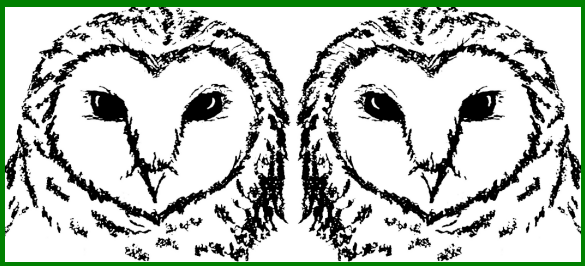
Position Paper

A QUICK OVERVIEW OF THE EARNED VALUE CONCEPT



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A QUICK OVERVIEW OF THE EARNED VALUE CONCEPT

What is earned value?...

Earned value in project work is the budgeted cost of work performed at standard or actual rates if budgets are not used. Determining earned value is a managerial accounting technique. Measuring earned value as work progresses is an essential project management technique.

This article emphasizes the earned value concept in the construction industry. However, the concept applies in many other disciplines, such as job or project-based manufacturing and systems development activities.

The budgeted cost of work performed should be based upon standard labor rates for all trades and crafts in a project, and standard estimating guidelines for time as modified by inflators or deflators for specific situations.

The labor rate used depends upon need – options include the straight time, partially loaded, fully loaded, or fully burdened rate. The choice depends upon the effort to calculate, whether a project-wide management system is being used, and if so, what the associated policy is for labor costing.

Partially loaded rates that include straight time, employment and unemployment taxes, and workers compensation, provide useful labor cost information. These rates are not subject to fluctuations in amounts charged for occupancy and equipment over time. However, employment and unemployment taxes are subject to caps when certain levels are reached.

Fully burdened labor rates provide a more accurate picture of costs when overruns occur because they include the impact of project overhead on unbudgeted or unscheduled work. However, these rates are subject to change if their components fluctuate over time, and should be reviewed regularly.

Regardless of which rate is used, the logic for determining earned value is the same.

Earned value performance indicators are measured in both work (hours or days) and monetary units. Consequences for not reviewing these indicators or taking remedial action include:

- Cost and schedule overruns that affect profit directly
- Penalties and liquidated damages for failure to perform as contractually obligated to do so

Life of a project...

All projects must be well planned, but even with the best of planning, actual performance can differ from assumptions and estimates. Therefore, it is best to anticipate change and uncertainty by building contingency into project budgets.

Because of the nature of competitive bidding, for some contractors may elect to make contingency nothing more than a markup for profit. Others build profit on top of contingency because they assume that it will be used entirely. However, to able to earn a reasonable profit, a cushion is always necessary for unanticipated events and costs, and performing less efficiently than planned. If the cushion erodes, then profit does too. A cushion can be maintained by giving project personnel less budget than is actually available so as to maintain the contingency reserve.

Owners of facilities for which construction work is being performed have the right to change their minds, even though there may be an associated cost in doing so. As a consequence, scope changes occur during the life of a project (often too frequently), and sometimes even before it starts. Scope changes can also occur because ideas and design concepts do not work as planned.

The framework for tracking actual performance against project budgets in work and monetary units includes:

- Original budget – at the beginning of the project before contingency
- Budget adjustment for scope changes before contingency

- Revised budget, which equals original budget plus budget adjustments for scope changes – this is the budget given to the project team

- Total budget, which equals the revised budget plus contingency – this is for use by project management and is approved by owner management – the expectation is that contingency will be fully used and that there will be no surplus or deficit

- Estimate to complete, which equals the revised budget plus contingency allocated

- Estimate at completion, which equals actual to date plus estimate to complete (forecast)

- Contingency allocated, which equals performance variances that have been recognized by project management, and included in the project accounting and reporting – contingency is recognized on a deliberate and anticipated basis – based upon both events that have occurred to date and are anticipated to happen in the future

- Performance variance – unbudgeted tasks adjustment (PVU) – the difference between budgeted and both actual incurred and anticipated behavior as a consequence of unforeseen unbudgeted tasks

- Performance variance – inefficiency/efficiency (PVE) – the difference between budgeted and both actual incurred and anticipated behavior as a consequence of efficiency or inefficiency:

    - Unfavorable variances require allocations from contingency and are positive amounts (inefficiency)

    - Favorable variances produce reallocations to contingency and are negative amounts (efficiency)

Note: this indicator is based on an estimate of current and/or future performance to completion – the variance may not have actually been incurred at any given time. Hence a project with positive cost and schedule variances at a point in time, could have forecasted negative performance variances due to anticipated future overruns.

Note: the more realistic the recognitions of performance variances are, the more accurate the current status of the project is likely to be for both the present and future; few surprises, if any, are likely to occur in the future.

