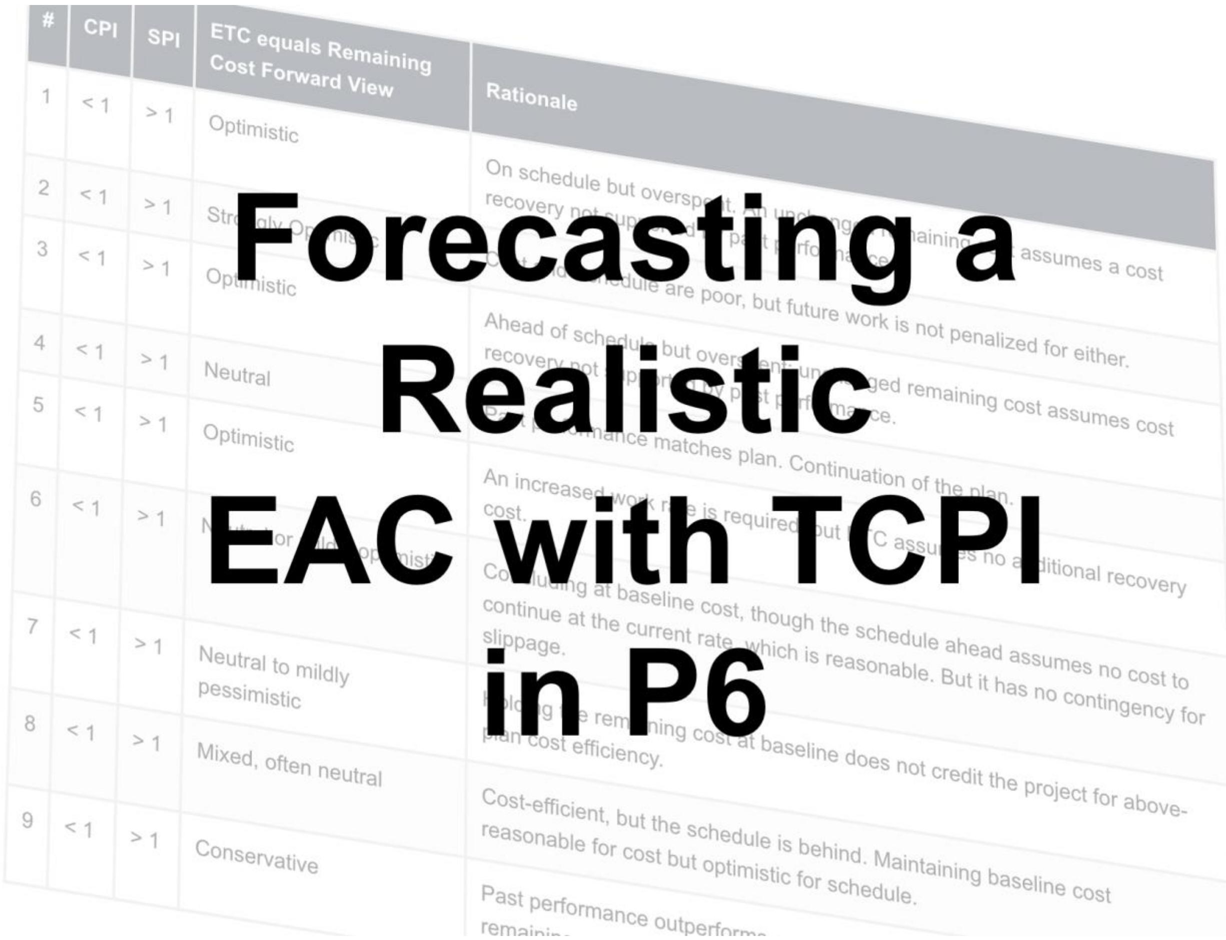


Forecasting a Realistic EAC with TCPI in P6

TENSIX®

Forecasting a Realistic EAC with TCPI in P6

Here we're taking a look at forecasting a realistic EAC with TCPI in P6. So, how does the P6 Professional scheduler accurately forecast the funds and cost efficiency required to complete an in-progress schedule? Let' see.

As the schedule progresses, a major duty of the project manager is to keep a watchful eye on the remaining costs to complete the schedule; this is the Estimate to Complete (ETC) at each update. Accurate and/or conservative forecasting of required funds and cost efficiency is highly dependent on the P6 Professional technique utilized to compute each task's ETC.

P6 Professional calculates a task's ETC using either the management-driven remaining cost method (manual/resource-driven, ignoring Earned Value (EV) performance) or a formula-based method using EV performance factors (PF).

Some PF options require a stable cost-efficiency metric: the cumulative Cost Performance Index (CPI). Empirical data show that CPI becomes reliable once 20% of the construction is complete, so acquiring accurate EV data at that point is important.

A project's ETC proves more reliable when it is the bottom-up sum of task-level estimates—whether using manual 'Remaining Cost' or task-specific formulas—rather than top-down project formulas assuming persistent project efficiency.

Schedulers should compare the two approaches and document any divergence that exceeds tolerances. When they align, project formulas add credence to the accuracy of the scheduler's bottom-up ETC. When ACs are added to the ETC, the result is the Estimate at Completion (EAC)—the forecasted total project cost.

The EAC, combined with the To Complete Performance Index (TCPI)—the required remaining work cost-efficiency metric from EV data—provides leadership with the decision-making data needed to choose and set course direction.

Table of Contents

1. Introduction

This P6 Professional Earned Value Management (EVM) article evaluates progress on a lump-sum, cost-loaded schedule, weighs task ETC calculation methods and demonstrates EAC/TCPI tabulation for decision-makers.

Readers are encouraged to download the companion demonstration schedule, baseline XER files, and PLF files from these links:

P6 XER Schedule Files

PLF Layout Files

Refer to the following article for a primer on exporting and importing PLF layouts.

2. Demonstration Project

Our demonstration schedule is a piping repair and improvement project that, in addition to pipe repairs, adds a cement thrust block to prevent movement of two 90-degree pipe elbows. This pipe elbow displacement is caused by fluid impulses during valve opening and closing.

A. Schedule

Figure 1 shows our project’s baseline schedule, including the activity table and Gantt chart.

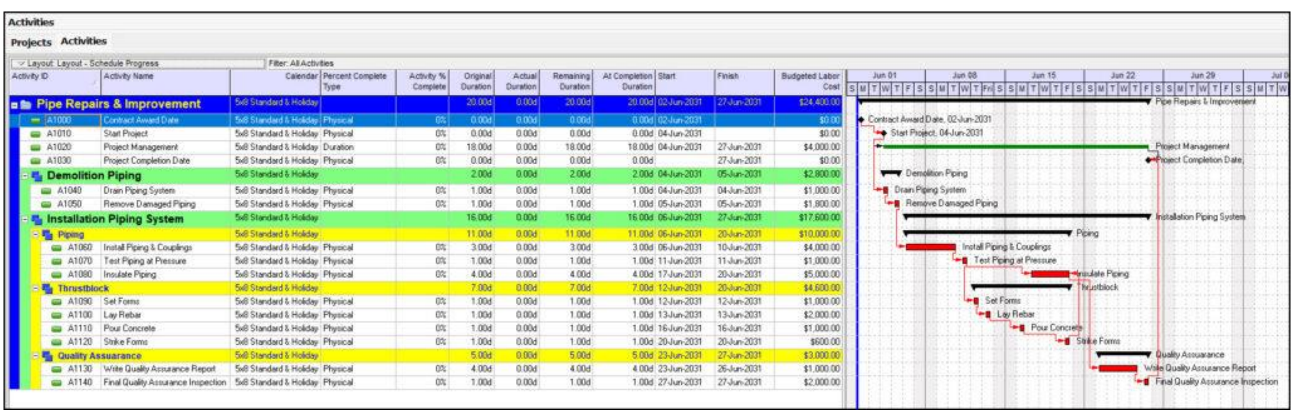


Figure 1

Tasks are assigned to a '5×8 Standard & Holiday' project calendar (five-day, eight-hour workweek). Our project calendar's only holiday during our work performance period is July 4th. The baseline finish date is June 27, 2031.

