the work actually performed (BCWP) and the work scheduled (BCWS). The schedule variance is calculated in terms of the difference in dollar value between the amount of work that should have been completed in a given time period and the work actually completed.
- Cost Variance (CV) – The difference between the planned cost of work performed (BCWP) and actual cost incurred for the work (ACWP). This is the actual dollar value by which a project is either overrunning or underrunning its estimated cost.
- Cost Performance Index (CPI) – The ratio of cost of work performed (BCWP) to actual cost (ACWP). CPI of 1.0 implies that the actual cost matches to the estimated cost. CPI greater than 1.0 indicates work is accomplished for less cost than what was planned or budgeted. CPI less than 1.0 indicates the project is facing cost overrun.
- Schedule Performance Index (SPI) – The ratio of work accomplished (BCWP) versus work planned (BCWS), for a specific time period. SPI indicates the rate at which the project is progressing.
- Estimate At Completion (EAC) – It is a forecast of most likely total project costs based on project performance and risk quantification. At the start of the project BAC

and EAC will be equal. EAC will vary from BAC only when actual costs (ACWP) vary from the planned costs (BCWP). Most common forecasting techniques are some variations of:

1. EAC = Actuals to date plus a new estimate for all remaining work. This approach is most often used when past performance shows that the original estimating assumptions were fundamentally flawed, or they are no longer relevant to a change in conditions.
2. EAC = Actuals to date plus remaining budget. This approach is most often used when current variances are seen as atypical and the project management team expectations are that similar variances will not occur in the future.
3. EAC = Actuals to date plus the remaining budget modified by a performance factor, often the cumulative cost performance index (CPI). This approach is most often used when current variances are seen as typical of future variances.
4. EAC = Budget At Completion (BAC) modified by a performance factor, cumulative cost performance index (CPI). This approach is most often used when no variances from BAC have occurred.

- Estimate To Complete (ETC) – The difference between Estimate At Completion (EAC) and the Actual Cost (AC). This is the estimated additional cost to complete the project from any given time.
- Variance At Completion (VAC) – The difference between Budget At Completion and Estimate At Completion (EAC). This is the dollar value by which the project will be over or under budget.

As of first quarter of year 2002 there is a shift in using the terms Planned Value (PV), Earned Value (EV) and Actual Cost (AC) instead of Budgeted Cost of Work Scheduled (BCWS), Budgeted Cost of Work Performed (BCWP) and Actual Cost of Work Performed (ACWP).

Following is the summary of important Earned Value terms and formula.

Earned Value Management Terms:

Term	Description	Interpretation
PV (BCWS)	Planned Value	What is the estimated value of the work planned to be done?
EV (BCWP)	Earned Value	What is the estimated value of the work actually accomplished?
AC (ACWP)	Actual Cost	What is the actual cost incurred?
BAC	Budget at Completion	How much did you BUDGET for the TOTAL JOB?
EAC	Estimate at Completion	What do we currently expect the TOTAL project to cost?
ETC	Estimate to Complete	From this point on, how much MORE do we expect it to cost to finish the job?
VAC	Variance at Completion	How much over or under budget do we expect to be?

Table 1

Earned Value Management Formula and Interpretation:

Name	Formula	Interpretation
Cost Variance (CV)	EV – AC	NEGATIVE is over budget, POSITIVE is under budget
Schedule Variance (SV)	EV – PV	NEGATIVE is behind schedule, POSITIVE is ahead of schedule
Cost Performance Index (CPI)	EV / AC	I am [only] getting _____ cents out of every $1.
Schedule Performance Index (SPI)	EV / PV	I am [only] progressing at ___% of the rate originally planned.
Estimate At Completion (EAC) **Note:** There are many ways to calculate EAC.	BAC / CPI AC + ETC	As of now how much do we expect the total project to cost $_____. • Used if no variances from the BAC have occurred • Actual plus a new estimate for remaining work. Used when original estimate was fundamentally flawed.

	AC + BAC – EV AC + (BAC – EV) / CPI	• Actual to date plus remaining budget. Used when current variances are atypical. • Actual to date plus remaining budget modified by performance. When current variances are typical.
Estimate To Complete (ETC)	EAC – AC	How much more will the project cost?
Variance At Completion (VAC)	BAC – EAC	How much over budget will we be at the end of the project?

Table 2

Illustrative explanation of Earned Value

In the following four periods, we expect to complete $100 of work:

	1	**2**	**3**	**4**	**Total**
Work Scheduled ($) [Planned Value (PV)]	25	25	25	25	100

Table 3

As time progresses, we can see what was actually spent in each period:

	1	**2**	**3**	**4**	**Total**
Work Scheduled ($) [Planned Value (PV)]	25	25	25	25	100
Actual Cost ($) [Actual Cost (AC)]	22	20	25	25	92
Variance	3	5	0	0	8 i.e. 8%

Table 4

From an accounting sense, it appears that this project is experiencing an underun of $8. It was expected to cost $100, and has actually cost $92. What is missing from this equation is the value of how much work actually was completed or “performed”.

	1	2	3	4	Total
Work Scheduled ($) [Planned Value (PV)]	25	25	25	25	100
Accomplished Value ($) [Earned Value (EV)]	20	20	20	20	80
Actual Cost ($) [Actual Cost (AC)]	22	20	25	25	92
Schedule Variance (SV) [SV = EV – PV]	-5	-5	-5	-5	-20 i.e. 20%
Cost Variance (CV) [CV = EV – AC]	-2	0	-5	-5	-12 i.e. 15%

Table 5

We now have a clearer picture of the actual status of the work. We currently have a schedule variance of -$20. We were scheduled to complete $100 of work, and have only completed $80. In addition, the work that was completed ($80) has cost more than we had planned ($92), creating a cost variance of -$12. The actual cost variance is not 8% as calculated by the traditional approach but it is 15% which is more accurate as it also considers the work accomplished.

Benefits of EVMS

Following are some of the benefits of EVMS, described by Fleming and Koppleman as the legacy of using the criteria on government contracts for three decades (1996, p.22). Note that they do not separate benefits of earned value data from the benefits of the criteria, perhaps because the reliability of data depends on the disciplined application of the management practices described by the criteria.

1. It is a single management control system that provides reliable data.
2. It integrates work, schedule and cost using a work breakdown structure (WBS).
3. The associated database of completed projects is useful for comparative analysis.

4. The cumulative cost performance index (CPI) provides an early warning signal.
5. The schedule performance index (SPI) provides an early warning signal.
6. The CPI is a predictor for the final cost of the project.
7. It uses an index-based method to forecast the final cost of the project.
8. The "to-complete" performance index allows evaluation of the forecasted final cost.
9. The periodic (e.g. weekly or monthly) CPI is a benchmark.
10. The management by exception principle can reduce information overload.

Conclusion

Earned Value Analysis is a better method of program/project management because it integrates cost, schedule and scope and can be used to forecast future performance and project completion dates. It is an "early warning" program/project management tool that enables managers to identify and control problems before they become insurmountable. It allows projects to be managed better – on time, on budget.

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