Tracking Budgets and Schedules

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One of the simplest questions you are likely to encounter as an engineering or project manager is: Are we on budget and schedule? While this is an easy question, the answer is not always easy to determine. Many of the popular software programs simply take the man-hours expended-to-date and divide this by the total man-hours estimated for the project. So, if we calculate that we have used 60 man-hours on a project that is estimated to take 100, then we are about 60% complete. If only it were that simple. The problem is, we may have used 60% of the man-hours, but have only accomplished 30% of the work! Referring to Figure 1, it appears that we are currently under budget on our $500,000 project. Our "instinct" tells us we are doing very well in managing this project's costs.

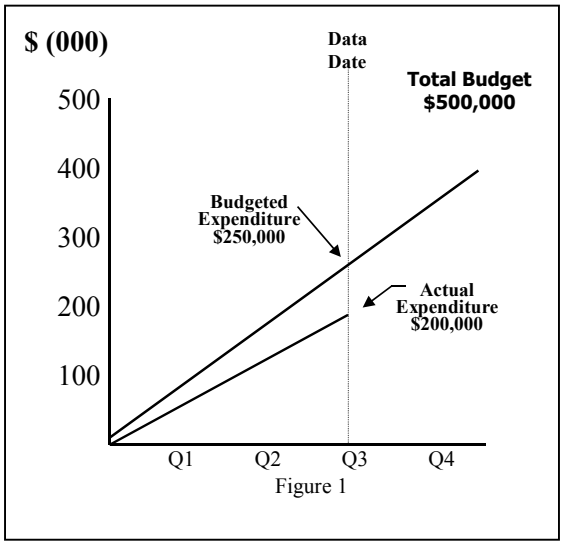


Figure 1

However, this is a misleading picture because we do not know if we are behind, ahead or on-track in our spending plan. It is entirely possible that we are behind schedule, which is skewing our cost report. Unfortunately, this graph does not show us anything about the schedule.

The question becomes: How can we derive the true picture of our budget and schedule?

Let's define a few key terms that will help us keep our thoughts straight:

- EV= Earned Value. This is the value of the completed work based on the approved budget
- AC= Actual Cost. The total costs actually incurred during a given time period (i.e. this is what is actually paid).
- Cost Variance= EV-AC

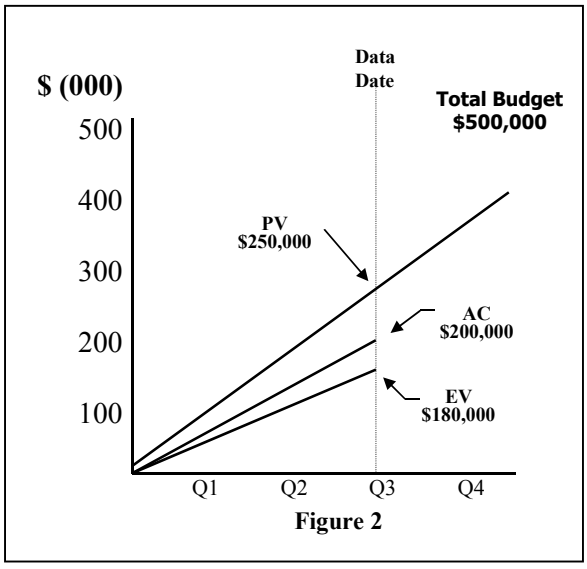


Figure 2

To get a better sense of what is really happening, refer to Figure 2. In this specific example, our cost variance is $180,000 - $200,000 = ($20,000). In this case, the earned value is the work that we actually accomplished. Yet, we have paid $200,000.

If we calculate the cost-performance index (CPI), here is a more definitive answer:

$$CPI = \frac{EV}{AC} = \frac{\$180{,}000}{\$200{,}000} = 0.90$$

This tells us that for each dollar we spend, we are only getting about 90 cents worth of value. If this

trend continues, we will overspend our budget. A project that is on track will have a CPI of 1.0 or more. For example, a CPI of 1.10 would tell us that the project is currently running under budget by 10%. That is, for each dollar we spend, we are getting $1.10 value.

