Project costs augmented by project monitoring can be used to generate forecasts of future costs.

Cost charts become much more useful if we add projected future costs calculated by adding the estimated costs of uncompleted work to the costs already incurred. Where a computer-based planning tool is used, revision of cost schedules is generally provided automatically once actual expenditure has been recorded. Figure 9.9 illustrates the additional information available once the revised cost schedule is included – in this case it is apparent that the project is behind schedule and over budget.

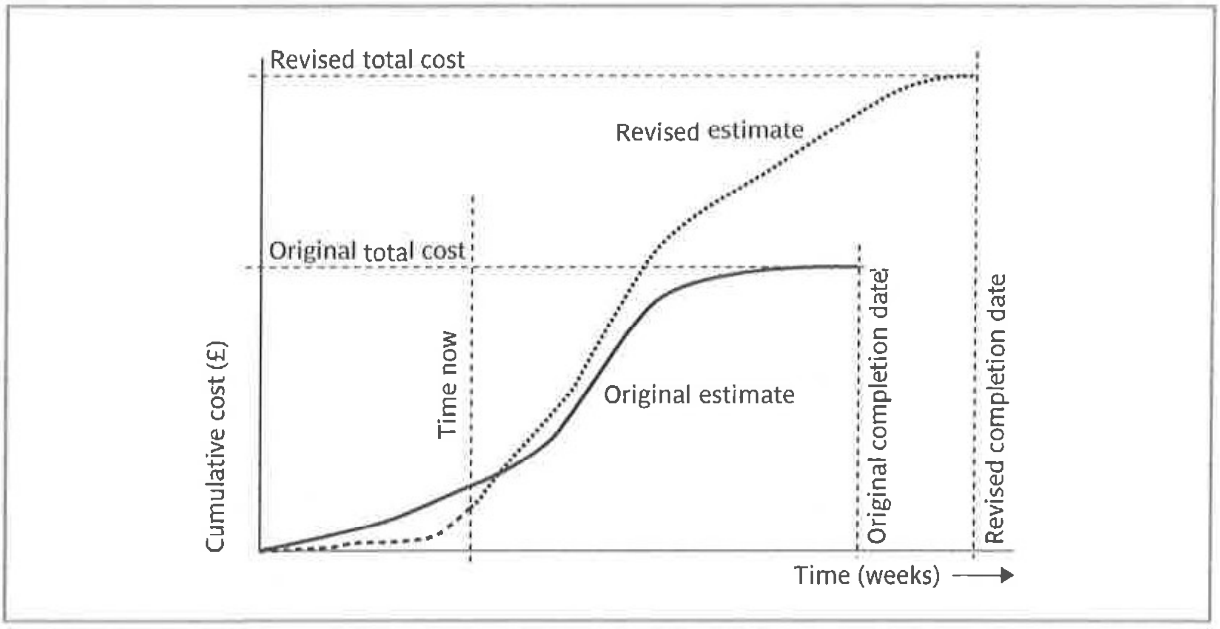

FIGURE 9.9 The cumulative expenditure chart can also show revised estimates of cost and completion date

9.6 Earned value analysis

Earned value analysis, also known as budgeted cost of work performed, is recommended by a number of agencies including the US and Australian departments of defence. It is also recommended in BS 6079.

Earned value analysis has gained in popularity in recent years and may be seen as a refinement of the cost monitoring discussed in the previous section. It originated in the USA's Department of Defense (DOD) as a part of a set of measures to control projects being carried out by contractors for the DOD. Earned value analysis is based on assigning a 'value' to each task or work package (as identified in the WBS) based on the original expenditure forecasts. One way of looking at this is as the equivalent of the price that might be agreed by a contractor to do the unit of work. The assigned value is the original budgeted cost for the item and is known as the *planned value* (PV) or *budgeted cost of work scheduled* (BCWS). A task that has not started is assigned an earned value of zero and when it has been completed, it, and hence the project, is credited with the original planned value of the task. The total value credited to a project at any point is known as the *earned value* (EV) or budgeted cost of work performed (BCWP) and this can be

represented as a money value, an amount of staff time or as a percentage of the PV. EV is thus analogous to the agreed price to be paid to the contractor once the work is completed.

