Integrating Cost and Schedule Control to Measure Work Performance

A well-known joke in project management circles states that the last 10 percent of a project typically takes 50 percent of the effort. We often encounter projects that are stuck at the 90 percent mark for months. It happens so frequently that I have given it a special name: the 90 percent hang-up. The problem is not that project staff are suddenly encountering insurmountable obstacles; rather, it is that the reporting on the amount of work achieved has been incorrect. On most projects, staff do not know how to measure work performance effectively.

Perhaps the most important control information project managers have is data on the amount of work that has been done. If they do not know how much work they have accomplished, they cannot really know whether they are overspending or underspending or whether they are near to meeting their schedule objectives. Effective project control requires that project organizations generate accurate measures of work performance.

Traditionally, work performance data are collected by having project staff report on "percentage of task completed" month by month. Staff are usually left to interpret what this means. Most ...
mate the percentage completed on the basis of gut feeling. I call this
the "dartboard school" of work performance measurement, since one
has the sense that the data are chosen by throwing darts at a board.
Their reliability is low. It is likely that five people reporting on the per-
centage of work completed will offer five different assessments.

Occasionally, staff may review their budget expenditures and re-
port the percentage of budget spent as their estimate of work com-
pleted. Unfortunately, in the real world of project management, the
correlation between money spent and work done is weak, so this is
not a good measure. Furthermore, with this approach, project staff
are not providing new insights to the organization, since the ac-
counting department already knows how much of the budget has been
spent.

So how does one measure work performance? This question is the
key concern of this chapter. As we shall see, the answer centers on the
concepts of earned value and integrated cost and schedule control.

A GRAPHICAL APPROACH TO INTEGRATED
COST AND SCHEDULE CONTROL

The interpretation of cost and schedule variance data must be under-
taken cautiously. If the project accounts show that we have a positive
cost variance of 10 percent in March, we should not jump to the con-
clusion that we have saved money. Perhaps the positive variance re-
flects the fact that we have not done much work. If we have not done
the job, we have not spent our money. Similarly, a negative variance
of 10 percent does not necessarily mean that we have overspent. It may
reflect the fact that we did more work than planned in March.

Common sense suggests that to have an accurate perception of
project status, we should look at cost and schedule variances concur-
rently. A 10 percent positive cost variance actually reflects a true sav-
ings if we are on or ahead of schedule. A negative 10 percent cost
variance indicates overspending if we are slipping our schedule or even
if we are on schedule.

An effective way to examine cost and schedule variance is to use
cumulative cost curves (also called S-curves) and Gantt charts. Em-
ployment of these control tools allows staff and managers to assess
overall project status at a glance. This is seen in Figure 13.1, which em-
plants Gantt charts and cumulative cost curves to illustrate three dif-
erent scenarios. The Gantt chart in part (a) of the figure shows that
the project is fundamentally on schedule, and the cumulative cost curve shows that money is being spent in conformance with the budget. This reflects a situation where progress appears to be going according to the plan.

Part (b) of the figure shows that tasks are being accomplished earlier than planned. At the same time, more money is being spent than budgeted in the time period under review. This reflects a situation of "crashing," in which extra resources are thrown into a project to either maintain or accelerate schedule.

Part (c) of the figure shows the worst possible situation. The project is experiencing both schedule slippage and a cost overrun.
The beauty of the simultaneous use of Gantt charts and cumulative cost curves is that managers can determine at a glance what their project status is. Furthermore, integrated cost and schedule control portrayed through graphical means is an effective communication tool. As such, it can be employed to report project status both to upper management and project staff in a way that is easy to understand. Another advantage of the graphical approach is that today’s project scheduling packages typically generate good-looking cost and schedule charts so that producing the graphics is no problem.