How do we determine the Earned Value? This is where one spends much time in planning a schedule of tasks and developing a cash flow based on that schedule. At best, it is a subjective analysis in the early stages because a schedule is an estimate: it is what we plan to do. But even the best plans can go off course. The best course of action is to meticulously define the project scope, identify all of the activities and their costs; then plan a budget (with monthly cash flows). Earned Value will only be as good as the scope and activities you identify. If you have endless scope changes and big gaps in your task list, then earned value analysis will not be much help.

But getting back to our example, if our CPI is .90, then we will ultimately overshoot our budget. To determine how much, we can use the following formula:

Estimate at Completion (EAC)

$$EAC = \$\$ \text{ Amount Spent} + \frac{\$\$ \text{ Amount Left}}{CPI}$$

$$\text{In this case, } EAC = \$200{,}000 + \frac{(\$500{,}000 - \$200{,}000)}{0.90} = \$533{,}333$$

If we do not reverse our current spending pattern, we will overrun our budget by $33,333 dollars. Essentially, we are not controlling our budget very well, at least based on today's "snapshot."

Controlling Schedule

Similar to the budget, there are several calculations we can perform to determine where we stand on schedule. Please refer again to Figure 2. Note that schedule variance is measured in dollars.

SV = EV – PV or $180,000 - $250,000 = -$70,000 Where PV = Planned Value

Planned Value is the authorized budget assigned to the work to be accomplished over a given time frame. This is also known as the Budgeted Cost of the Work Scheduled (BCWS).

This tells us that to be on schedule today, we would need to accomplish an additional $70,000 worth of work. And, similar to costs, there is a *schedule* performance index:

$$SPI = \frac{EV}{PV} = \frac{\$180{,}000}{\$250{,}000} = 0.72$$

In this case, our schedule is only 72% as effective as it should be. Therefore, the "project" we are evaluating is only getting 90 percent value, will overrun its budget by $33,333 and is also behind schedule. Not a very pleasant prospect. However, do not despair; let's look a little further.

Keeping it in Perspective

There are a few key points to remember when performing budget and schedule status evaluations:

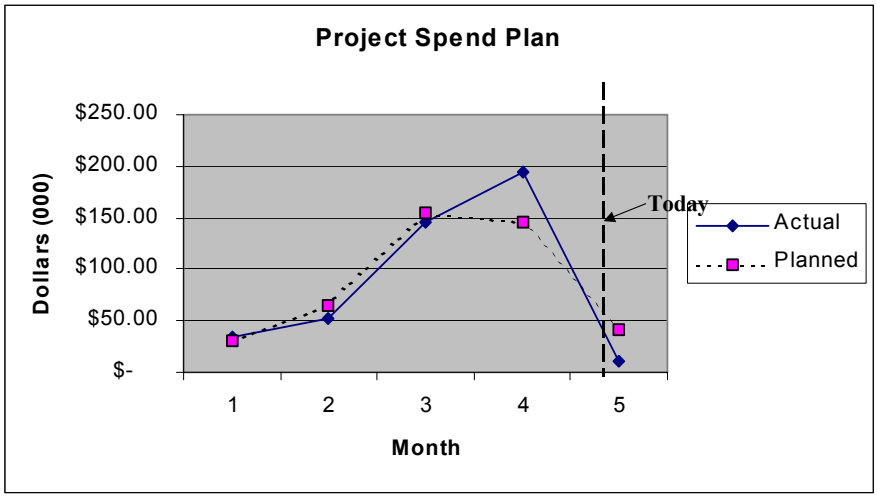
- Earned Value calculations are useful for spotting trends over time. A project should not be evaluated simply on one "point" in time. We are looking for trends over a three-month, four-month or six-month time frame.
- Trends will begin to appear around 20 percent into a project. Therefore, if your numbers are starting to head south, you should have enough time to take corrective action.
- Recognize that you will need accurate and timely numbers from whoever is tracking your project costs (usually someone in accounting). Be sure that the numbers you receive are in a format that is conducive to performing the analysis.