B. Resource Loading

The demonstration schedule has resource lump-sum cost loading, where the contractor agrees to complete each task, including labor, materials and equipment, for a single fixed price.

We placed our lump-sum cost data in the Activity Table's labor cost columns, e.g., the Budgeted Labor Cost column in Figure 1. If you want to know more about lump-sum resource loading, check out the link below:

Lump-Sum Resource Loading in P6 Professional

The Resource Details and Units & Prices for the lump-sum cost loading are shown in Figures 2 and 3. The resource uses a global 'Corporate – Standard Full-Time' calendar (five-day, eight-hour workweek), Figure 2.

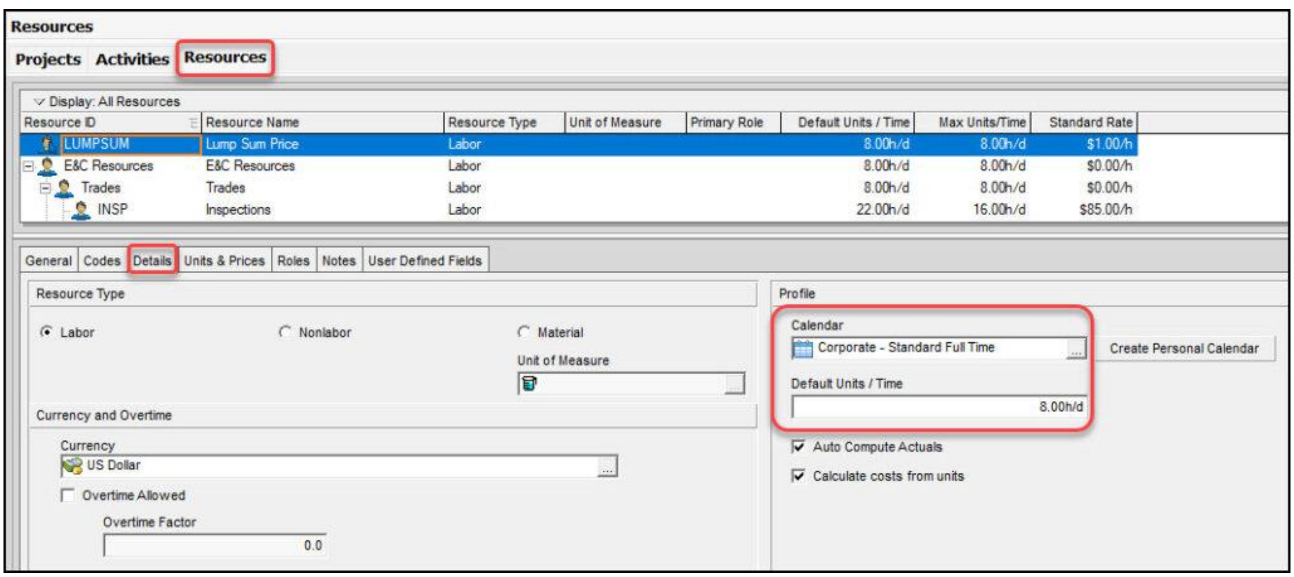


Figure 2

This calendar usually loads by default with sample data. Check if your database includes it. You can also make the task's '5×8 Standard & Holiday' project calendar global (resources require Global, Shared or Personal calendars—not Project calendars) and assign it to the lump-sum resource.

Like our task project calendar, this global resource calendar's default Units/Time is 8h/d units/time, as shown in Figure 2. The lump-sum resource has a maximum units/time of 8/h/d, so eight hours is a full day's work. Its standard rate is $1/h, so each hour of work costs $1, Figure 3.

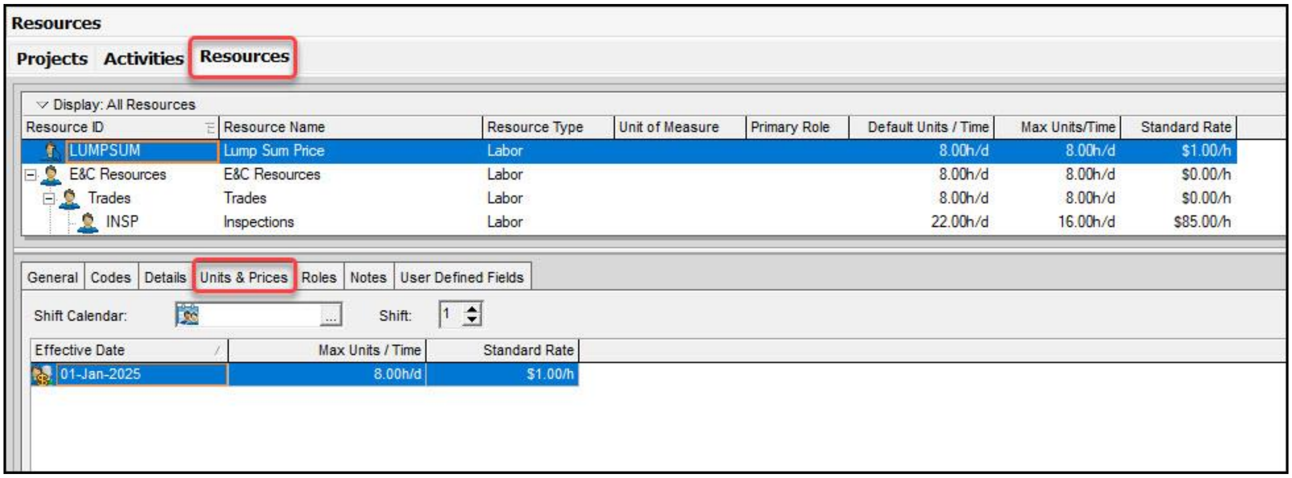


Figure 3

Figure 4 shows the baseline's lump-sum resource loading for the Project Management task (Resources tab, bottom details).

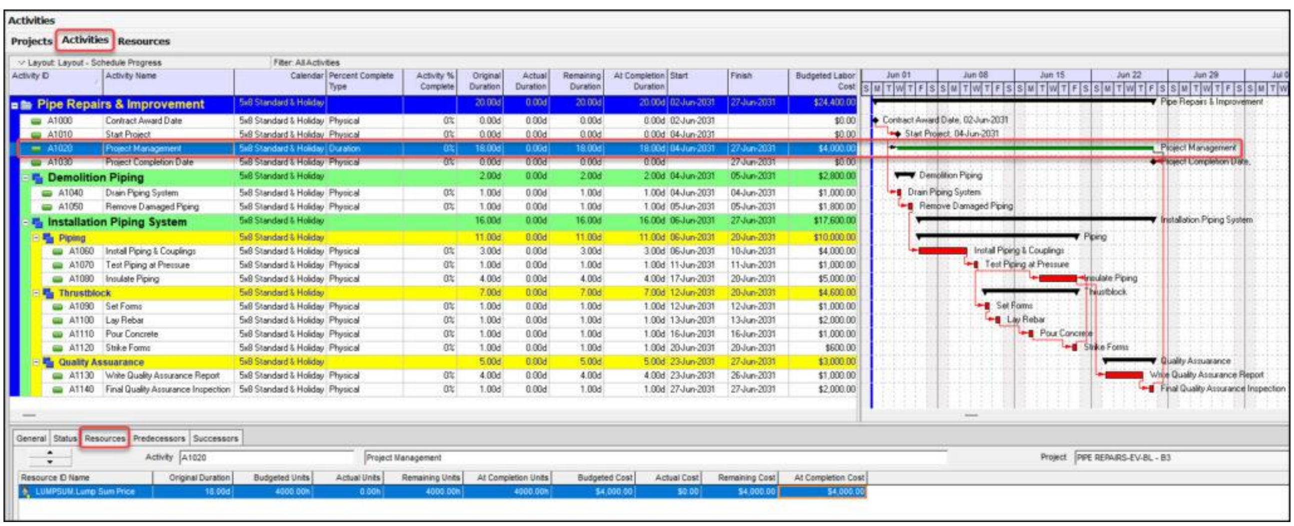


Figure 4

As shown in this example, Figure 4, each task uses a single assigned, lump-sum resource.