Where tasks have been started but are not yet complete, some consistent method of assigning an earned value must be applied. Common methods in software projects are:

- *the 0/100 technique:* where a task is assigned a value of zero until such time that it is completed when it is given a value of 100% of the budgeted value;
- *the 50/50 technique:* where a task is assigned a value of 50% of its value as soon as it is started and then given a value of 100% once it is complete – this matches some contractual arrangements where a contractor is given half the agreed price when starting the work, perhaps to help pay for raw materials, and the remainder on successful completion;
- *the 75/25 technique:* where the task is assigned 75% on starting and 25% on completion – this is often used when a large item of equipment is being bought: 75% is paid when the equipment is actually delivered and the remainder when installation and testing has been satisfactorily completed;
- *the milestone technique:* where a task is given a value based on the achievement of milestones that have been assigned values as part of the original budget plan;
- *percentage complete:* in some cases there may be a way of objectively measuring the amount of work completed – for example, as part of the implementation of an information system, a number of data records have to be manually typed into a database and the actual number so far completed can be objectively counted.

Of these, we prefer the 0/100 technique for software development. The 50/50 technique can give a false sense of security by over-valuing the reporting of activity starts. The milestone technique might be appropriate for activities with a long duration estimate but, in such cases, it is better to break that activity into a number of smaller ones.

The baseline budget

The first stage in setting up an earned value analysis is to create the *baseline budget*. The baseline budget is based on the project plan and shows the forecast growth in earned value through time. Earned value may be measured in monetary values but, in the case of staff-intensive projects such as software development, it is common to measure earned value in person-hours or workdays. Amanda's baseline budget, based on the schedule shown in Figure 8.7, is shown in Table 9.2 and diagrammatically in Figure 9.10. Notice that she has based her baseline budget on workdays and is using the 0/100 technique for crediting earned value to the project.

Amanda's project is not expected to be credited with any earned value until day 34, when the activity 'specify overall system' is to be completed. This activity was forecast to consume 34 person-days and it will therefore be credited with 34 person-days of earned value when it has been completed. The other steps in the baseline budget chart coincide with the scheduled completion dates of other activities.

Task	Budgeted workdays	Scheduled completion	Cumulative workdays	% cumulative earned value
Specify overall system	34	34	34	14.35
Specify module B	15	49	64	27.00
Specify module D	15	49		
Specify module A	20	54	84	35.44
Check specifications	2	56	86	36.28
Design module D	4	60	90	37.97
Design module A	7	63	97	40.93
Design module B	6	66	103	43.46
Specify module C	25	74	128	54.01
Check module C spec	1	75	129	54.43
Design module C	4	79	133	56.12
Code and test module D	25	85	158	66.67
Code and test module A	30	93	188	79.32
Code and test module B	28	94	231	97.47
Code and test module C	15	94		
System integration	6	100	237	100.00