- At completion:

  - Total budget at completion, which equals total revised budget plus contingency surplus (positive contingency – underrun)

  - Total budget at completion, which equals total revised budget less contingency deficit (negative contingency – overrun)

The methodology for tracking actual performance against project budgets in work and monetary units is as follows:

- Budgeted cost of work scheduled (BCWS) – planned cost of the total amount of work scheduled by the milestone date – the planned earned value (PEV) (based upon the revised budget before contingency)

- Actual cost of work performed (ACWP) – cost incurred to accomplish the actual work that has been performed to date

- Budgeted cost of work performed (BCWP) – the planned cost to complete the work that has been performed to date at standard or actual rates – the actual earned value (AEV) (based upon the revised budget before contingency):

  - If the actual earned value is based upon standard rates, then it equals the planned earned value upon completion of the project – the difference between the actual earned value and the actual cost of work performed is an adjustment to profit

  - If the actual earned value is based upon actual rates then it equals the actual cost of work performed throughout the project

- Schedule variance (SV) equals BCWP less BCWS:

  - The difference between the budgeted cost of work that was performed and the budgeted cost of work that was scheduled

  - A negative variance means that the project is currently behind schedule

- Cost variance (CV) equals BCWP less ACWP:

  - The difference between the budgeted cost and the actual cost of the work performed

  - A negative variance means that the project is currently over budget

- Schedule performance index (SPI):

  - SPI equals BCWP divided by BCWS

  - SPI < 1 means that the project is behind schedule

- Cost performance index (CPI):

  - CPI equals BCWP divided by ACWP

  - CPI < 1 means that the project is over budget

- Cost schedule performance index (CSPI) is the cost performance index multiplied by the schedule performance index

- Efficiency ratio – measure of productivity – measure of output/input:

  - ACWP/BCWP

- Activity ratio – measure of activity:

  - BCWP/BCWS

- Variance due to hours:

  - (Budgeted hours less actual hours) multiplied by budgeted rate

- Variance due to rate:

  - (Budgeted rate less actual rate) multiplied by actual hours

Note: cost and schedule variances are based upon actual performance; performance variances are based upon both actual and anticipated.

Note: the pitfall in any process that requires an estimate to complete, or an estimate of budget versus actual, is in the accuracy of the forecast. Poorly forecasted estimates to complete have a tendency to mask actual performance.

Milestones should be scheduled such that interim deliverables can be achieved on a regular basis; the tasks and steps to produce the results should be defined in detail so that performance is easy to measure.

The use of contingency can help buffer project management from surprises by the project team.

Projects must be managed on the basis of work and monetary units because situations can arise where a project is on budget from a work unit perspective, but is overrunning on monetary unit basis due to rate variances.

For example, the use of higher cost resources can cause a monetary unit overrun even if they incurred less work units than budgeted due to experience.

Life of a project – revised budgets example...

In this example, a simple project has an original budget of 25 days with 5 days of contingency for a total budget of 30. 25 days are allocated to the project team. A budget adjustment of 5 days for a change in scope occurs in the third period, increasing the total budget to 35 days – 30 days to the project team, and 5 for contingency.

At the end of the first period, project management is optimistic that the project will require only 24 days, and credits contingency one day for a total of 6.

However, circumstances change, and all of the contingency is allocated by the end of the fifth period, by which time the estimate at completion equals the revised budget plus contingency – the total budget.

The project overruns the total budget by one day – the overrun being in the last period. The cost variance is (6) days to the project team and (1) day to management, and hence, even the contingency reserve overruns impacting profit negatively.