3. Assessing Schedule Progress

The demonstration project, as displayed in Figure 5, has progressed to the beginning of the third workweek, June 16, 2031, at 8:00 AM.

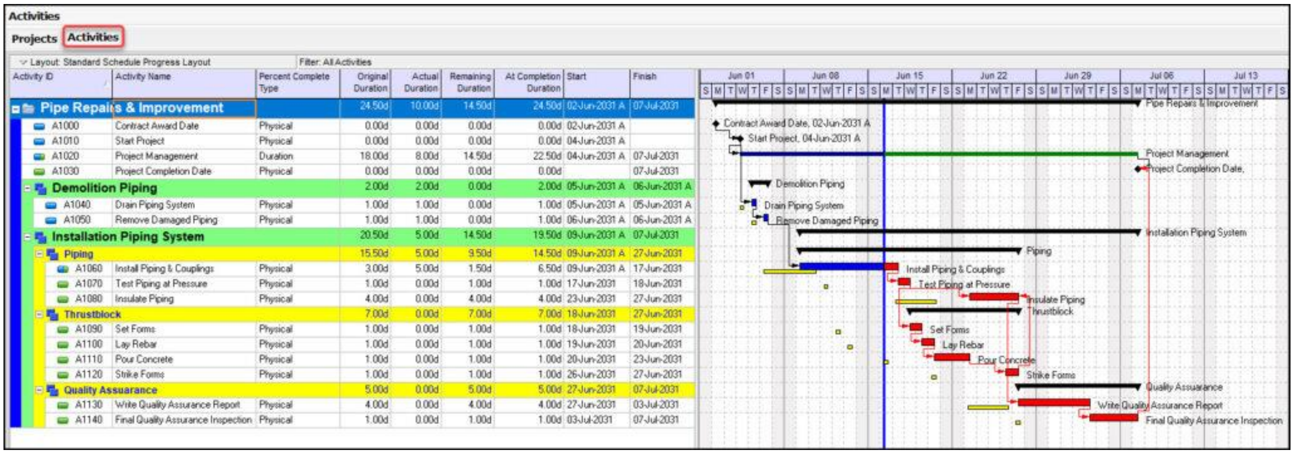


Figure 5

A. Progress Schedule

Assessing a resource-loaded schedule's progress against the baseline requires understanding P6 Professional's project calculation settings and how each task's progress is measured.

i) P6 Professional Project Calculation Settings

All computations in this article use the project Calculations settings shown in Figure 6.

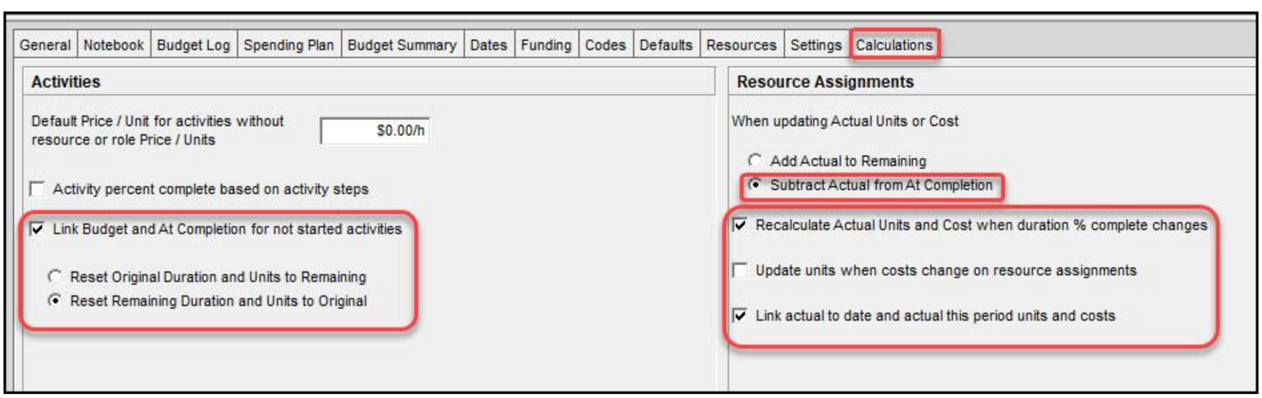


Figure 6

Furthermore, enable “Recalculate assignment costs after scheduling” in the scheduling options. This populates the Actual Cost (AC) for each Level of Effort (LOE) task, which is assigned a Duration % as shown in Figure 7.

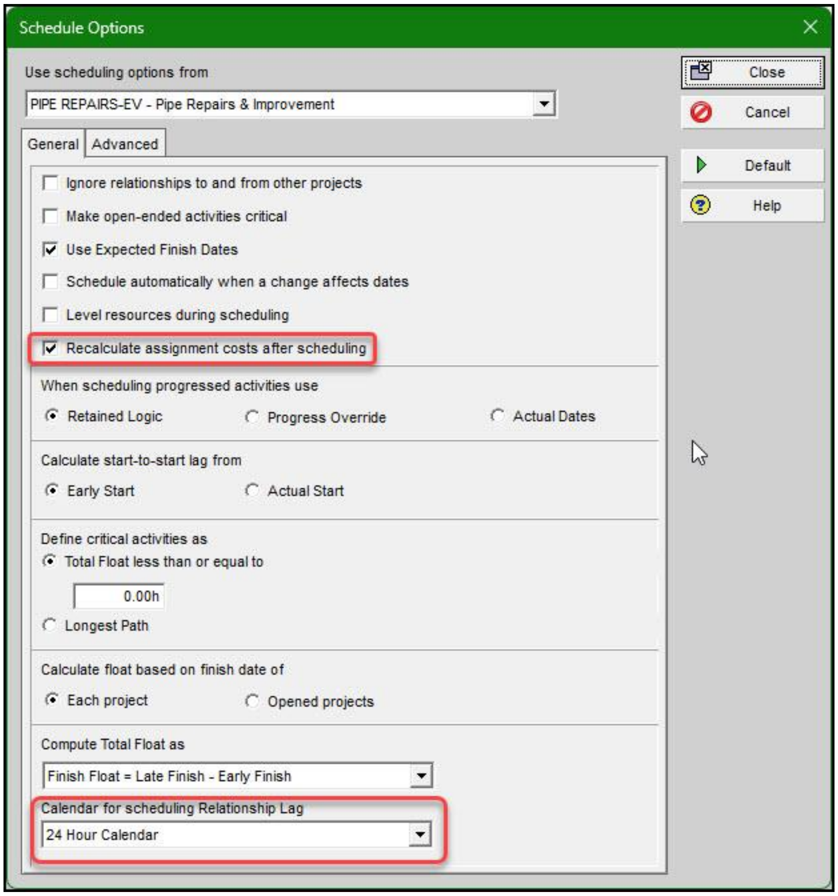


Figure 7

The thrust block installation also requires concrete curing lag, so we set the scheduling relationship lag to the 24-Hour Calendar, as concrete cures 24/7.

ii) Activity % Complete Definition

Task progress in the Activity % Complete field depends on the Percent Complete Type (either Duration % or Physical % in our schedule). Duration % measures progress against Original Duration (OD) and Remaining Duration (RD) timespan estimates. Each task’s % complete drives its RD.

a) Duration % Complete

In P6, the Duration % complete and RD fields are directly correlated, and the computation can go both ways. If you enter the Duration % complete, it computes the RD and vice versa. The equation and forms are as follows:

$$Duration\ \%\ Complete = \frac{OD - RD}{OD} \times 100$$

$$RD = OD\ \times \left(1 - \frac{Duration\ \%\ Complete}{100}\right)$$

Figure 8 shows the bottom status tab details for the Project Management effort in our demonstration schedule. It is assigned to the Duration % type.

