CHAPTER 7

PROJECT CONTROL

The limited objective of project control deserves emphasis. Project control procedures are primarily intended to identify deviations from the project plan rather than to suggest possible areas for cost savings. This characteristic reflects the advanced stage at which project control becomes important. The time at which major cost savings can be achieved is during planning and design for the project. During the actual construction, changes are likely to delay the project and lead to inordinate cost increases. As a result, the focus of project control is on fulfilling the original design plans or indicating deviations from these plans, rather than on searching for significant improvements and cost savings. It is only when a rescue operation is required that major changes will normally occurring in the construction plan.

7.1 Problems that may Arise During Construction

In construction, no project, almost, is executed as planned. Control needs to be carried-out due to the dynamic nature of the construction process. Controlling after project finish is trivial and updates are usually done periodically. Controlling can be done for project schedule and/or project cost. As the construction stage of project starts, the project mostly will face delays and/or cost overruns. The following is a list of the factors that may cause such problems:

- Change in activity durations and quantities.
- Sudden changes of the availability of resources.
- Change orders.
- Accidents.
- Procurement delays.

7.2 Schedule Updating

Construction typically involves a deadline for work completion, so contractual agreements will force attention to schedules. More generally, delays in construction represent additional costs due to late facility occupancy or other factors. Just as costs incurred are compared to budgeted costs, actual activity durations may be compared to expected durations. In this process, forecasting the time to complete particular activities may be required.

It is important to devise efficient and cost effective methods for gathering information on actual project accomplishments. Generally, observations of work completed are made by inspectors and project managers and then work completed is estimated. Once estimates of work complete and time expended on particular activities are available, deviations from the original duration estimate can be estimated.

For example, Figure 7.1 shows the originally scheduled project progress versus the actual progress on a project. This figure is constructed by summing up the percentage of each activity which is complete at different points in time; this summation can be weighted by the magnitude of effort associated with each activity. In Figure 7.1, the project was ahead of the original schedule for a period including point A, but is now late at point B by an amount equal to the horizontal distance between the planned progress and the actual progress observed to date.

In evaluating schedule progress, it is important to bear in mind that some activities possess float, whereas delays in activities on the critical path will cause project delays. In particular, the delay in planned progress at time t may be soaked up in activities' float (thereby causing no overall delay in the project completion) or may cause a project delay. As a result of this ambiguity, it is preferable to update the project schedule to devise an accurate portrayal of the schedule adherence. After applying a scheduling algorithm, a new project schedule can be obtained.

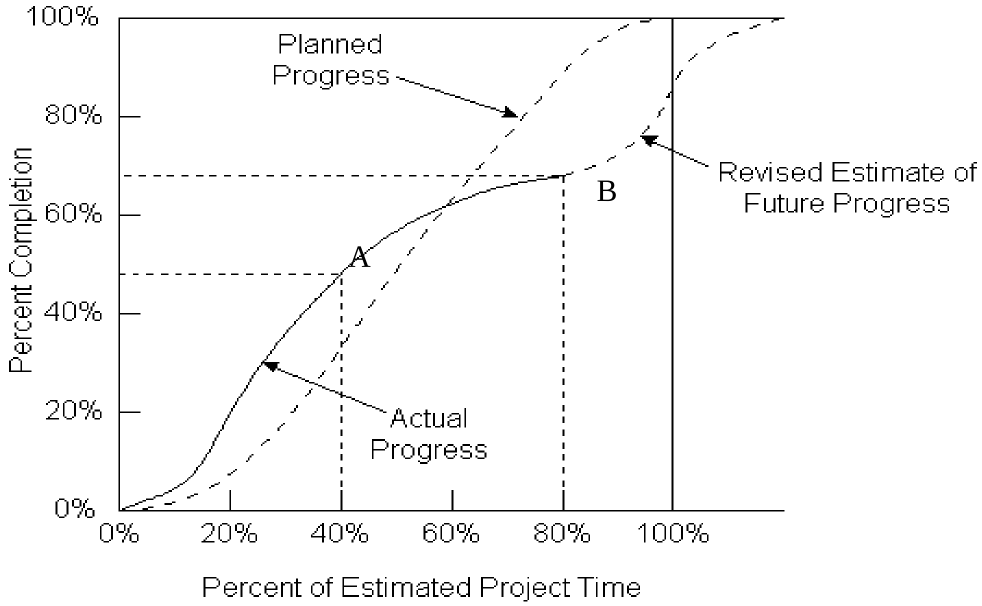

Figure 7.1: Planned versus actual progress over time on a project

It is common that actual durations of activities differ from those estimated. Furthermore, there may be additions or deletions to the scope of the contract that will affect the time at which activities can be started or completed. Schedule updating is a procedure for introducing the latest progress information into the schedule.