The principal deficiency of the graphical approach is that it is cumbersome from an analytical perspective. The graphs provide a visual impression of project status. By themselves, they do not offer other important information, such as the rate at which the budget is being spent vis-à-vis the amount of work being accomplished, the contribution of individual tasks to budget and schedule performance, or the percentage of the work that has been carried out. In addition, on projects of moderate or substantial size, the number of Gantt and cost curves that must be generated can be overwhelming.

Next we will examine an analytical approach to reviewing budget and schedule status called the earned value management (EVM) method. It is one of the cleverest techniques developed in the arena of management. Although it originated in the late 1960s, its early use was exclusively in large defense programs. Today, project managers have discovered that it can be usefully employed in small projects as well as large ones, and its popularity on projects of all sizes is growing rapidly.

THE 50-50 RULE FOR MEASURING WORK PERFORMANCE

Here we introduce the earned value approach by examining one method cost accountants have developed to measure work performance, the 50-50 rule.

Using the 50-50 rule is quite straightforward. At the moment a task begins, we assume we have achieved half its value, where value is measured by the budgeted cost of the task. Thus for a $1,000 budgeted task, we assume that $500 in work has been accomplished the moment the task begins. We do not assume that the full value of the work has been achieved until the task actually ends. Thus once our hypothetical $1,000 task has been completed—whether it is completed early, late, or on time—we say we have achieved $1,000 worth of work.
The utility of the 50-50 rule in measuring work performance can be seen in Figure 13.2, which presents the Gantt chart for a very simple four-task project. To keep the arithmetic simple, each task has a budgeted value of $100.

Task A begins on time, and when it begins, we assume that we have accomplished $50 in work. Task 1 finishes on schedule, and upon its completion, we note that the full $100 value of the task has been achieved.

Task B begins on time, so we assume that we have done $50 of work. At the time of its scheduled finish, work remains to be done, so we do not close the books on it. We note that the task has achieved its full $100 value only when it has been completed.

Task C begins late. We do not indicate the accomplishment of any work until the task actually begins. At that time, we note the achievement of $50 in work. The task slips its deadline. Not until it actually finishes do we state that it has achieved its full $100 value.

Finally, we see that task D begins late and that it is still incomplete. Consequently, we report that it has achieved only half its $100 value, or $50.

In making a status report, we compute that as of today, we have achieved $350 worth of work out of a planned $400 of effort. The measure of the $350 of work performed is called earned value. The

![Figure 13.2. The 50-50 Rule in Action.](image-url)
Integrating Cost and Schedule Control to Measure Performance

The fact that $350 of work out of a planned $400 of work has been achieved suggests that we have reached 87.5 percent of our target.

Note that we have said nothing about how much it cost us to accomplish our work. Let's assume that a tally of time sheets and invoices tells us that we spent $700 to achieve $350 of work. Thus for each dollar actually spent, we attained 50 cents of value. If this project has a $10,000 total budget and if we continue to get 50 cents of value for each dollar spent, the final cost of this project will reach $20,000!

This simple example demonstrates the power of the earned value approach. It gives us a method for calculating the percentage of the job that has been achieved. It also lets us measure the "burn rate" of our expenditures, thus allowing us to calculate the budget impact of our performance. Earned value computations can be carried out at any level of the work breakdown structure (WBS): we can examine project performance from the perspective of the whole project down to the level of individual work packages (that is, the lowest level of the WBS). In other words, the earned value approach allows us to conduct integrated cost and schedule control analyses analytically, in contrast to the graphical approach discussed earlier.

OTHER WAYS TO CALCULATE EARNED VALUE

There are several ways to calculate earned value beyond the 50-50 rule. Data processing personnel tend to be very conservative. To them, the 50-50 rule is recklessly optimistic because it is based on the premise that the work is half-finished the moment it is begun. Anyone who has written software code realizes that half-finished software has no value. Consequently, they employ the 0-100 rule in calculating earned value. When a task begins, it is not assumed that anything has been accomplished. Only when the task has been completed is it given its full value. In the example shown in Figure 13.2, the total earned value as of today using the 0-100 rule is $300. This means that the project has achieved only 75 percent of its target.