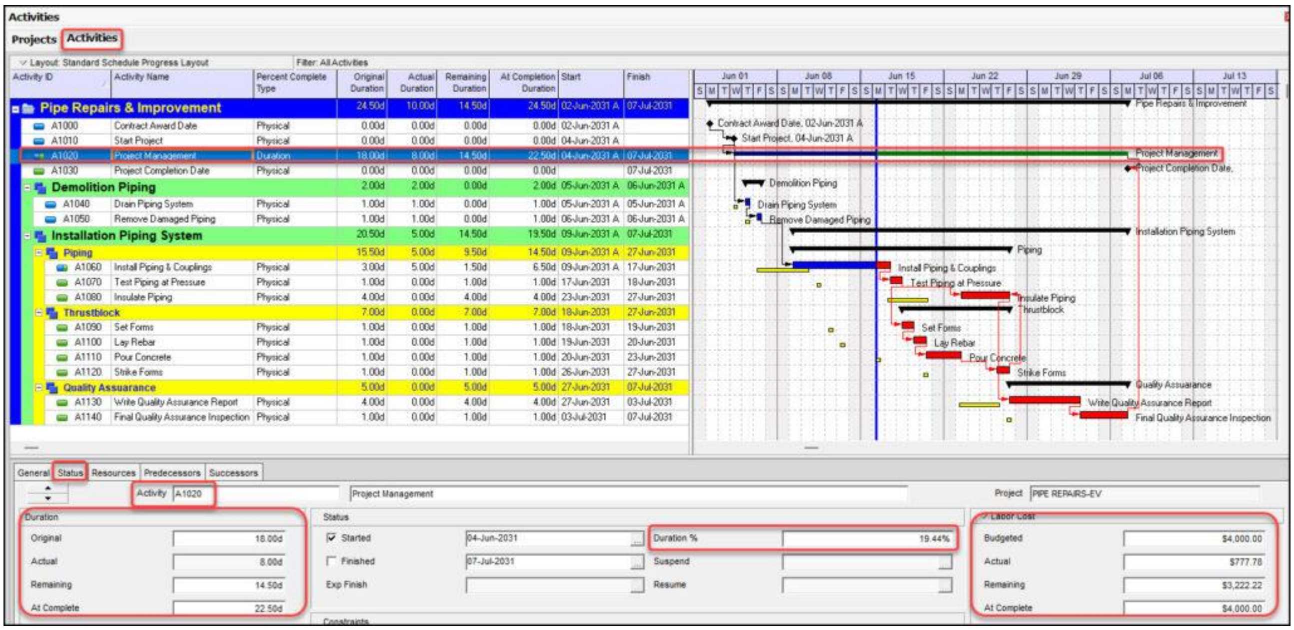


Figure 8

Note in the Percent Complete Type column in Figure 8 that Project Management is the sole task assigned Duration %. In Figure 8, when Duration % equals 19.94% and OD 18-day, the RD is computed as follows:

$$RD = 18\ \times \left(1 - \frac{19.94}{100}\right) = 14.5$$

b) Physical % Complete

For the Physical Percent Complete Type, the percentage complete and RD are not directly correlated; RD is independent of task achievement. And the scheduler provides either a revised remaining duration (RD_revised) or an expected finish date. If an expected finish date is entered, the scheduler will use the current data date (DD) to calculate an updated RD_revised. Figure 9 shows the status for the Install Piping & Couplings task (bottom details, Status tab).

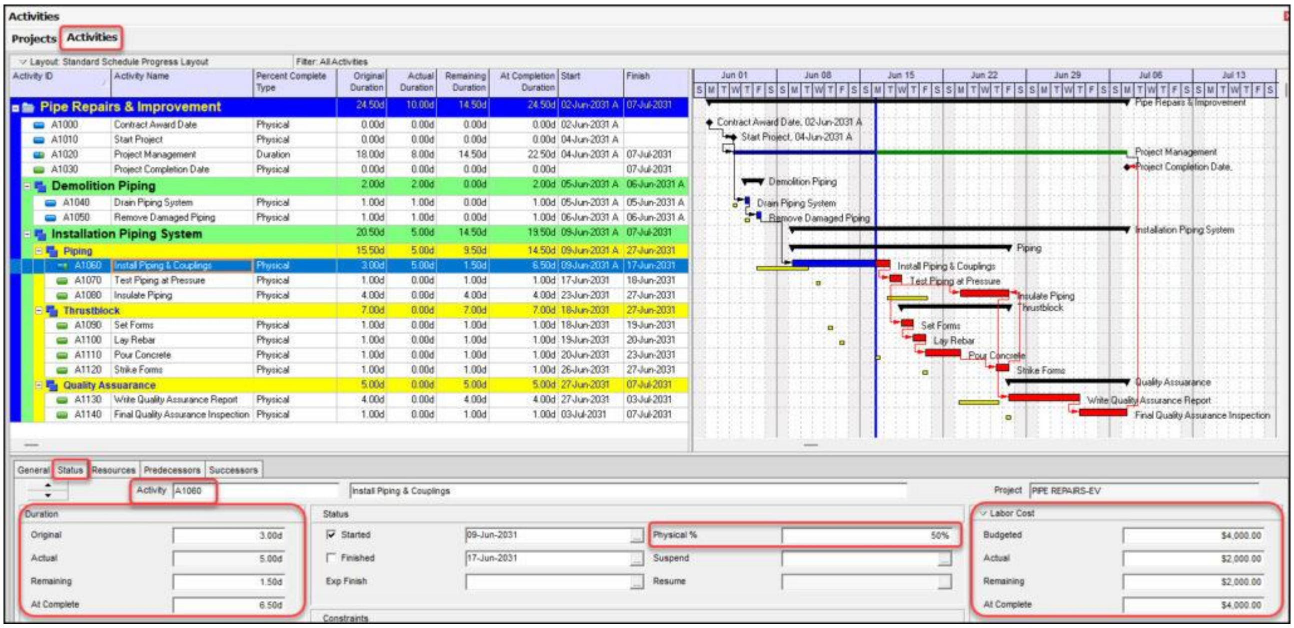


Figure 9

The scheduler specified the 50.0% Physical % progress and the 1.5-day RD for the Install Piping & Couplings task.

B. Progress Earned Value Data

We want to analyze the progress of our demonstration schedule using EV data. The data values Planned Value (PV), EV and AC, together with the Budget At Completion (BAC), constitute the primary building blocks for an EVM analysis of our demonstration schedule. For a write-up providing more insight into these EVM parameters, refer to the article at the following link:

The Earned Value Management (EVM) Building Blocks

To compute these EVM building blocks, the schedule needs a baseline. For the basics on baselining a P6 schedule, the following P6 article will help:

[Schedule Baselines In Primavera P6]

To compute the PV and EV, a basic understanding of how to progress a schedule in P6 Professional is required. Schedules are progressed in P6 Professional with a rigorous three-step process. Refer to the following article for the three steps to progressing a P6 schedule, along with an addendum on how to check for any resulting schedule drift.