Period	Original Budget	Budget Adjustment	Revised Budget	Contingency Reserve	Revised Budget with Contingency	Budgeted Cost of Work Scheduled PEV	Budgeted Cost of Work Performed AEV	Actual Cost of Work Performed	Performance Variance Unbudgeted Tasks	Performance Variance Inefficiency Efficiency	Estimate to Complete	Estimate at Completion	Cost Variance Against Revised Budget	Schedule Variance Against Revised Budget	Cost Performance Index	Schedule Performance Index	Cost Schedule Performance Index	Efficiency Ratio	Activity Ratio
1	25.00	0.00	25.00	6.00	31.00	3.00	3.00	2.00	0.00	(1.00)	22.00	24.00	1.00	0.00	1.50	1.00	1.50	0.67	1.00
2	25.00	0.00	25.00	2.00	31.00	6.00	6.00	5.00	2.00	1.00	23.00	28.00	1.00	0.00	1.20	1.00	1.20	0.83	1.00
3	25.00	5.00	30.00	5.00	35.00	9.00	11.00	9.00	2.00	0.00	23.00	32.00	2.00	2.00	1.00	1.22	1.22	0.82	1.22
4	25.00	5.00	30.00	2.00	35.00	12.00	14.00	14.00	2.00	1.00	19.00	33.00	0.00	2.00	0.86	1.17	1.00	1.00	1.17
5	25.00	5.00	30.00	0.00	35.00	15.00	17.00	17.00	2.00	3.00	18.00	35.00	0.00	2.00	0.88	1.13	1.00	1.00	1.13
6	25.00	5.00	30.00	0.00	35.00	18.00	20.00	19.00	2.00	3.00	16.00	35.00	1.00	2.00	0.95	1.11	1.05	0.95	1.11
7	25.00	5.00	30.00	0.00	35.00	21.00	21.00	22.00	2.00	3.00	13.00	35.00	(1.00)	0.00	0.95	1.00	0.95	1.05	1.00
8	25.00	5.00	30.00	0.00	35.00	24.00	23.00	25.00	2.00	3.00	10.00	35.00	(2.00)	(1.00)	0.96	0.96	0.92	1.09	0.96
9	25.00	5.00	30.00	0.00	35.00	27.00	25.00	28.00	2.00	3.00	7.00	35.00	(3.00)	(2.00)	0.96	0.93	0.89	1.12	0.93
10	25.00	5.00	30.00	0.00	35.00	30.00	27.00	31.00	2.00	3.00	4.00	35.00	(4.00)	(3.00)	0.97	0.90	0.87	1.15	0.90
11	25.00	5.00	30.00	0.00	35.00	30.00	29.00	33.00	2.00	3.00	2.00	35.00	(4.00)	(1.00)	0.91	0.97	0.88	1.14	0.97
12	25.00	5.00	30.00	(1.00)	35.00	30.00	30.00	36.00	2.00	4.00	0.00	36.00	(6.00)	0.00	0.83	1.00	0.83	1.20	1.00

Unfavorable variances are in parentheses except performance variances due to efficiency

Life of a project – monitoring partially loaded labor rates example...

In this example, a contractor bids a small project with a carpenter and a painter. The project is tracked using partially loaded rates, which are based upon prevailing wages to which employment and unemployment taxes and workers compensation costs have been added – these rates are the standard for budgeting purposes. The work hours are based upon the contractor's own standard estimating guidelines for each task to be performed.

Therefore, the budget is based upon both standard rates and hours for the work to be performed.

The rate cards are as follows:

- Partially loaded carpenter:
  - Straight time rate: $64.24
  - Time-and-a-half rate: $84.98
  - Double rate: $104.62
- Partially loaded painter:
  - Straight time rate: $61.71
  - Time-and-a-half rate: $82.01
  - Double time rate: $102.24

Note: fringe benefits are not subject to the overtime premium.

Note: workers compensation experience rates vary by contractor.

Note: unfavorable variances are shown in parentheses, except for performance variances due to inefficiency. Performance variances due to efficiency are shown in parentheses, which result in a credit to contingency.

Budgeted	Hours	Week 1	Week 2	Week 3	Week 4	Week 5	Total
Carpenter	Straight	40.00	40.00	40.00	40.00	0.00	160.00
	Time-and-a-half	0.00	0.00	0.00	0.00	0.00	0.00
	Double	0.00	0.00	0.00	0.00	0.00	0.00
	Total	40.00	40.00	40.00	40.00	0.00	160.00
Painter	Straight	40.00	40.00	40.00	40.00	0.00	160.00
	Time-and-a-half	0.00	0.00	0.00	0.00	0.00	0.00
	Double	0.00	0.00	0.00	0.00	0.00	0.00
	Total	40.00	40.00	40.00	40.00	0.00	160.00
All Trades	Straight	80.00	80.00	80.00	80.00	0.00	320.00
	Time-and-a-half	0.00	0.00	0.00	0.00	0.00	0.00
	Double	0.00	0.00	0.00	0.00	0.00	0.00
	Total	80.00	80.00	80.00	80.00	0.00	320.00

The project is scheduled over a four week period with no allowance for overtime for a total of 320 hours.