The favored way to calculate earned value is to make computations based on historical experience. I will illustrate this with a simplified example of a company that assembles computers. The assembly process involves five steps. First, auxiliary memory chips are installed on the motherboard. Experience suggests that when this step is complete, the assembly process has reached the 25 percent mark. Then the
motherboard is installed in the chassis (the 30 percent mark). After this, a hard drive is installed in the hard drive slot (the 70 percent mark). All cables are linked to their appropriate connectors (the 85 percent mark), and then the chassis is slipped into the computer housing (the 100 percent mark).

To calculate earned value status each month, a tabulation is made of the number of computers found at each stage of the assembly process, and a weighted average is computed estimating the total value of work achieved during the month. For example, suppose that the work value of a complete assembly operation is $100. If during the review of work in progress it is found that five computers have had auxiliary memory installed (the 25 percent mark), the value of work achieved for these computers is $100 times 5 times 0.25, or $125. If another two computers have just had the motherboards installed in the chassis (the 30 percent mark), the value of work achieved for these computers is $100 times 2 times 0.30, or $60. The value of work completed for all seven computers is $125 plus $60, or $185.

Calculating earned value based on gut feeling is not forbidden but is the least preferred approach. In this case, a task leader might guess that she has achieved 85 percent of her $1,000 assigned effort, indicating that she has accomplished an earned value of $850 worth of work.

A NEW LOOK AT COST AND SCHEDULE VARIANCE

The traditional approach to measuring cost variance has been to subtract actual costs from planned costs. A negative variance suggests that more has been spent than planned; a positive variance indicates that less has been spent than planned. For example, suppose that for the month of March, we planned to spend $1,000 but actually spent $900. This would yield a positive cost variance of $100. As we saw earlier, this cost variance cannot be interpreted meaningfully by itself. It must be examined in conjunction with information on schedule status.

With the earned value approach, we take a different tack to calculating cost variance. It is computed by subtracting actual costs from earned value. Staying with the example in the preceding paragraph, if earned value is computed to be $850, cost variance will be $850 minus $900, or –$50. This means that we paid $900 to do $850 worth of work. For the work we have done, we have overspent by $50. Note that cost variance here is being assessed against the value of the work.
that has been performed. In this case, it is not necessary to look at the Gantt chart to determine that we have overspent our money. By itself, the cost variance data indicate that we have spent too much. Any negative cost variance figure suggests overspending, and positive cost variance indicates cost saving.

Schedule variance is defined as earned value minus planned cost. In our example, this is $850 minus $1,000, or $-150. In words, this says that although we were supposed to have achieved $1,000 in work, we accomplished only $850, resulting in a work shortfall valued at $150.

Note that schedule variance is being measured in monetary units, not time units. This may seem peculiar at first because people normally think of schedules in the context of time. However, the logic of the approach takes on meaning when we realize that earned value measures work performance and that when less work is performed than planned, schedule slippages ensue.

The viability of earned value in measuring schedule variance is seen clearly when earned value schedule variance is mapped to the Gantt chart. This is illustrated in Figure 13.3.

The Gantt chart in part (a) of Figure 13.3 shows a two-task project that is experiencing schedule slippage. The first task (valued at $700) is complete, but the second task (valued at $300) is only half complete. Although the planned amount of effort to be accomplished is $1,000, earned value is only $850. Schedule slippage is thus $850 minus $1,000, or $-150. In general, a negative schedule variance figure indicates schedule slippage and reflects a Gantt chart that shows such slippage, whether the Gantt chart has two tasks, twenty tasks, or two hundred tasks!

Part (b) of the figure shows a project on which the planned work has been achieved. As of today, $1,000 in work was supposed to have been accomplished, and $1,000 in work has actually been finished. Schedule variance is $1,000 minus $1,000, or 0. In general, a zero variance indicates that the planned effort has been accomplished.