[Progressing a Schedule in P6 Professional]

When updating the schedule, it is important to understand that LOE tasks are updated automatically by P6 and should require no status input. Refer to the following articles for a primer on LOE tasks:

[Primavera P6 Level of Effort]
[P6 Cost Loaded LOE Tasks and EVM Metrics]

In our demonstration schedule, the Project Management task is an LOE task. Its PV and EV should be computed automatically when the schedule is calculated. For a P6 Professional EVM primer—a basic demonstration of how to generate PV and EV, and how to generate or specify AC on a simple P6 schedule with baseline—refer to the article at the following link:

[Primavera P6 and Earned Value Management]

i. Planned Value Data

A tenet of EVM is that work is worth the planned or negotiated value (budget). PV is the term for the value of work and is the sum of each task's time-phased budget. As noted in the P6 EVM primer article above, the PV fields populate only after (1) task status entry, (2) the DD is moved forward and (3) schedule recalculation. After the schedule recalculation, we should confirm that there is no schedule drift and reset the RD for tasks that were falsely extended. Refer to the 'Progressing a Schedule in P6 Professional' article above.

ii. Earned Value Data

EV is the authorized work physically accomplished, valued at management's authorized budget (i.e., the negotiated price) for the completed work. We want to set how each Work Breakdown Structure (WBS) element (or deliverable) earns value. In Figure 10, the EV Technique for Computing Performance Percent Complete was set to Activity Percent Complete.

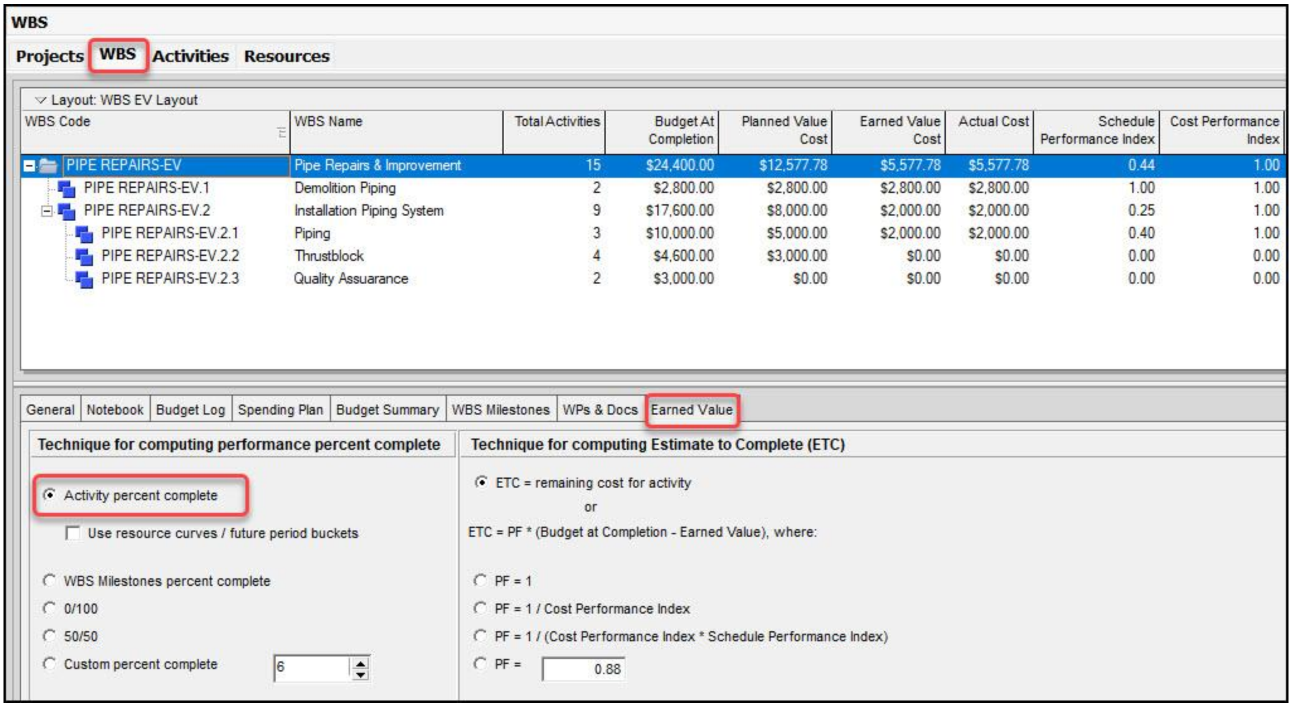


Figure 10

With this setting, the deliverable's EV is computed directly from the activity's percentage complete. Here, you do not have the conservative 0/100, where you receive credit only for completing the entire task. You also do not have the 50/50 setting, which gives you 50% credit just for starting the task, even if you make no progress early on.

The EV for each percentage complete type is computed from the BAC for each task, BAC_{task}:

$$EV_{Duration\,\%} = Duration\,\% \times BAC_{task}$$

$$EV_{Physical\,\%} = Physical\,\% \times BAC_{task}$$

The % completes come from the same field but are labeled differently for a Duration % task versus a Physical % task. Refer to Figures 8 and 9.

iii. Actual Cost Data

AC is the Funds spent on completing each activity. As with EV data, the AC for each task is driven by the assigned Percent-Complete Type: Duration % or Physical %.

For Duration % Complete, the AC equation is computed from the task's budgeted cost. The equation is as follows:

$$AC_{Duration\ \%} = Duration\ \% \times BC_{task} = Duration\ \% \times BAC_{task}$$

The BC_{task} is also the BAC_{task}—they are equivalent in the context of a specific task; they refer to the same amount.

A comparison of the $EV_{Duration\ \%}$ and $AC_{Duration\ \%}$ formulas shows the same structure for both (percent complete x BAC_{task}). For the project management LOE task without discrete deliverables (no invoices) but timesheets, AC is set to approximate EV. Figure 11 shows lump-sum loading for the Project Management task (bottom details, Resources tab).

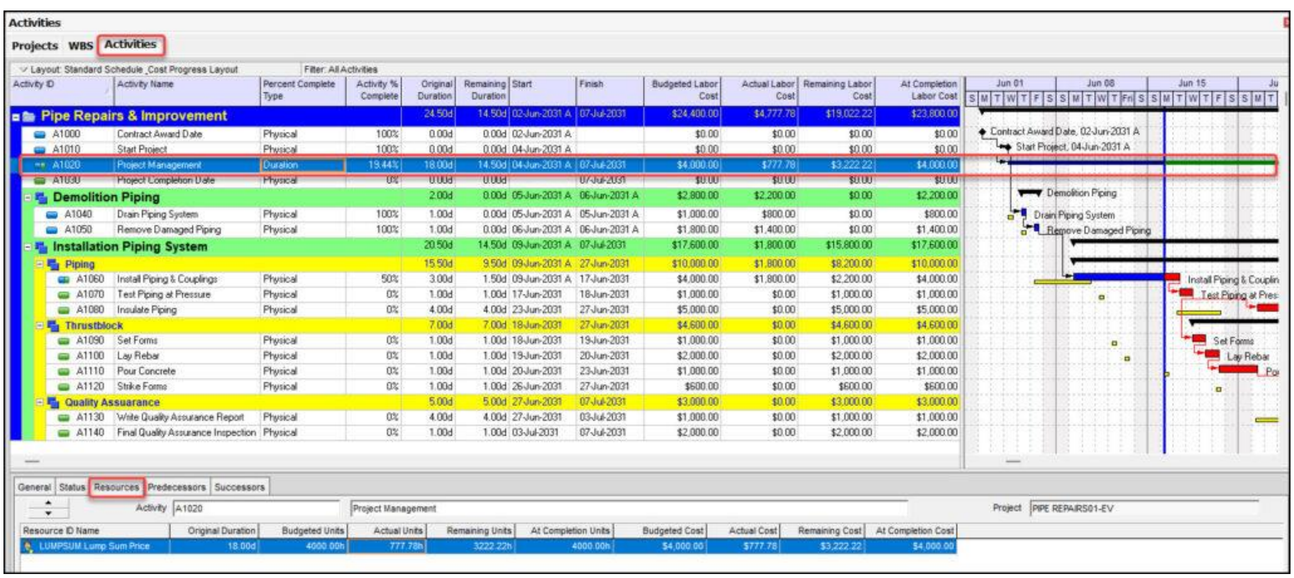


Figure 11

In Figure 11, the Project Management task has a budgeted cost of $4,000, an Activity % Complete of 19.44%, an AC of $777.78 and a remaining cost (RC) of

$3,222.22. The lump-sum resource loading for the Install Piping & Couplings task is shown in Figure 12 (bottom details, Resources tab).