Budgeted	Cost	LR	Week 1	Week 2	Week 3	Week 4	Week 5	Total
Carpenter	Straight	$64.24	$2,569.61	$2,569.61	$2,569.61	$2,569.61	$0.00	$10,278.44
	Time-and-a-half	$84.98	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	Double	$104.62	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	Total		$2,569.61	$2,569.61	$2,569.61	$2,569.61	$0.00	$10,278.44
Painter	Straight	$60.71	$2,428.37	$2,428.37	$2,428.37	$2,428.37	$0.00	$9,713.48
	Time-and-a-half	$82.01	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	Double	$102.24	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	Total		$2,428.37	$2,428.37	$2,428.37	$2,428.37	$0.00	$9,713.48
All Trades	Straight		$4,997.98	$4,997.98	$4,997.98	$4,997.98	$0.00	$19,991.92
	Time-and-a-half		$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	Double		$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	Total		$4,997.98	$4,997.98	$4,997.98	$4,997.98	$0.00	$19,991.92
	Contingency							$2,998.79
								$22,990.71

The budget uses partially loaded rates (LR) for a total of $19,991.92. The contractor adds a 15 per cent contingency of $2,998.79 for a total budget of $22,990.71.

Note: for the remainder of the example, partially loaded labor rates are referred to merely as “loaded labor rates.”

Actual	Hours	Week 1	Week 2	Week 3	Week 4	Week 5	Total
Carpenter	Straight	36.00	40.00	40.00	25.00	25.00	166.00
	Time-and-a-half	6.00	0.00	0.00	0.00	0.00	6.00
	Double	1.00	0.00	0.00	0.00	0.00	1.00
	Total	43.00	40.00	40.00	25.00	25.00	173.00
Painter	Straight	0.00	40.00	40.00	35.00	35.00	150.00
	Time-and-a-half	0.00	0.00	0.00	0.00	7.00	7.00
	Double	0.00	0.00	0.00	0.00	0.00	0.00
	Total	0.00	40.00	40.00	35.00	42.00	157.00
All Trades	Straight	36.00	80.00	80.00	60.00	60.00	316.00
	Time-and-a-half	6.00	0.00	0.00	0.00	7.00	13.00
	Double	1.00	0.00	0.00	0.00	0.00	1.00
	Total	43.00	80.00	80.00	60.00	67.00	330.00

Actual	Cost	LR	Week 1	Week 2	Week 3	Week 4	Week 5	Total
Carpenter	Straight	$64.24	$2,312.65	$2,569.61	$2,569.61	$1,606.01	$1,606.01	$10,663.89
	Time-and-a-half	$84.98	$509.86	$0.00	$0.00	$0.00	$0.00	$509.86
	Double	$104.62	$104.62	$0.00	$0.00	$0.00	$0.00	$104.62
	Total		$2,927.13	$2,569.61	$2,569.61	$1,606.01	$1,606.01	$11,278.37
Painter	Straight	$61.79	$0.00	$2,471.43	$2,471.43	$2,162.50	$2,162.50	$9,267.86
	Time-and-a-half	$83.64	$0.00	$0.00	$0.00	$0.00	$585.45	$585.45
	Double	$104.40	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	Total		$0.00	$2,471.43	$2,471.43	$2,162.50	$2,747.95	$9,853.31
All Trades	Straight		$2,312.65	$5,041.04	$5,041.04	$3,768.51	$3,768.51	$19,931.75
	Time-and-a-half		$509.86	$0.00	$0.00	$0.00	$585.45	$1,095.31
	Double		$104.62	$0.00	$0.00	$0.00	$0.00	$104.62
	Total		$2,927.13	$5,041.04	$5,041.04	$3,768.51	$4,353.96	$21,131.68
	Contingency remaining							$1,859.03
								$22,990.71

The actual performance differs from planned. The project overruns by one week due to materials delays and weather problems. It requires an additional 10 hours of work. The carpentry work overruns the budgeted hours, but the painting work underruns. Both the carpenter and the painter incurred overtime hours.

The total hour variance for the carpenter is 13 hours over, and the total hour variance for the painter is 3 hours under.

Variances	Hours	Week 1	Week 2	Week 3	Week 4	Week 5	Total
Carpenter	Straight	(4.00)	0.00	0.00	(15.00)	25.00	6.00
	Time-and-a-half	6.00	0.00	0.00	0.00	0.00	6.00
	Double	1.00	0.00	0.00	0.00	0.00	1.00
	Total	3.00	0.00	0.00	(15.00)	25.00	13.00
Painter	Straight	(40.00)	0.00	0.00	(5.00)	35.00	(10.00)
	Time-and-a-half	0.00	0.00	0.00	0.00	7.00	7.00
	Double	0.00	0.00	0.00	0.00	0.00	0.00
	Total	(40.00)	0.00	0.00	(5.00)	42.00	(3.00)
All Trades	Straight	(44.00)	0.00	0.00	(20.00)	60.00	(4.00)
	Time-and-a-half	6.00	0.00	0.00	0.00	7.00	13.00
	Double	1.00	0.00	0.00	0.00	0.00	1.00
	Total	(37.00)	0.00	0.00	(20.00)	67.00	10.00