TABLE 9.2 Amanda's baseline budget calculation

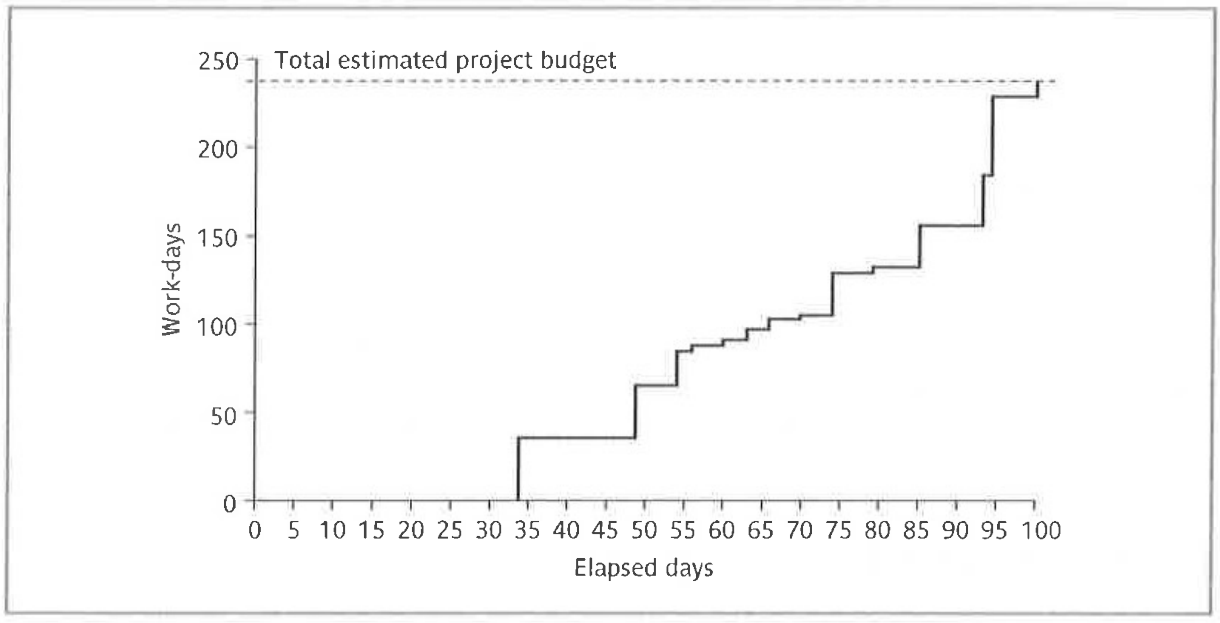

FIGURE 9.10 Amanda's baseline budget

Monitoring earned value

Having created the baseline budget, the next task is to monitor earned value as the project progresses. This is done by monitoring the completion of tasks (or activity starts and milestone achievements in the case of the other crediting techniques).

EXERCISE 9.3

Figure 9.11 shows Amanda's earned value analysis at the start of week 12 of the project. Note that here both PV and EV are measured in 'work-days' and that the 0/100 rule is being applied. The earned value (EV) is clearly lagging behind the baseline budget, indicating that the project is behind schedule.

By studying Figure 9.12, can you tell exactly what has gone wrong with her project and what the consequences might be?

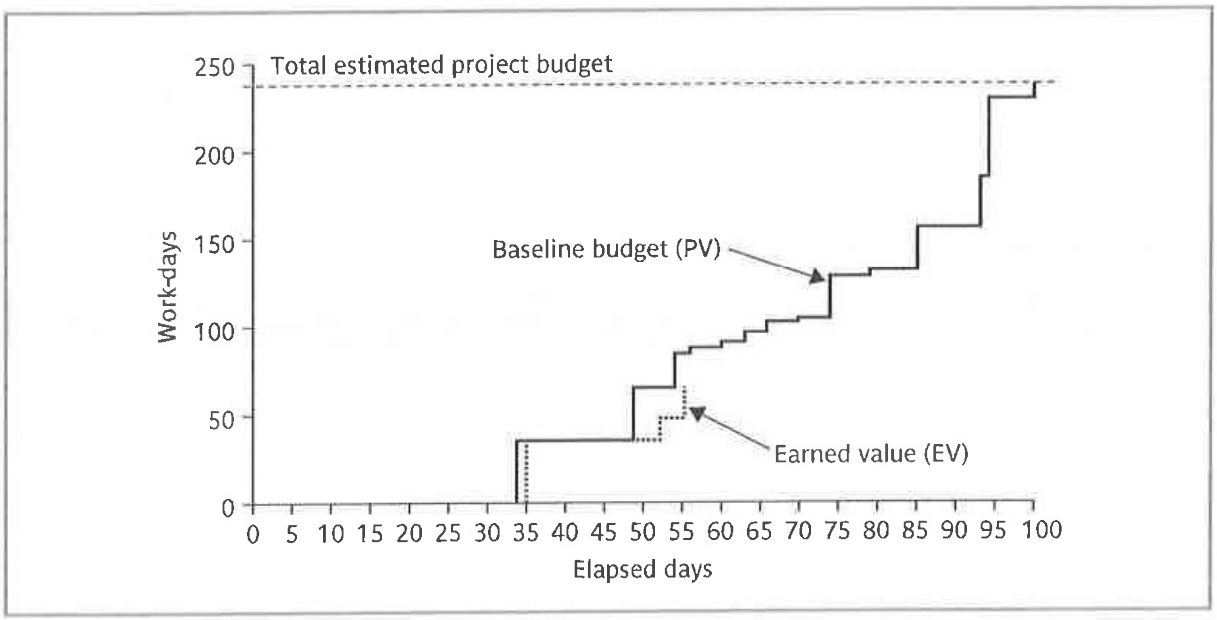

FIGURE 9.11 Amanda's earned value analysis at week 12

As well as recording EV, the actual cost of each task can be collected as *actual cost* (AC). This is also known as the *actual cost of work performed* (ACWP). This is shown in Figure 9.12, which, in this case, records the values as percentages of the total budgeted cost.