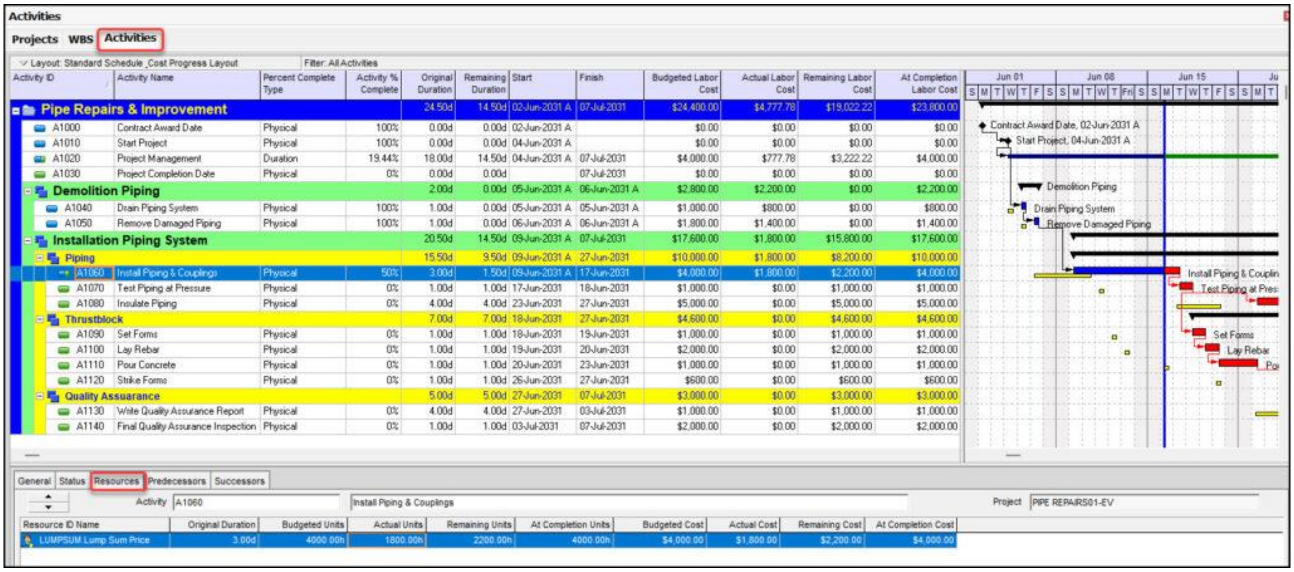


Figure 12

The Install Piping & Couplings task is Physical %. These Physical % tasks have two options:

1) Scheduler manually specifies (preferred)

2) Auto-calculated: $AC_{Physical} = \left(\frac{OD - RD_{revised}}{OD}\right) \times BAC_{task}$

For tasks like Install Piping & Couplings with discrete deliverables (invoices) and timesheets, AC is more typically user-specified. This ensures AC reflects real-world spending, making it unlikely to equal EV and allowing proper cost variance analysis. In Figure 12, the Install Piping & Couplings task has a BACof $4,000, a specified (manual-entry) AC of $1,800 and an RC of $2,200.

iv. Measures of Efficiency

Using the PV, EV, and AC EV data, we can compute the Schedule Performance Index (SPI) and the CPI. SPI shows progress efficiency, not exactly how far ahead or behind schedule it is time-wise. SPI is EV divided by PV.

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

CPI is the most significant utility; CPI enables statistical forecasting of final cost requirements. CPI is the EV divided by the AC.

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

Historical empirical project data have shown that there are likely no better indicators of project health than SPI and CPI.

4. Forecasting with Earned Value Data

We want to predict cost requirements (e.g., ETC, EAC, and CPI) to meet schedule and cost targets going forward. Period data captures PV, EV and AC for a single reporting period (e.g., a week or a month). Cumulative PV, EV and AC data sum these values from project start through the end of the current reporting period. Whereas period data shows immediate variance and short-term trends, cumulative data smooths volatility, yielding an overall performance measure useful for reliable long-term analysis.

A. P6 Professional Cumulative vs. Period Data

Figure 13 (Activities Table) displays EV columns: PV, EV, AC, SPI and CPI.

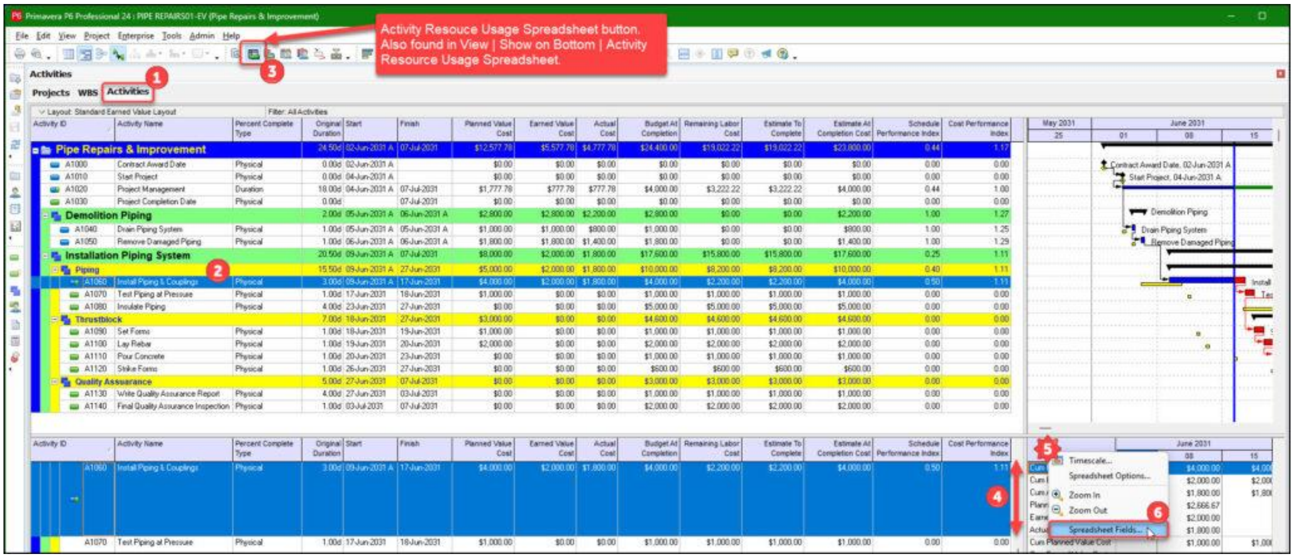


Figure 13

But are these cumulative or period data? The Activity Usage Spreadsheet clarifies this—showing the period and cumulative EV for a task (e.g., the Install Piping & Couplings task), which we can compare with the Activity Table EV values.

We proceeded in Figure 13 and performed the following left-clicks identified by numbered circular stamps and right-clicks identified by star stamps: (1) select (left-click) the Activities tab, (2) select (left-click) the Install Piping & Couplings task, (3) in the Bottom Layout tool group, left-click the Activities Usage Spreadsheet (4) left-click and drag vertical scroll to adjust the Activities Usage Spreadsheet (5) right-click next to (and left of) the spreadsheet timescale and (6) left-click the Spreadsheet Fields option.

This opens the Fields dialog box, where you can select options to view period PV, EV and AC data, as well as cumulative PV, EV, and AC data, Figure 14.

