



Earned Value Management

Financial analysis that goes one step beyond “Budget versus Actual”

Tom Carlos

Overview

There are “lucky” project managers whose projects were completed “on time” and “within budget.” But I am guessing they are in the minority. Everyone else has probably faced a situation where one of the following statements is true:

- The project is within budget and schedule but we do not see the “expected” results
- The project is taking longer than expected
- The project is costing more than anticipated

I am betting that the managers of these projects used analysis tools that are considered “two-dimensional.” “Budget” and “Actual” are the two dimensions. But in looking at a broader picture, there is a much needed third dimension- one that reflects “performance and efficiency.”

“Performance and efficiency” indicate whether or not we are actually completing the intended tasks and producing the expected project deliverables within the designated budget and schedule. To examine this concept, let’s look at the following case study.

Case Study

The Assumptions:

- John is managing a software development project.
- The project estimates include a total of 100 hours of development time.
- There are five separate tasks that will take 20 hours each.
- Each task has 4 subtasks that take 5 hours to complete.
- John hires five programmers. Each will each have twenty percent of the work that can be completed concurrently.
- Each programmer will charge \$100 per hour. Total budget for the project is \$10,000.
- Based on the distribution of work, it is determined that the project can be completed within one week.

Initial Reports

- At the end of the week, the programmers turn in time sheets.
- A total of 90 hours is reported.
- Based on this information, John quickly assumes the project is 90% complete.
- John realizes that the project will not be completed on time.
- John’s status report claims that the project is within budget but not on time.

Question for you

Would you agree with John’s assessment of the project?

If you answered “No” or “I do not have enough information to support that claim” you’re right on track. And to understand why that is the correct answer, let’s dig further into the problem.

What do we Know (for a fact)?

- The project has 5 tasks, 20 hours each, total 100 hours.
- The programmers were given 1 week to complete their tasks.
- Timesheets show 90 hours of work.

What do we Not Know (to be true)?

- How many of the tasks (or portions of a task) have been completed?
- Do we know that work performed was solely dedicated to completing tasks or was the time spent on non-related tasks or inefficiencies?

To answer this question, John calls each programmer and gathers the following information:

Programmer	Budgeted Time	Actual time spent	Invoices Submitted	Percentage of all tasks completed
Bob	20 hours	15 hours	\$1,500	60%
Sue	20 hours	25 hours	\$2,500	75%
Roger	20 hours	5 hours	\$500	10%
Mike	20 hours	30 hours	\$3,000	50%
Jill	20 hours	15 hours	\$1,500	80%
Total time and costs incurred		90 hours	\$9,000	

Table 1

Without going any further John can see the project has encountered a serious problem. Collectively, the programmers show 90 hours of work. However, no one programmer can make the claim that they have completed 90% of their assigned task (and final deliverable).

John scratches his head and is dumbfounded when it comes to understanding

- (1) What has happened and
- (2) What to do next.

So he asks an associate for help and she comes to the rescue.

Margie introduces John to a project management tool called *Earned Value Management (EVM)*. In fact, she gives him an article that has the following definition:

Earned Value Management - The process of considering scope, schedule, and resources, measured against a project’s actual performance. It compares the planned amount of work to the completed tasks, to the projects’ cost, to determine if the cost, schedule, and work completed (thus far) are all in synch and in accordance with the plan. This analysis will show past performance and will estimate future efforts to complete the project (with the desired results).

The article provided by Margie also contains a table that shows all the terms, definitions, and formulas needed to conduct EVM analysis. Refer to Appendix 1.

At this point, John feels overwhelmed and has no idea how to apply the EVM terms and formulas to his project. So with Margie’s help, they slowly begin the analysis by defining the terms and plugging in the known figures.

Step 1 – The Starting Point Calculations

Symbol	Description	Formula	Explanation
PV	Planned Value	None	The estimated value of the work planned to be done thus far. In this case, the project’s PV is the estimated cost of \$10,000 because we estimated the project would be completed within a week.
AC	Actual Costs	None	The total costs incurred to date, based on timesheets, invoices, other expenses, etc. In this case \$9,000
EV	Earned Value	Sum of all (Task Budget * % Completed)	The estimated value of (intended) work completed thus far, as it relates to the expected deliverables.

Table 2

PV (Planned Value) and AC (Actual Cost) are easily derived. PV is based on what should have been completed thus far. For multi-period projects, it will seldom equal the full budget figure. The idea is to calculate a figure that represents “the amount of intended work; the work performed (thus far) in relationship to the assigned tasks.” In reality, EVM analysis will be done over several periods and the value for PV will be constantly changing.

To derive EV, multiply the *budget* figure by the percentage of all tasks completed (see Table 1). For example, Bob was given 20 hours to complete 4 subtasks. He estimated that 60% of the subtasks are completed. You multiply \$2,000 by 60% and this gives a value of \$1,200. So you can clearly see that Bob’s (real) work does not equal the actual cost of \$1,500. As a result, Bob has fallen behind (in schedule and cost) based on this one calculation.

To calculate EV for the entire project, simply add the individual EV values for each programmer. Refer to Table 3.