Variances	Cost	Week 1	Week 2	Week 3	Week 4	Week 5	Total
Carpenter	Straight	($256.96)	$0.00	$0.00	($963.60)	$1,606.01	$385.45
	Time-and-a-half	$509.86	$0.00	$0.00	$0.00	$0.00	$509.86
	Double	$104.62	$0.00	$0.00	$0.00	$0.00	$104.62
	Total	$357.52	$0.00	$0.00	($963.60)	$1,606.01	$999.93
Painter	Straight	($2,428.37)	$43.06	$43.06	($265.87)	$2,162.50	($445.62)
	Time-and-a-half	$0.00	$0.00	$0.00	$0.00	$585.45	$585.45
	Double	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	Total	($2,428.37)	$43.06	$43.06	($265.87)	$2,747.95	$139.83
All Trades	Straight	($2,685.33)	$43.06	$43.06	($1,229.47)	$3,768.51	($60.17)
	Time-and-a-half	$509.86	$0.00	$0.00	$0.00	$585.45	$1,095.31
	Double	$104.62	$0.00	$0.00	$0.00	$0.00	$104.62
	Total	($2,070.85)	$43.06	$43.06	($1,229.47)	$4,353.96	$1,139.76

The painter who was scheduled to work is not available due to an accident; a higher rate painter is substituted, and is able to complete the work with less hours.

The total cost variance for the carpenter is $999.93. The total cost variance for the painter is $139.83. The total cost variance is $1,139.76.

Carpenter	Week 1	Week 2	Week 3	Week 4	Week 5
Hours					
Budgeted cost of work scheduled (PEV)	40.00	80.00	120.00	160.00	160.00
Budgeted cost of work performed (AEV)	37.00	72.00	108.00	147.00	160.00
Actual cost of work performed	43.00	83.00	123.00	148.00	173.00
Estimate to complete	120.00	85.00	49.00	25.00	0.00
Estimate at completion	163.00	168.00	172.00	173.00	173.00
Performance variance due to budget adjustment	3.00	3.00	3.00	3.00	3.00
Performance variance due to efficiency	0.00	5.00	9.00	10.00	10.00
Total performance variance	3.00	8.00	12.00	13.00	13.00
Contingency remaining	21.00	16.00	12.00	11.00	11.00
Total contingency	24.00	24.00	24.00	24.00	24.00
Total project budget	184.00	184.00	184.00	184.00	184.00
Cost variance	(6.00)	(11.00)	(15.00)	(1.00)	(13.00)
Schedule variance	(3.00)	(8.00)	(12.00)	(13.00)	0.00
Cost performance index	0.86	0.87	0.88	0.99	0.92
Schedule performance index	0.93	0.90	0.90	0.92	1.00
Cost schedule performance index	0.80	0.78	0.79	0.91	0.92
$					
Budgeted cost of work scheduled (PEV)	$2,569.61	$5,139.22	$7,708.83	$10,278.44	$10,278.44
Budgeted cost of work performed (AEV)	$2,376.89	$4,625.30	$6,937.94	$9,443.31	$10,278.44
Actual cost of work performed	$2,927.13	$5,496.74	$8,066.35	$9,672.36	$11,278.37
Contingency remaining					$541.83
Total project budget					$11,820.20
Actual loaded labor rate	$68.07	$64.24	$64.24	$64.24	$64.24
Budget loaded labor rate	$64.24	$64.24	$64.24	$64.24	$64.24
Loaded labor rate variance	($3.83)	($0.00)	($0.00)	($0.00)	($0.00)
Cost variance	($550.24)	($871.44)	($1,128.41)	($229.05)	($999.93)
Schedule variance	($192.72)	($513.92)	($770.88)	($835.12)	$0.00
Cost performance index	0.81	0.84	0.86	0.98	0.91
Schedule performance index	0.93	0.90	0.90	0.92	1.00
Cost schedule performance index	0.75	0.76	0.77	0.90	0.91

	Cost of variances		
	Hours	Rate	Total
Straight	($385.44)	$0.00	($385.44)
Time-and-a-half	($385.44)	($124.42)	($509.86)
Double	($64.24)	($40.38)	($104.62)
Total	($835.12)	($164.80)	($999.92)

Note: due to rounding, the total cost variance is shown in the spreadsheet as either $999.92 or $999.93.