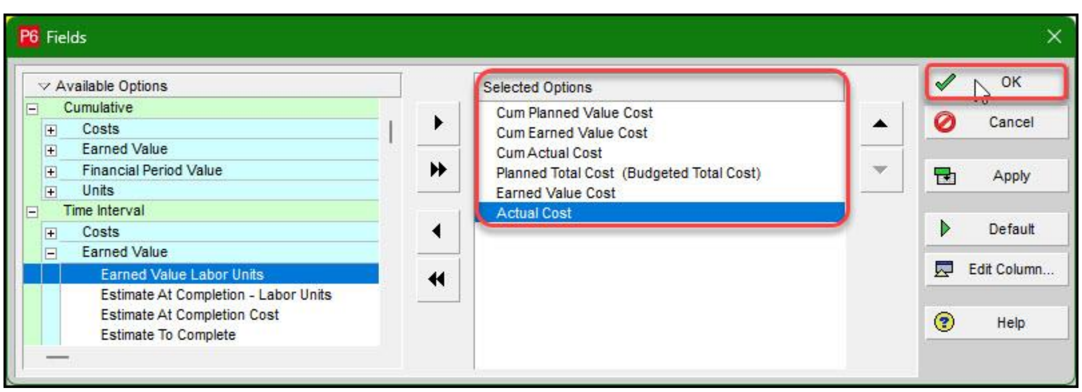


Figure 14

Click OK, Figure 14. Figure 15 shows (in the bottom details) the Activity Usage Spreadsheet for the reporting period ending June 16, 2031, at 8:00 AM.

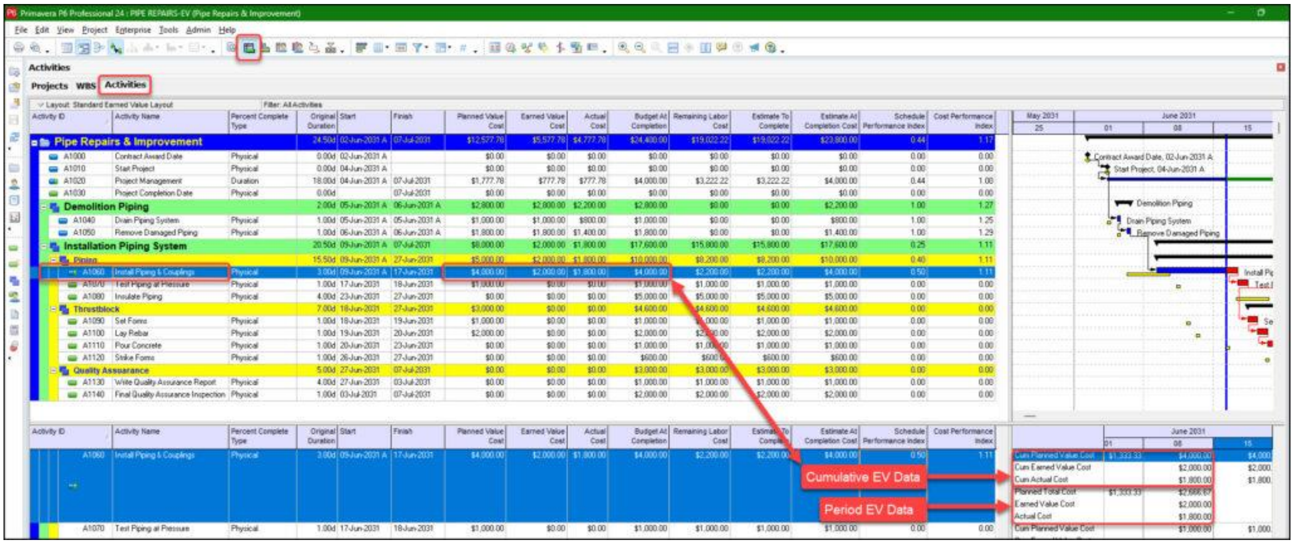


Figure 15

The Activity Usage Spreadsheet (Figure 15) lists the Cumulative EV Values and the Period EV Values below, based on the Selected Options in the Fields dialogue above. In Figure 15, the Activity Usage Spreadsheet shows that the cumulative EV data for the week (from June 8th at 8:00 AM to June 16th at 8:00 AM) matches the Activity Table values. Those table values represent cumulative EV data.

Note also that the Install Piping & Couplings task's SPI and CPI metrics, Figures 15, are computed as follows:

$$SPI = \frac{EV}{PV} = \frac{\$2{,}000}{\$4{,}000} = 0.5$$

$$CPI = \frac{EV}{AC} = \frac{\$2{,}000}{\$1{,}800} = 1.11$$

They are calculated from the cumulative PV, EV, and AC values. Therefore, confirming that the activity table lists the cumulative SPI and cumulative CPI. Moving forward, cumulative PV, EV, AC, SPI and CPI will be labeled simply PV, EV, AC, SPI, and CPI.

B. Additional Earned Value Data

Note also from Figure 15 at the project level, the BAC, the ETC and the EAC. The BAC is the original budget for the project; the cumulative PV equals BAC at the project completion. The ETC is the project funds required to complete the remaining work. The EAC forecasts the total funds required to complete the work.

C. Forecasting Estimate at Completion

The To Complete Performance Index (TCPI) in P6 Professional (and in EV generally) tells you, in cost terms, how efficiently you must perform the remaining work to meet a particular cost target, such as BAC or EAC. TCPI—the required CPI-like efficiency for remaining work to achieve BAC/EAC targets— is computed in P6 Professional ($_{P6}$) as follows:

$$TCPI_{P6} = \frac{BAC - EV}{EAC - AC}$$

In practice, however, as long as the project manager deems that the budget remains achievable, the hand calculation to compute $TCPI_{hand}$ is as follows:

$$TCPI_{hand} = \frac{BAC - EV}{BAC - AC}\text{, where the budget is achievable}$$

When EAC = BAC, $TCPI_{hand}$ calcs match P6. But when CPI > 1.0 or < 1.0 and EAC ≠ BAC, the $TCPI_{P6}$ differs from $TCPI_{hand}$ because P6 always computes it using EAC in the denominator—even when CPI > 1.0, underspending where no budget revision is needed.

In practice, schedulers hand-calculate $TCPI_{hand}$ using BAC—unless the CPI deteriorates materially below 1.0, making the budget unattainable (per project manager direction). Then they switch to $TCPI_{Revised\ Budget}$ using EAC in the denominator:

$$TCPI_{Revised\ Budget} = \frac{BAC - EV}{EAC - AC}$$

Where EAC is computed as follows:

$$EAC = AC + ETC$$

Again, EAC is the forecasted total project cost as of the status update.

i. Estimate to Complete Settings

But how P6 Professional computes ETC is dependent on the EV setting for the project and/or deliverable (WBS element). Figure 16 displays (stamps) the five settings or techniques available for P6 Professional's ETC computation in the WBS tab, bottom details, Earned Value tab.