Figure 9.12 also illustrates the following performance statistics, which can be shown directly or derived from the earned value chart.

Schedule variance (SV)

The schedule variance is measured in cost terms as EV – PV and indicates the degree to which the value of completed work differs from that planned. Say, for example, that

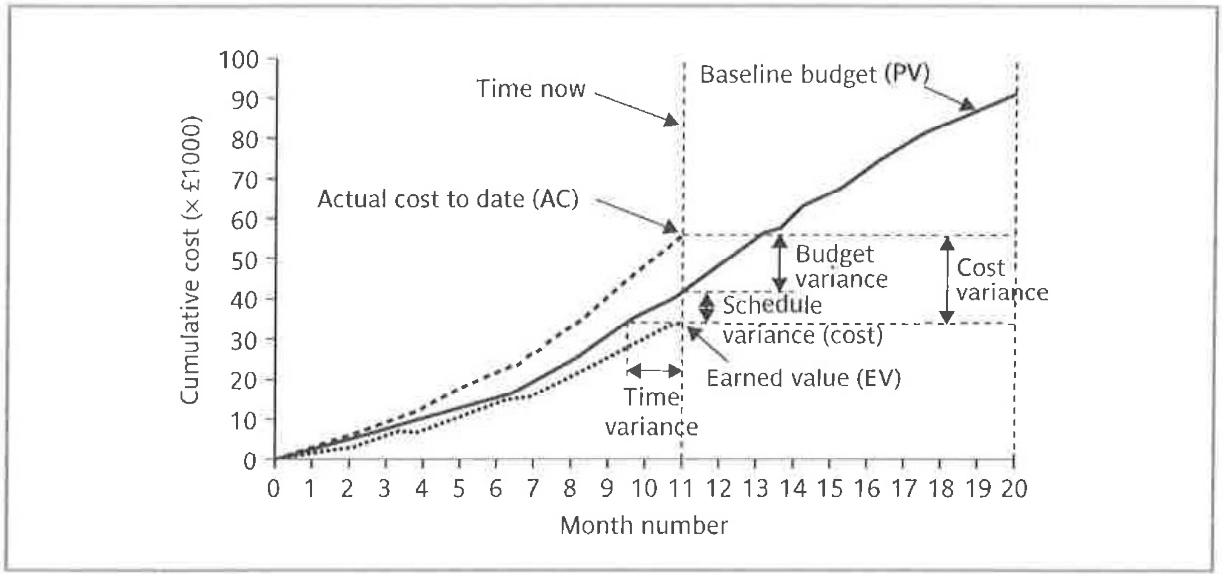

FIGURE 9.12 An earned value tracking chart

work with a PV of £40,000 should have been completed by now. In fact, some of that work has not been done so that the EV is only £35,000. The SV would therefore be £35,000 – £40,000, that is –£5,000. A negative SV means the project is behind schedule.

Time variance (TV)

Figure 9.12 also indicates the *time variance* (TV). This is the difference between the time when the achievement of the current earned value was planned to occur and the time now. In this case, the current EV should have been achieved in the early part of month 9 and as the time now is the end of month 11, the TV is about –1.75 months.

Cost variance (CV)

This is calculated as EV – AC and indicates the difference between the earned value or budgeted cost and the actual cost of completed work. Say that when the SV above was calculated as –£5,000, £55,000 had actually been spent to get the EV. The CV in this case would have been £35,000 – £55,000 or –£20,000. It can also be an indicator of the accuracy of the original cost estimates. A negative CV means that the project is over cost.

Performance ratios

Two ratios are commonly tracked: the cost performance index (CPI = EV/AC) and the schedule performance index (SPI = EV/PV). Using the examples above, CPI would be £35,000/£55,000, that is, 0.64, and SPI would be £35,000/£40,000, that is, 0.88. The two ratios can be thought of as a 'value-for-money' indices. A value greater than one indicates

that work is being completed better than planned, whereas a value of less than one means that work is costing more than and/or proceeding more slowly than planned.