Finally, these evaluations will not work for projects that are short in duration, for example, less than four months. It will take time to spot trends and by the time a trend has developed in a four-month project, the project is over.

What else can we do to manage our budget and schedule more effectively? Here are a few tips.

- Place some milestones in your schedule (e.g. date for contract award, date for 1st phase design review, etc.). If you can meet key milestones, you are probably tracking your schedule fairly well.
- Cash flow diagrams (Figure 3) can be helpful if you have taken the time to determine what you should be spending for each month of your project. This allows comparison of actual vs. planned spending.

As an example of how to use the earned value formulas to assess a project, the following table (next page) represents two actual projects that used earned value analysis to monitor progress:



Project 1 Metrics: (total project budget = $7-M)

	Cost Variance	CPI	Schedule Variance	SPI
Design	($16,557)	0.98	$1,850	1.0
Construction	(28,230)	0.87	($3,600)	.98
Equipment	$1,980,000	1.1	$27,600	1.01
Other activities	N/A	N/A	N/A	N/A
Total Project	($25,600)	0.92	$44,440	1.01

Discussion of Project 1

The above table represents a project that had an estimated budget of around $7-million dollars. The numbers, for the date the evaluation was performed, are pretty good. The only metric that should be watched more closely is the Construction CPI (0.87). This shows the cost is starting to run over what they had planned at this date. It is quite possible that the numbers next month will be more favorable (i.e. closer to 1.0). The key point is the metrics act as a flag to alert management to be on guard for this particular group of activities. The CPI numbers 0.92 and 0.98 are close enough to 1.0 to be considered acceptable. Schedule activities appear to be on track.

Project 2 Metrics: (total budget = $55-M)

	Cost Variance	CPI	Schedule Variance	SPI
Design	$183,651	1.07	$408,170	1.16
Construction	$160,000	1.07	($10,100,000)	0.24
Equipment	($2,540,000)	1.05	($2,500,000)	0.82
Other activities	N/A	N/A	N/A	N/A
Total Project	$1,183,300	1.05	($2,365,000)	0.50

Discussion of Project 2

This project is in trouble. Note that the overall budget is around $55-million dollars. Therefore, a cost variance of negative $2.5 million—while significant—is not a large percentage in terms of overall project expenditures. The CPI numbers indicate that costs are tracking well; however, we are far behind schedule on all activities except design. Keep in mind that the only way to catch up is usually to add resources and dollars: jeopardizing the budget. Therefore, this project is seriously behind schedule now and has a very strong probability of exceeding the budget later. This one should send up red flags requiring corrective action and monitoring more closely.

Note: Some numbers/categories in the above tables have been deleted to keep the client anonymous.

Summary

The use of schedule and cost variance analysis is a useful tool to spot trends over time and help the engineering or project manager track project metrics. The key advantage is that trends will develop early in a project giving him or her time to take corrective action and avoid surprises at the end. The cost/schedule analysis formulas are summarized below:

Summary of Earned Valued Formulas

Variance

Cost variance = EV - AC

Schedule Variance = EV - PV

Performance Indices

$$CPI = \frac{EV}{AC}$$

$$SPI = \frac{EV}{PV}$$

Estimate at Completion

$$EAC = \text{\$ Amount Spent} + \frac{\text{\$ Amount Left}}{CPI}$$

PV = Budgeted cost of work scheduled
EV = Budgeted cost of work performed
AC = Actual cost of work performed
EAC = Estimate at completion
CPI = Cost performance index
SPI = Schedule performance index

It is desired to have CPI and SPI equal to or greater than 1.0

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