Part (c) of the figure shows a project on which work has been accelerated so that more work has been accomplished as of today than originally planned. The first task (valued at $700) is finished early, so work on the second task begins. This second task (valued at $300) is also finished early, so work on the third task (valued at $200) begins early. As of today, $1,200 of work was supposed to have been accomplished, whereas $1,200 has actually been achieved. Schedule variance is $1,200 minus $1,000, or $200. In general, a positive schedule
variance indicates that more work has been accomplished than planned.

Integrated cost and schedule control occurs when cost and schedule variances are examined concurrently. This is done in Table 13.1, which shows seven different cost and schedule variance scenarios that might be encountered. On project A, cost and schedule targets have been achieved, yielding zero cost and schedule variances. On project
Table 13.1. Cost and Schedule Variance Scenarios.

<table>
<thead>
<tr>
<th></th>
<th>Planned Cost</th>
<th>Actual Costs</th>
<th>Earned Value</th>
<th>Cost Variance</th>
<th>Schedule Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project A</td>
<td>$800</td>
<td>$800</td>
<td>$800</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Project B</td>
<td>800</td>
<td>800</td>
<td>600</td>
<td>-200</td>
<td>-200</td>
</tr>
<tr>
<td>Project C</td>
<td>800</td>
<td>600</td>
<td>1000</td>
<td>200</td>
<td>200</td>
</tr>
<tr>
<td>Project D</td>
<td>800</td>
<td>1000</td>
<td>1000</td>
<td>0</td>
<td>200</td>
</tr>
<tr>
<td>Project E</td>
<td>800</td>
<td>600</td>
<td>800</td>
<td>200</td>
<td>0</td>
</tr>
<tr>
<td>Project F</td>
<td>800</td>
<td>1200</td>
<td>1000</td>
<td>-200</td>
<td>200</td>
</tr>
<tr>
<td>Project G</td>
<td>800</td>
<td>400</td>
<td>600</td>
<td>200</td>
<td>-200</td>
</tr>
</tbody>
</table>

B, the value of work performed ($600) is less than what was planned ($800). In addition, the actual cost of this work ($800) was greater than the value achieved. Thus project B has experienced a cost overrun and a schedule slippage. The other projects can be examined in like fashion.

A NEW VOCABULARY

One of the confusing features of the fully developed earned value approach is that it has its own terminology that does not reflect the commonsense understanding of words. I find when teaching the earned value approach that students spend more energy trying to master the vocabulary than they do mastering the concepts.

In the earned value approach, planned cost is called budgeted cost of work scheduled (BCWS). Actual cost is called actual cost of work performed (ACWP). Both BCWS and ACWP correspond exactly to traditional understandings of the meanings of planned and actual cost, respectively. Earned value itself is called budgeted cost of work performed (BCWP).

Using this new vocabulary, we define schedule variance (SV) as

\[ SV = BCWP - BCWS \]

We define cost variance (CV) as

\[ CV = BCWP - ACWP \]
The portion of a job achieved, which is called the \textit{schedule performance index} (SPI), is computed as

\[
SPI = \frac{BCWP}{BCWS}
\]

The "burn rate" at which we are spending money—it can also be interpreted as an efficiency rate—is called the \textit{cost performance index} (CPI) and is computed as

\[
CPI = \frac{BCWP}{ACWP}
\]

The estimate of final project cost is called \textit{estimate at completion} (EAC) and is computed as

\[
EAC = \frac{BAC}{CPI}
\]

where BAC stands for \textit{budgeted at completion}, which is the total budgeted value of the project. EAC allows us to forecast final project costs on the basis of the efficiency with which work performance is achieved for each dollar actually spent. If a project is budgeted to cost $500,000 (that is, BAC = $500,000) and 80 cents of work is being generated for each dollar spent (that is, CPI = 0.8), the final estimated cost of the project will be $500,000 divided by 0.8, or $625,000 (that is, EAC = $625,000).