Carpenter performance results in a cost overrun of $999.92 with a 13 hour overrun:

- During the project, actual earned value lags planned earned value
- A performance variance for a budget adjustment of 3 hours is necessary to finance unplanned work
- A performance variance for inefficiency of 10 hours is incurred – the 10 hours were incurred at straight, time-and-a-half, and double time rates – the result is an hour variance cost of $835.12
- No rate variance occurs for straight time work
- Rate variances occur because hours are incurred at time-and-a-half and double time rates – the result is a rate variance cost of $164.80
- In the first week, the actual loaded labor rate is higher than budget due to overtime

Painter	Week 1	Week 2	Week 3	Week 4	Week 5
Hours					
Budgeted cost of work scheduled (PEV)	40.00	80.00	120.00	160.00	160.00
Budgeted cost of work performed (AEV)	0.00	40.00	80.00	116.00	160.00
Actual cost of work performed	0.00	40.00	80.00	115.00	157.00
Estimate to complete	160.00	120.00	77.00	42.00	0.00
Estimate at completion	160.00	160.00	157.00	157.00	157.00
Performance variance due to budget adjustment	0.00	0.00	0.00	0.00	0.00
Performance variance due to efficiency	0.00	0.00	(3.00)	(3.00)	(3.00)
Total performance variance	0.00	0.00	(3.00)	(3.00)	(3.00)
Contingency remaining	24.00	24.00	27.00	27.00	27.00
Total contingency	24.00	24.00	24.00	24.00	24.00
Total project budget	184.00	184.00	184.00	184.00	184.00
Cost variance	0.00	0.00	0.00	1.00	3.00
Schedule variance	(40.00)	(40.00)	(40.00)	(44.00)	0.00
Cost performance index	~	1.00	1.00	1.01	1.02
Schedule performance index	0.00	0.50	0.67	0.73	1.00
Cost schedule performance index	~	0.50	0.67	0.73	1.02
$					
Budgeted cost of work scheduled (PEV)	$2,428.37	$4,856.74	$7,285.12	$9,713.49	$9,713.49
Budgeted cost of work performed (AEV)	$0.00	$2,428.37	$4,856.74	$7,042.28	$9,713.49
Actual cost of work performed	$0.00	$2,471.43	$4,942.86	$7,105.36	$9,853.31
Contingency remaining					$1,317.20
Total project budget					$11,170.51
Actual loaded labor rate	~	$61.79	$61.79	$61.79	$65.43
Budget loaded labor rate	$60.71	$60.71	$60.71	$60.71	$60.71
Loaded labor rate variance	~	($1.08)	($1.08)	($1.08)	($4.72)
Cost variance	$0.00	($43.06)	($86.12)	($63.08)	($139.82)
Schedule variance	($2,428.37)	($2,428.37)	($2,428.37)	($2,671.21)	$0.00
Cost performance index	~	0.98	0.98	0.99	0.99
Schedule performance index	0.00	0.50	0.67	0.73	1.00
Cost schedule performance index	~	0.49	0.66	0.72	0.99

	Cost of variances		
	Hours	Rate	Total
Straight	$607.09	($161.48)	$445.62
Time-and-a-half	($424.97)	($160.49)	($585.45)
Double	$0.00	$0.00	$0.00
Total	$182.13	($321.96)	($139.83)

Note: due to rounding, the total cost variance is shown in the spreadsheet as either $139.82 or $139.83.

Painter performance results in a cost overrun of $139.83 with a 3 hour underrun:

- During the project, actual earned value lags planned earned value
- A negative performance variance for efficiency of 3 hours is earned – this credit increases contingency
- An unfavorable rate variance of $321.96 results from an actual higher painter rate than budgeted – this variance is partially offset by favorable hours variance of $182.13
- Higher actual loaded rates than budgeted and overtime incurred

Budgeted cost of work scheduled (PEV)	80.00	160.00	240.00	320.00	320.00
Budgeted cost of work performed (AEV)	37.00	112.00	188.00	263.00	320.00
Actual cost of work performed	43.00	123.00	203.00	263.00	330.00
Estimate to complete	280.00	205.00	126.00	67.00	0.00
Estimate at completion	323.00	328.00	329.00	330.00	330.00
Performance variance due to budget adjustment	3.00	3.00	3.00	3.00	3.00
Performance variance due to efficiency	0.00	5.00	6.00	7.00	7.00
Total performance variance	3.00	8.00	9.00	10.00	10.00
Contingency remaining	45.00	40.00	39.00	38.00	38.00
Total contingency	48.00	48.00	48.00	48.00	48.00
Total project budget	368.00	368.00	368.00	368.00	368.00
Cost variance	(6.00)	(11.00)	(15.00)	0.00	(10.00)
Schedule variance	(43.00)	(48.00)	(52.00)	(57.00)	0.00
Cost performance index	0.86	0.91	0.93	1.00	0.97
Schedule performance index	0.46	0.70	0.78	0.82	1.00
Cost schedule performance index	0.40	0.64	0.73	0.82	0.97
Efficiency ratio	1.16	1.10	1.08	1.00	1.03
Activity ratio	0.46	0.70	0.78	0.82	1.00
$					
Budgeted cost of work scheduled (PEV)	$4,997.98	$9,995.96	$14,993.94	$19,991.92	$19,991.92
Budgeted cost of work performed (AEV)	$2,376.89	$7,053.67	$11,794.69	$16,485.59	$19,991.92
Actual cost of work performed	$2,927.13	$7,968.17	$13,009.21	$16,777.72	$21,131.68
Contingency remaining					$1,859.03
Total project budget					$22,990.71
Actual loaded labor rate	$68.07	$63.01	$63.01	$62.81	$64.98
Budget loaded labor rate	$62.47	$62.47	$62.47	$62.47	~
Loaded labor rate variance	($5.60)	($0.54)	($0.54)	($0.33)	
Cost variance	($550.24)	($914.50)	($1,214.52)	($292.13)	($1,139.76)
Schedule variance	($2,621.09)	($2,942.29)	($3,199.25)	($3,506.33)	$0.00
Cost performance index	0.81	0.89	0.91	0.98	0.95
Schedule performance index	0.48	0.71	0.79	0.82	1.00
Cost schedule performance index	0.39	0.62	0.71	0.81	0.95