Term	Value	Notes
PV	\$10,000	Our budgeted figure
AC	\$9,000	Total invoices submitted thus far
EV	\$5,500	$(\$2,000 * 60\%) + (\$2,000 * 75\%) + (\$2,000 * 10\%) + (\$2,000 * 50\%) + (\$2,000 * 80\%)$

Table 3

Again, we can see that the group as a whole has fallen behind on their work. They have submitted \$9,000 as the cost but produced only \$5,500 of (Earned) value. So at this point in time, the project appears to be \$3,500 over budget. And we also know the project is behind schedule (because the tasks were not completed within the 1 week time frame).

Step 2 – The Performance Index Calculations

The Performance Index figures help us quantify efficiency. They are also used in subsequent EVM calculations.

Symbol	Description	Formula	Explanation
CPI	Cost Performance Index	EV/AC	I am (only) getting <u>(blank)</u> cents performance out of every \$1 spent
SPI	Schedule Performance Index	EV/PV	I am only progressing at <u>(blank)</u> % of the rate originally planned

Table 4

By plugging in our known values for PV, AC, and EV, we can calculate CPI and SPI.

Term	Value	Notes
CPI	61.11%	Using (EV/AC); $(\$5,500 / \$9,000)$
SPI	55.0 %	Using (EV/PV); $(\$5,500 / \$10,000)$

Table 5

Based on these results, John can see that his team is working at an average of 61.11% performance efficiency. The 55% SPI index tells him that the project will most likely need another week for completion.

Step 3 – The Final Cost Estimates

John then asks Margie; “Based on this information can we calculate the project’s final cost?” So Margie rolls out the next set of terms and calculations.

Symbol	Description	Formula	Explanation
BAC	Budget At Completion		The original budget for the total job
EAC	Estimate At Completion	(See Appendix 1)	The amount "currently expected" for the total project cost
ETC	Estimate To Complete	EAC-AC	From this point on, how much MORE do you expect the cost will be to finish the job
VAC	Variance At Completion	BAC-EAC	How much over or under budget will the project come in at
CV	Cost Variance (in dollars)	EV-AC	Negative is over budget, Positive is under budget
SV	Schedule Variance (in dollars)	EV-PV	Negative is behind schedule, Positive is ahead of schedule

Table 6

BAC is the original budget total. For this project, it is \$10,000.

Calculating a value for EAC can be tricky. There are four different methods for calculating EAC. Each method can yield a different result. Since Bob employs the principle of “conservatism” and wants the “worst case scenario” he uses the formula the yields the highest figure. (Refer to the Appendix 1 for all EAC formulas).

ETC is an easy calculation. This figure represents the additional costs from this point forward in order to finish the project.

Term	Value	Notes
BAC	\$10,000	The original budget
EAC	\$16,363	Using (BAC/CPI); [$\$10,000/.611$]
ETC	\$7,363	Using (EAC-AC); ($\$16,363 - \$9,000$)
VAC	- \$6,363	Using (BAC-EAC); ($\$10,000 - \$16,363$)
CV	- \$3,500	Using (EV-AC) with answer in dollars; $\$5,500 - \$9,000$
SV	- \$4,500	Using (EV-PV) with answer in dollars; ($\$5500 - \$10,000$)

Table 7

At this point in time, the project appears to be \$6,363 over budget (VAC). It will be next to impossible to hit the original target figure of \$10,000. The current EAC value assumes that the programmers will continue working at the same pace.

The Cost (CV) and Schedule (SV) variances indicate that the project is “over budget” and “behind schedule.”

Step 4 – Overall Efficiency Ratings

John is shaking his head in disbelief. Not only is his project struggling to meet the original estimates, but he must now report the bad news at the next steering committee meeting. He knows that the management team will not be able to follow the calculations shown above. So he needs to simplify the reporting to three simply values.

Symbol	Description	Formula	Explanation
PE	Planned Earned	EV/BAC	Project % Complete (as it relates to time and deliverables)
PS	Percent Spent	AC/BAC	Project % Spent (as it relates to cost)
CSI	Cost Schedule Index	CPI * SPI	The overall efficiency rating. The further CSI is from 1.0, the project will have difficulties in recovering.

Table 8

Using the known values, John calculates PE, PS, and CSI.

Term	Value	Notes
PE	55%	Using (EV/BAC); (\$5,500 / \$10,000)
PS	90%	Using (AC/BAC); (\$9,000 / \$10,000)
CSI	.336	Using (CPI * SPI)

Table 9

The values for PE and PS do not surprise John. He has seen these figures before. But CSI is surprising. This value is far from “1” and indicates the seriousness of the project’s inefficiency.

The formulas provide a mathematical analysis of performance. Unfortunately, they cannot explain “why” the inefficiencies have occurred. For this, John will need to examine the work of each programmer in order to understand why they are all running over the allotted time for each task. Hopefully, he can correct the problems.

The other issue to consider is that the task lengths were severely underestimated. Interviews with the programmers may show that they in fact are working to the best of their ability. The problem may have occurred in the original project estimates.

Conclusion

There is much more to EVM than discussed in this article. But you are now aware of the third dimension of a project's financial analysis. All three dimensions are key elements that must be considered when analyzing project performance.