Data have to be collected on the actual progress of completed activities and those under execution. A completely new estimate of the amount of work remaining to be done should be made for each activity. The probable output of various resources should be assessed. If the job is found to be behind schedule, corrective actions must be made to retrieve position. A procedure for manual schedule updating can be summarized in the following steps:

-Change the duration of all completed activities to zero.

-Identify all activities on which work is currently processing as Live Activities

-Put early start time of live activities equals the updating date and their durations equal remaining duration.

-Change duration of future activities as given in the update report.

-Carry-out network analysis in the normal way and prepare a new activity schedule.

To illustrate the above hand procedure for schedule updating, consider the following example with the planning data given in Table 7.1. The corresponding precedence network along with time analysis is shown in Figure 7.2. It is evident that initial project duration is 20 weeks and the activities A, B, F, and K comprises the critical path.

Table 7.1: Planning data of the example problem

Activity	Predecessors	Duration (wks)	Overlap (wks)
A	---	2	
B	A	2	
C	A	5	
D	A	3	
E	B	2	
F	B	6	-3
G	C	6	
H	D	6	
I	D	4	-2
J	E, F	2	
K	F, G	8	3 with G
L	H	3	
M	H, I	2	

At the end of the 7th week, new filed data are collected and the project status activities is as follows:

-Activities A, B, D, and E have been completed.

-Remaining Duration of activity C is one week.

-Remaining Duration of activity H is 4 weeks.

-Activity G will not start until beginning of week 10.

-Overlap between activities K and G is one week only

-Volume of work of activity L has been increased by 33%.

-Activity J has been omitted.

The updated precedence network and the corresponding updated schedule are shown in Figure 7.3. It is shown that a new critical path is developed. The new project completion time is 21 weeks which indicates that a delay of one week is encountered. Corrective actions should be taken to improve project performance during the remaining portion.