	Cost of variances		
	Hours	Rate	Total
Straight	$221.65	($161.48)	$60.18
Time-and-a-half	($810.41)	($284.90)	($1,095.31)
Double	($64.24)	($40.38)	($104.62)
Total	($653.00)	($486.76)	($1,139.76)

Overall performance resulted in a cost overrun of $1,139.76 with a 10 hour overrun:

- During the project, actual earned value lags planned earned value
- A performance variance for a budget adjustment of 3 hours is necessary to finance unplanned work
- A performance variance for inefficiency of 7 hours is incurred
- There is an unfavorable rate variance of $486.76 resulting from an actual higher painter rate than budgeted and overtime and an unfavorable hour variance cost of $653.00
- There are higher actual loaded rates due to use of a higher rate than budgeted and overtime
- As a consequence of the overrun for the carpenter time, the contractor revised the time standards for carpentry work

The total project cost was $21,131.68. The unused contingency is $1,859.03.

Work power loading...

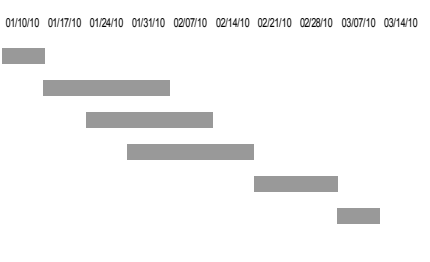
Work power loading is process of scheduling project activities with resources over time. The activities are laid out over time from the work breakdown structure, and resources are scheduled based upon elapsed time commitments.

Resources include materials and supplies, facilities, and equipment, and human – the workers that make up the work power loading schedule. The resources are first assigned by full time equivalents and planned skill levels. Workers are then matched to activities based upon availability and actual skill levels. Because of differences between planned and actual workers at certain skill levels, the cost and schedule estimates may change.

A Gantt chart is used to show the scheduled activities in the work breakdown structure according to budget and start and end dates. This chart should be updated as the project progresses to show actual progress against budget and schedule. Budgets can be shown at a high level in work days and converted to work hours to be reconcilable with other project management documents as necessary.

In the example that follows, a project is organized over a nine week period, with six activities in the work breakdown structure. The project has a budget of 90 work days before contingency.

Activity		Start Date	End Date	Work Days
Demolition	Scheduled	01/04/10	01/08/10	10
Framing	Scheduled	01/11/10	01/29/10	24
Drywall	Scheduled	01/18/10	02/05/08	27
Taping	Scheduled	01/25/10	02/12/10	14
Painting	Scheduled	02/15/10	02/26/10	10
Clean-up	Scheduled	03/01/10	03/05/10	5
Total				90

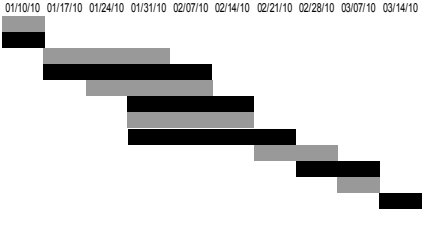


The work power loading schedule shows workers assigned to activities by week, with work day estimates per week.