CPI can be used to produce a revised cost estimate for the project (or *estimate at completion* – EAC). EAC is calculated as BAC/CPI where BAC (budget at completion) is the current projected budget for the project. If the BAC was £100,000 then a revised estimate at completion (EAC) would be £100,000/0.64 or £156,250. Similarly, the current SPI can be used to project the possible duration of the project given the current rate of progress. Say the planned total duration for the project is 23 months – in earned value terminology this is the *schedule at completion* (SAC). A time estimate at completion (TEAC) can be calculated as SAC/SPI. In this case it would be 23/0.88, that is, 26.14 months. This is only an approximate guide: where there are several parallel chains of activities being carried out concurrently – as we saw in Chapter 6 – the project duration will depend on the degree to which the activities that have been delayed are on the critical path.

In the same way that the expenditure analysis in Figure 9.8 was augmented to show revised expenditure forecasts, we can augment the simple earned value tracking chart with forecasts as illustrated in Figure 9.13.

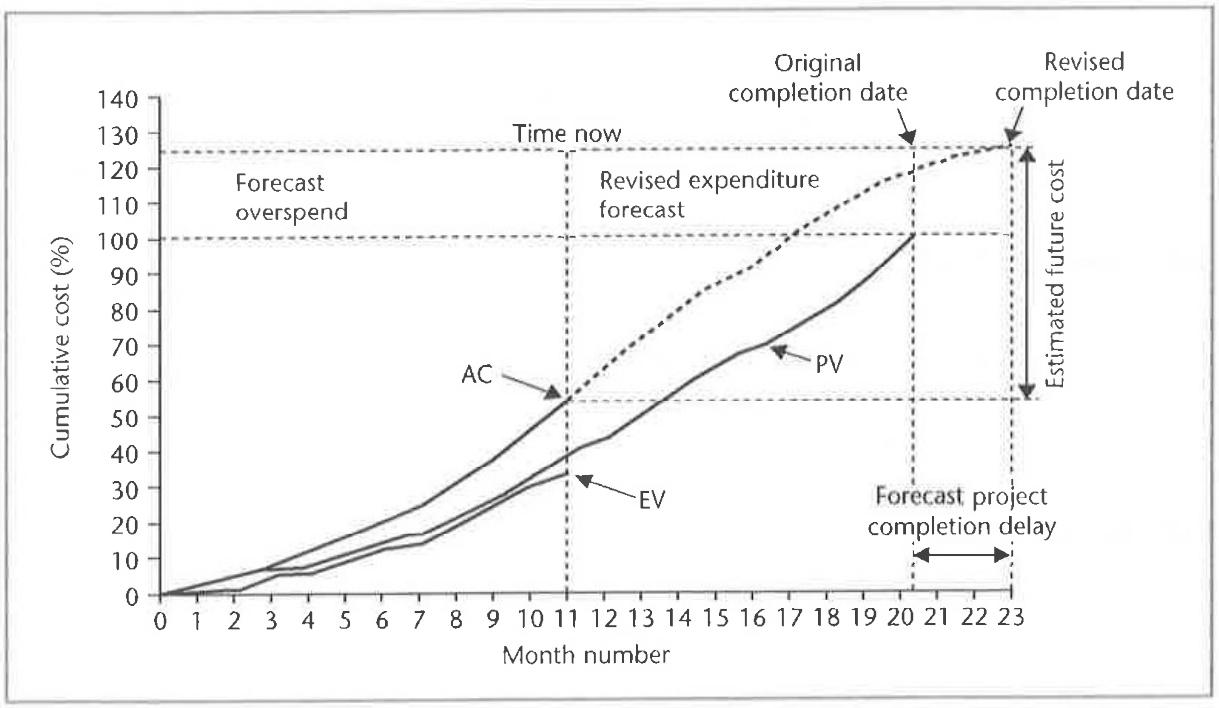

FIGURE 9.13 An earned value chart with revised forecasts

Earned value analysis has not yet gained universal acceptance for use with software development projects, perhaps largely because of the attitude that, whereas a half-built house has a value reflected by the labour and materials that have been used, a half-completed software project has virtually no value at all. This is to misunderstand the purpose of earned value analysis, which, as we have seen, is a method for tracking what has been achieved on a project – measured in terms of the budgeted costs of completed tasks or products.