About the author

Tom Carlos has over 20 years of cumulative experience in business, technical, and training environments. He is a Certified Project Management Professional (PMP) and member of the Sacramento Valley PMI Chapter. For other articles on similar subjects, you can visit www.carlosconsulting.com or contact him at tom@carlosconsulting.com.

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Appendix 1 - The spreadsheet below summarises the situation with this project.

Earned Value Management Analysis

Project Information	
Project duration (weeks)	1
Project start date	3/1/07
This report date	3/5/07
Estimated end date	3/5/07

Task #	Description	Budget Hrs	Hrly Cost	Total Est Cost
T1	Bob's Tasks	20.00	\$ 100	\$ 2,000.00
T2	Sue's Tasks	20.00	\$ 100	\$ 2,000.00
T3	Roger's Tasks	20.00	\$ 100	\$ 2,000.00
T4	Mike's Tasks	20.00	\$ 100	\$ 2,000.00
T5	Jill's Tasks	20.00	\$ 100	\$ 2,000.00
(Enter values were you see a blue font)		100.00		\$ 10,000.00

Actual	Cost To Date	Percentage of Tasks Completed *1
15.00	\$ 1,500.00	60%
25.00	\$ 2,500.00	75%
5.00	\$ 500.00	10%
30.00	\$ 3,000.00	50%
15.00	\$ 1,500.00	80%
90.00	\$ 9,000.00	

(Enter values were you see a blue font)
*1 - Information as reported by programmers

Term	Description	Value
PV	Planned Value *2	\$ 10,000.00
AC	Actual Cost	\$ 9,000.00
EV	Earned Value	\$ 5,500.00
CPI	Cost Performance Index	61.11%
SPI	Schedule Performance Index	55.00%

(Enter values were you see a blue font)
*2 Remember that PV is based on what should have been completed thus far.
For multi-period projects, it will not equal the same value as BAC.

Term	Description	Value
PE	Planned Earned	55.0%
PS	Percent Spent	90.0%
CSI	Cost Schedule Index	0.336

Alternate methods to Calculate EAC

Term	Description	Value
EAC #1	BAC/CPI	\$ 16,363.64
EAC #2	AC + ETC	\$ 16,363.64
EAC #3	AC + BAC - EV	\$ 13,500.00
EAC #4	AC + [(BAC-EV)/CPI]	\$ 16,363.64

Term	Description	Value
BAC	Budget At Completion	\$ 10,000.00
EAC *3	Estimate At Completion	\$ 16,363.64
ETC	Estimate To Complete	\$ 7,363.64
VAC	Variance At Completion	\$ (6,363.64)
CV	Cost Variance (in dollars)	\$ (3,500.00)
SV	Schedule Variance	\$ (4,500.00)

(Enter values were you see a blue font)
*3 Using Max Value of EAC #1, EAC #3, or EAC #4
(Using EAC #2 will create a circular error)

Your project Status:	
If EV > =PV and EV >= AC	
If EV < PV	Schedule Problem
If EV < AC	Cost Problem
If EV < PV and EV < AC	Cost and Schedule Problem



Appendix 2

EVM Terms, Definitions, and Calculations

Symbol	Description	Formula	Explanation
PV	Planned Value		(Also known as BCWS - Budgeted Cost of Work Scheduled) The estimated value of the work planned to be done thus far.
AC	Actual Costs		(Also known as ACWP – Actual Cost of Work Performed)The total costs incurred to date, based on timesheets, invoices, other expenses, etc
EV	Earned Value	Sum of all (Task Budget * % Completed)	(Also known as BCWP – Budgeted Cost of Work Planned)The estimated value of (intended) work completed thus far, as it relates to the expected deliverables
CPI	Cost Performance Index	EV/AC	I am (only) getting ___ cents performance out of every \$1 spent
SPI	Schedule Performance Index	EV/PV	I am only progressing at ___% of the rate originally planned
BAC	Budget At Completion		The original budget for the total job
EAC	Estimate At Completion	Four options; see below.	The amount "currently expected" for the total project cost
EAC (#1)		BAC/CPI	Used if no variances from the BAC have occurred
EAC (#2)		AC + ETC	Used when original estimate is fundamentally flawed
EAC (#3)		AC + BAC - EV	Used when the current variances are atypical
EAC (#4)		AC + [(BAC-EV)/CPI]	Used when current variances are typical
ETC	Estimate To Complete	EAC-AC	From this point on, how much MORE do you expect the cost will be to finish the job
VAC	Variance At Completion	BAC-EAC	How much over or under budget will the project come in at

CV	Cost Variance (in dollars)	EV-AC	Negative is over budget, Positive is under budget
SV	Schedule Variance (in dollars)	EV-PV	Negative is behind schedule, Positive is ahead of schedule
PE	Planned Earned	EV/BAC	Project % Complete (as it relates to time and deliverables)
PS	Percent Spent	AC/BAC	Project % Spent (as it relates to cost)
CSI	Cost Schedule Index	CPI * SPI	The overall efficiency rating. The further CSI is from 1.0, the project will have difficulties in recovering.