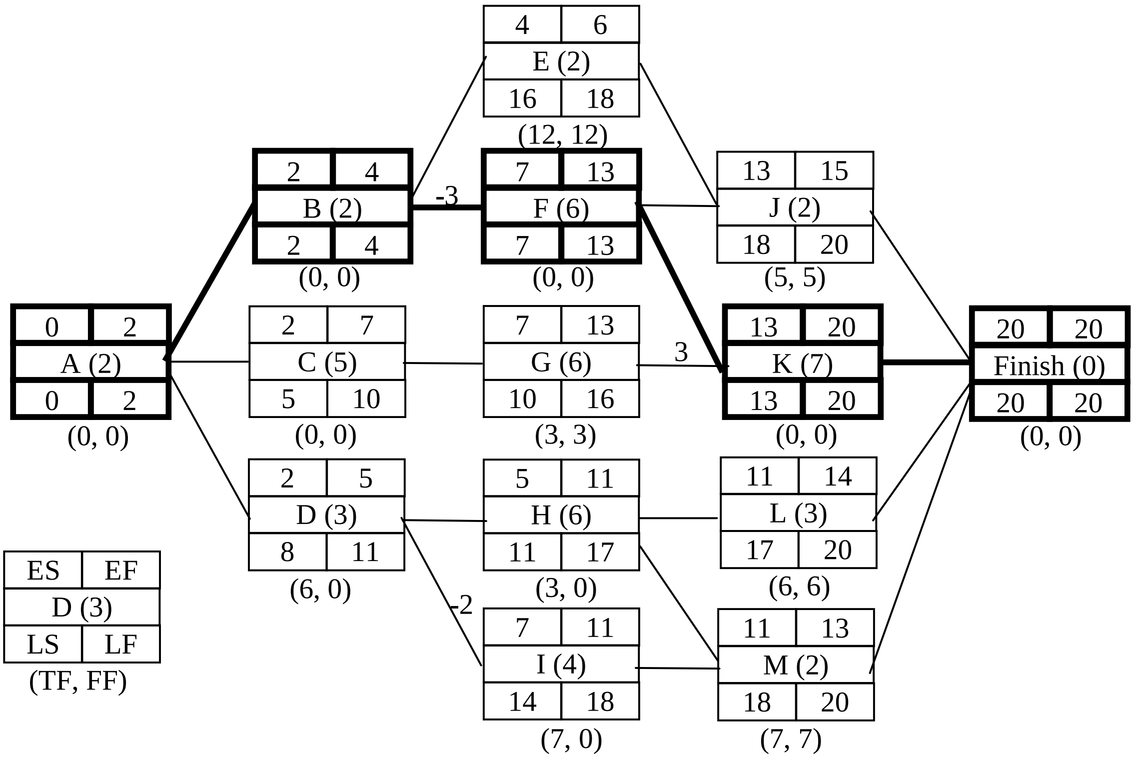

Figure 7.2: Scheduling data of the example problem

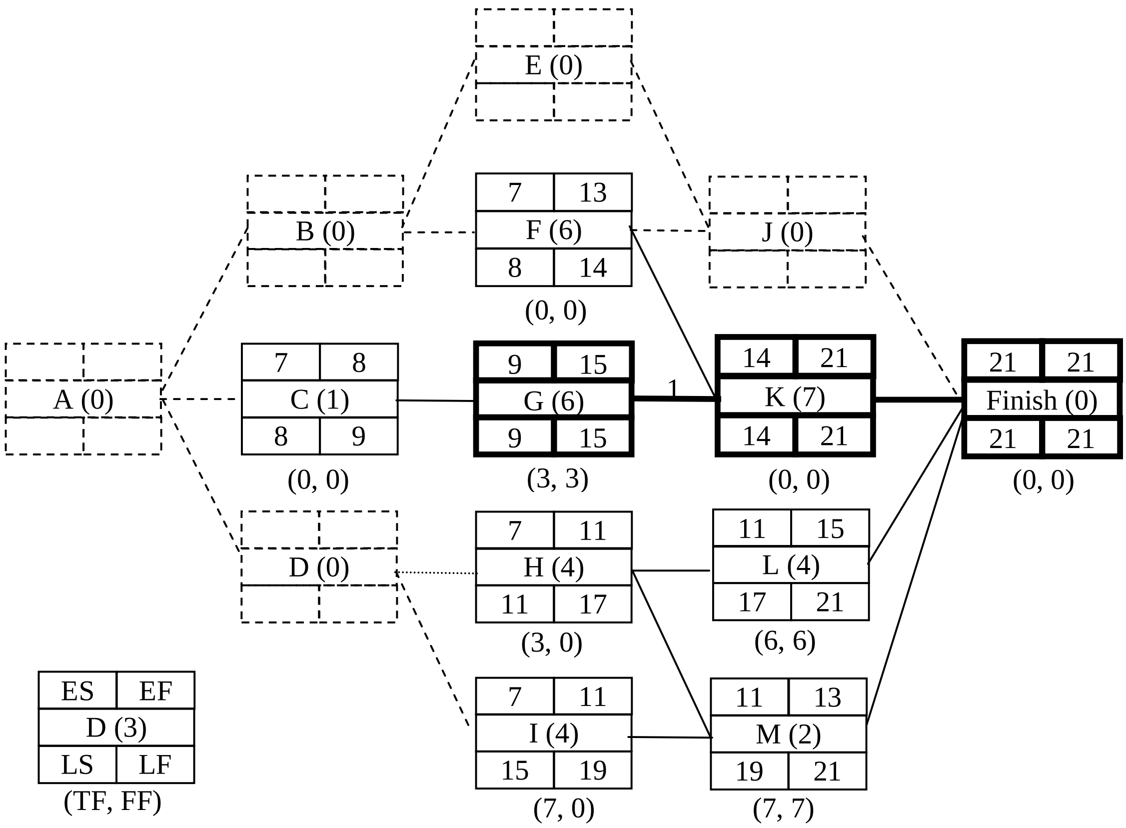

Figure 7.3: Updated network of the example problem

7.3 Earned Value Management

For cost control on a project, the construction plan and the associated cash flow estimates can provide the baseline reference for subsequent project monitoring and control. The final or detailed cost estimate provides a baseline for the assessment of financial performance during the project. To the extent that costs are within the detailed cost estimate, then the project is thought to be under *financial control*. Overruns in particular cost categories signal the possibility of problems and give an indication of exactly what problems are being encountered.