Activity	Start Date	End Date	Work Days	01/10/10	01/17/10	01/24/10	01/31/10	02/07/10	02/14/10	02/21/10	02/28/10	03/07/10	03/14/10
Demolition	01/04/10	01/08/10											
Laborer 1			5	5									
Laborer 1			5	5									
Framing	01/11/10	01/29/10											
Framer 1			14		5	5	4						
Framer 2			10			5	5						
Drywall	01/18/10	02/05/08											
Drywall 1			14			4	5	5					
Drywall 2			13			4	4	5					
Taping	01/25/10	02/12/10											
Taper			14				5	4	5				
Painting	02/15/10	02/26/10											
Painter			10							5	5		
Clean-up	03/01/10	03/05/10											
Laborer			5									5	
Totals			90	10	5	18	23	14	5	5	5	5	

The actual performance overruns both budget and schedule by 13 work days and one elapsed week respectively. The problem began in the framing activity, and rippled through the project from that point on.

Activity		Start Date	End Date	Work Days
Demolition	Scheduled	01/04/10	01/08/10	10
	Actual	01/04/10	01/08/10	10
Framing	Scheduled	01/11/10	01/29/10	24
	Actual	01/11/10	02/05/10	30
Drywall	Scheduled	01/18/10	02/05/10	27
	Actual	01/25/10	02/12/10	27
Taping	Scheduled	01/25/10	02/12/10	14
	Actual	01/25/10	02/19/10	22
Painting	Scheduled	02/15/10	02/26/10	10
	Actual	02/22/10	03/15/10	10
Clean-up	Scheduled	03/01/10	03/05/10	5
	Actual	03/08/10	03/12/10	4
Total Scheduled				90
Total Actual				103
Cost Variance				(13)



In addition to the cost of the work day overrun, there are additional cost overruns due to the project overhead being incurred for one extra week.

If fully burdened labor rates are used, the approximate cost of the project overhead is included in the cost overrun calculations, whereas straight and loaded labor rates do not pick up the full cost.

Note: in overrun situations, actual overhead costs may differ from planned because either more or less resources are being used than standard.

Critical path analysis...

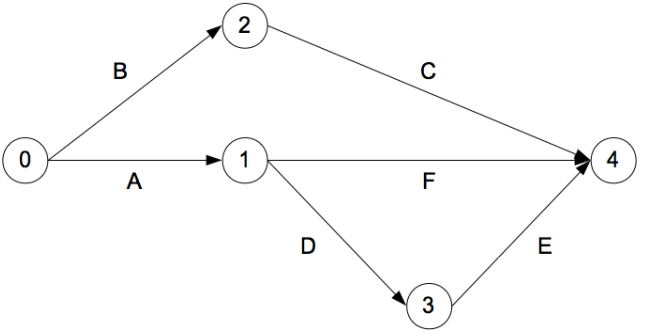
The project critical path is sequence of activities that represent the longest duration. The critical path is determined by tracking the elapsed time for activities in the work breakdown structure and their interdependencies, using the Program Evaluation and Review Technique (PERT) and the Critical Path Method (CPM).

A PERT chart shows the activities and dependencies. Coding conventions for PERT charts can be quite complex.

Critical path analysis requires properly sequencing activities and determining the impact of schedule changes in one activity that affect others. This type of analysis is useful when multiple activities can be performed concurrently. A delay in one activity may cause the entire project to slip behind schedule.

The critical path determines the shortest time in which the project can be completed. A delay in a critical path activity impacts the planned project completion date. Lead time is the difference between two activities that are scheduled to start in sequence, i.e., one must start before the other. Lag time is the difference between two activities that are scheduled to end in sequence.

Float or slack is the amount of time that an activity can be delayed without impacting subsequent activities (the free float) or the project end date (total float).



In this simplistic example, there are 6 activities with 4 milestones to be achieved as follows:

Activity	Work Day Estimate	Predecessor	Successor
A	10		D,F
B	15		C
C	20	B	
D	15	A	E
E	15	D	
F	18	A	
A+F	28		
B+C	35		
D+E	30		
A+D+E	40		

The critical path at the beginning of the project consists of activities A, D, and E = 40 days.

The path of activities A and F has 12 days of float.

The path of activities B and C has 5 days of float.

Owners may have specific requirements for the use of critical path analysis for work power, materials and supplies, facilities, and equipment scheduling. These requirements may include the definition of an activity for scheduling purposes to ensure that no intermediate deliverable milestone is more than a defined period of weeks in duration. (Two weeks is a common standard.)

Critical path analysis a complex subject, for which there are many books and seminars.

Project management software...

Two common project management software packages are:

- Microsoft Project:

  www.microsoft.com/project/en/us/default.aspx

- Oracle Primavera:

  www.oracle.com/us/products/applications/primavera/index.html

Key success factor...

It is important that the follow-on activities from the project definition be monitored with milestones and progress reporting. It is easy to lose control of such activities if they are not properly monitored, especially if new opportunities and threats subsequently arise.

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