The key to a profitable project is to keep construction costs within the budget and to know when and where job costs are deviating. The budget determines the amount of cash that will be required over the various periods of the project. Various techniques are usually used for cost control such as S-curve method and earned value technique. Because it is the most widely used method, only earned value technique will be described next. Earned value technique involves a combination of three measures that are needed for the analysis. These measures include:

Budgeted Cost of Work Scheduled (BCWS)

BCWS measures what is planned in terms of budget cost of the work that should to place (i.e., according to the baseline schedule of the project). BCWS curve can be plotted by accumulating the budget cost of the initial schedule.

Budgeted Cost of Work Performed (BCWP) (Earned value – EV)

BCWP measures what is done in terms of the budget cost of work that has actually had been accomplished to date. BCWP curve can be plotted point by point after each reporting period. Here we accumulate the budget cost on the schedule that shows the actual percent complete.

Actual Cost of Work Performed (ACWP)

ACWP measures what is paid in terms of the actual cost of work that has actually been accomplished to date. BCWS curve can also be plotted point by point after each reporting period. Here we accumulate the actual expenditures on the schedule that shows the actual percent complete.

The significance of these three measures is that they directly indicate schedule and cost performances of the project at different reporting periods. This illustrated as shown in Figure 7.5. Using these three measures, different project performance indicators can be calculated. Among these indicators are:

Schedule Variance (SV)

it is the difference between the earned value (BCWP) and the planned budget cost (BCWS).

SV = BCWP – BCWS; SV > 0 indicates ahead of schedule

Cost Variance (CV)

it is the difference between the actual cost (ACWP) and the earned value or the budget cost (BCWP).

CV = BCWP – ACWP; CV > 0 indicates cost saving

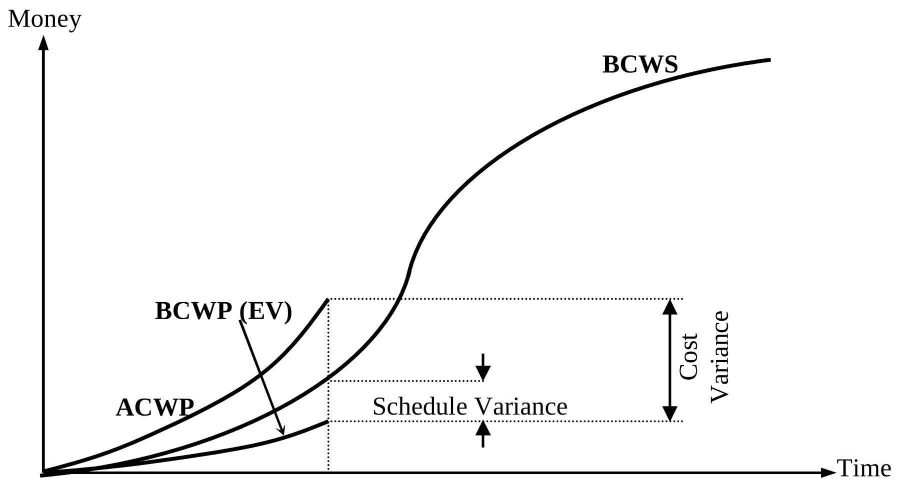

Figure 7.5: Earned value measures and indictors

These concepts are best illustrated by the example problem with the planning data given in Table 7.1. The price of each activity is given Table 7.4.The schedule of the example problem is given in Figure 7.2. At the end of week number 5, the project status is recorded as given in Table 7.4. Actual costs are also recorded as given in Table 7.5.

Table 7.4: Cost data of the example problem

Activity	A	B	C	D	E	F	G	H	I	J	K	L	M
Price (1000)	36	24	145	84	126	168	126	78	80	216	70	228	120
Actual Start	0	2	2	2	4								
Projected Completion	2	5	7	6	7								

Table 7.5: Actual cost at the end of week 5

Week	1	2	3	4	5	Total
Cost	18	18	72	72	125	305

Figure 7.6 shows the project schedule in bar chart format. The planned expenditure of each activity is assumed to be uniformly distributed over activity duration. The BCWP are calculated as shown in Figure 7.7. The weekly budgets are plotted on a cumulative basis as the BCWS are as shown in Figure 7.8. In Figure 9.8, BCWS as well as BCWP and ACWP to the end of week 5 are plotted on the same graph. It now possible to calculate schedule and cost control indicators as:

SV = 262 – 294 = -ve which indicates that the project is behind schedule.

CV = 262 – 305 = -ve which indicates that the cost is overrun

Example 7.1

A cost control report of a certain contract gives the following figures as percentages of the contract a-completion budgeted cost:

BCWP = 25% BCWS = 47% ACWP = 72%

Calculate, cost and schedule variances and comment on the status of the contract.

Solution

Cost variance (CV) = BCWP – ACWP = 25 – 72 = -47%

Schedule variance (SV) = BCWP – BCWS = 25 – 47 = -22%

The contract is behind schedule with over cost.

Act.	Budget/w	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
A	18	18	18																		
B	12			12	12																
C	29			29	29	29	29	29													
D	28			28	28	28															
E	63					63	63														
F	28								28	28	28	28	28	28							
G	21								21	21	21	21	21	21							
H	13						13	13	13	13	13	13									
I	20								20	20	20	20									
J	108														108	108					
K	10														10	10	10	10	10	10	10
L	76												76	76	76						
M	60												60	60							
	Weekly	18	18	69	69	120	105	42	82	82	82	82	185	185	194	118	10	10	10	10	10
	Cumulative	18	36	105	174	294	399	441	523	605	687	769	954	1139	1333	1451	1461	1471	1481	1491	1501

Figure 7.6: Bar chart showing budgeted expenditures (BCWS)

Act.	Budget/w	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
A	18	18	18																		
B	18			8	8	8															
C	29			29	29	29	29	29													
D	21			21	21	21	21														
E	42					42	42	42													
	Weekly	18	18	58	58	100															
	Cumulative	18	36	94	152	262															

Figure 7.7: Bar chart updated at end of week 5 (BCWP)

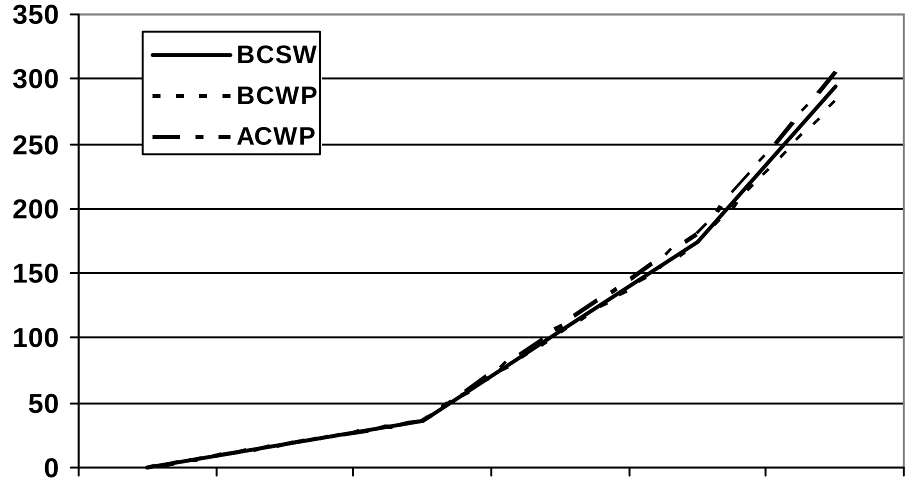

Figure 7.8: Cost curves

7.4 Exercises

1. The activities involved in the construction of one kilometer of a pipeline are given together with their estimated durations in the table below. Each of the activities will be done using a separate gang. All of them are sequential except "Excavate trench" and "String pipe" are done concurrently. The project consists of 3 similar kilometers.

Activity name	Duration (days)
(LC) Locate and clear	1
(ET) Excavate trench	5
(SP) String pipe	2
(LP) Lay pipe	6
(PT) Pressure test	1
(BF) Backfill	2

a. Prepare complete plan of the works and determine the activity schedule. Mark the critical path.

b. Assume now that the project is being constructed according to ES timings determined in "a" above. At the end of day 10, the following information is obtained from the project site:

- Activities LC were completed on schedule.
- Duration of the first part of activity ET was prolonged by 1 day but that of the second part will be the same as the original duration.
- Activities SP were completed although ES of the third part had been delayed by 3 days.
- Remaining duration of the first part of activity LP is 3 days.
- The first part of activity PT will not start until beginning of day 16.

Update your network and mark the critical path.

c. If the activities direct cost is listed as below:

Activity	Direct Cost (LE)
LC	400
ET	3000
SP	600
LP	1800
PT	200
BF	1000

The contract site overhead amounts to LE77.777/day and distributed among activities according to their relative direct costs. If the actual cumulative cost at the end of day 10 is LE9270, calculate schedule and cost performance ratios and comment on the progress of the contract.

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