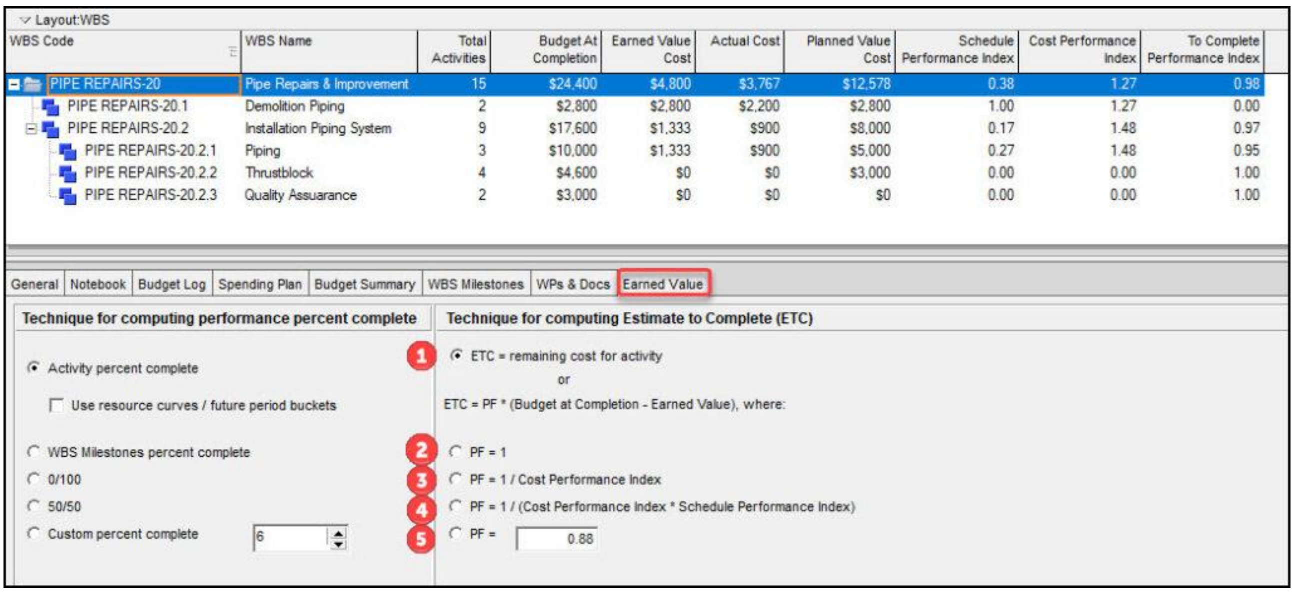


Figure 16

a) Core Attributes

Table 1 lists the Core Attributes for each of the five ETC computation technique settings, Figure 16 stamps 1 through 5.

Table 1 – ETC Setting Core Attributes

#	ETC Setting	Progress Stage	Performance Data	Optimism	ETC $ Range
1	Remaining Cost	Start < 10%	None	Neutral	Mid-High
2	PF = 1	Early (10 to 25%)	None	Optimistic	Optimistic
3	PF = 1/CPI	Mid (> 25%)	CPI	Most Likely	Mid
4	PF = 1/(CPI x SPI)	Mid (> 25%)	CPI and SPI	Pessimistic	Highest
5	User-Specified	Mature (>30%)	Data from 3+ Periods	Neutral	Neutral

In Table 1, the number 1 ETC Setting means ETC equals Remaining Cost, and numbers 2 through five, the ETC equation is as in Figure 16 and as follows:

$$ETC = PF \times (BAC - EV)$$

Where PF is defined for each ETC setting, settings 2 through 5.

In Table 1, note the progress stage at which the ETC technique is considered accurate, the performance (EV) data required and optimism. The ETC dollar ranges are estimates.

b) Decision-Making Details

Table 2 lists the Decision-Making Details for each ETC setting; Figure 16, settings 1 through 5.

Table 2 – Decision-Making Details

Stamp	ETC Setting	ETC Setting	Rationale	Forward Plan
1	Remaining Cost	Pure Baseline	Project start, no EV Data	Original Rates apply to the remaining schedule
2	PF = 1	Reset to Plan	Recovery Expected	No recovery/outperformance adjustment required, and 100% efficient anticipated
3	PF = 1/CPI	History Continues	Stable Cost Performance	Past CPI persists
4	PF = 1/(CPI x SPI)	Severe slippage	Troubled Projects	Adjust as required for slippage and overspending
5	User-Specified	Expert Judgment	Trend Change Expected	Customized CPI expected

c) Technique Usage

We now discuss each technique for computing ETC individually.

1. ETC = remaining cost of activity

This setting does not account for the project's EV and ignores historical cost efficiency (i.e., CPI). There is no reforecast of the remaining cost; it remains at the baseline even when the schedule is behind. Table 3 lists all CPI and SPI scenarios (assuming their values do not deviate significantly from 1), their forward views when the ETC setting equals the remaining cost, and the rationale for each scenario.

Table 3 – Scenarios for ETC Equals Remaining Cost and Forward View

#	CPI	SPI	ETC equals Remaining Cost Forward View	Rationale
1	< 1	= 1	Optimistic	On schedule but overspent. An unchanged remaining cost assumes a cost recovery not supported by past performance.
2	< 1	< 1	Strongly Optimistic	Cost and Schedule are poor, but future work is not penalized for either.
3	< 1	> 1	Optimistic	Ahead of schedule but overspent; unchanged remaining cost assumes cost recovery not supported by past performance.
4	= 1	= 1	Neutral	Past performance matches plan. Continuation of the plan.
5	= 1	< 1	Optimistic	An increased work rate is required, but ETC assumes no additional recovery cost.
6	= 1	> 1	Neutral or mildly optimistic	Concluding at baseline cost, though the schedule ahead assumes no cost to continue at the current rate, which is reasonable. But it has no contingency for slippage.
7	> 1	= 1	Neutral to mildly pessimistic	Holding the remaining cost at baseline does not credit the project for above-plan cost efficiency.
8	> 1	< 1	Mixed, often neutral	Cost-efficient, but the schedule is behind. Maintaining baseline cost reasonable for cost but optimistic for schedule.

#	CPI	SPI	ETC equals Remaining Cost Forward View	Rationale
9	> 1	> 1	Conservative	Past performance outperforms cost and schedule, maintaining current remaining cost under-credits that performance.

*Scenario 9 Forward View is conservative: under-crediting strong performance by reverting to the baseline (cautious relative to history) without assuming worse-than-baseline, pessimistic performance.

When ETC is computed using the remaining costs, the resulting interpretation varies dramatically across CPI/SPI combinations, as shown in Table 3. In Table 3, when CPI < 1, optimistic (i.e., it ignores poor cost history); CPI = 1, schedule-driven (behind = optimistic; on/ahead = neutral); CPI > 1: conservative (setting under-credits performance by reverting to baseline, not assuming worse-than-baseline/pessimistic).

2. ETC = PF x (BAC – EV) where: PF =1

Here, P6 Professional assumes that work moving forward will remain on budget, with CPI = 1. So, P6 Professional either ignores past performance as an indicator of future performance and sets ETC equal to BAC minus EV, or (1) the project manager anticipates corrections to past slippage, or (2) these variances come from atypical early issues not expected to persist. It assumes 100% cost efficiency when moving forward.

3. ETC = PF x (BAC – EV) where: PF =1/CPI

This ETC-computing technique assumes that moving forward, work will continue at its current cost efficiency, CPI. Empirical data from historical projects demonstrate that once construction progress reaches 20%, the cumulative CPI metric stabilizes. The most reliable forecast is to assume that the cumulative CPI remains at its current level for the remainder of the project. This ETC technique makes sense for forecasting the most likely outcome after 20% of the construction is complete.

4. ETC = PF x (BAC – EV) where: PF =1/(CPI x SPI)

This pessimistic forecast assumes past cost (CPI) and schedule (SPI) inefficiencies continue unchanged through completion. SPI captures the contribution of schedule inefficiencies to cumulative cost variances. Use after 25% progress when no cost recovery is expected, producing the highest ETC forecast.

5. ETC = PF x (BAC – EV) where: PF equals a value the scheduler specifies.

Use when the scheduler confidently predicts future efficiency differing from standard options. Here, PF > 1 forecasts more difficult/slower work (higher ETC); PF < 1 expects efficiency gains (lower ETC). Ideal after 30% progress, with clear trend changes expected.

D. Task vs. Project Level Earned Value Data

Task-level EV data tracks individual activity progress. Project-level data aggregates all project deliverables. Moving from task to project level introduces computational issues.

i. Clean Sums

BAC, PV and AC sum cleanly with no issues—they match the baseline exactly. Each WBS should have unique, non-overlapping BAC values (overlapping BACs cause double counting). Figure 17 shows clean rollups from the task → project level.

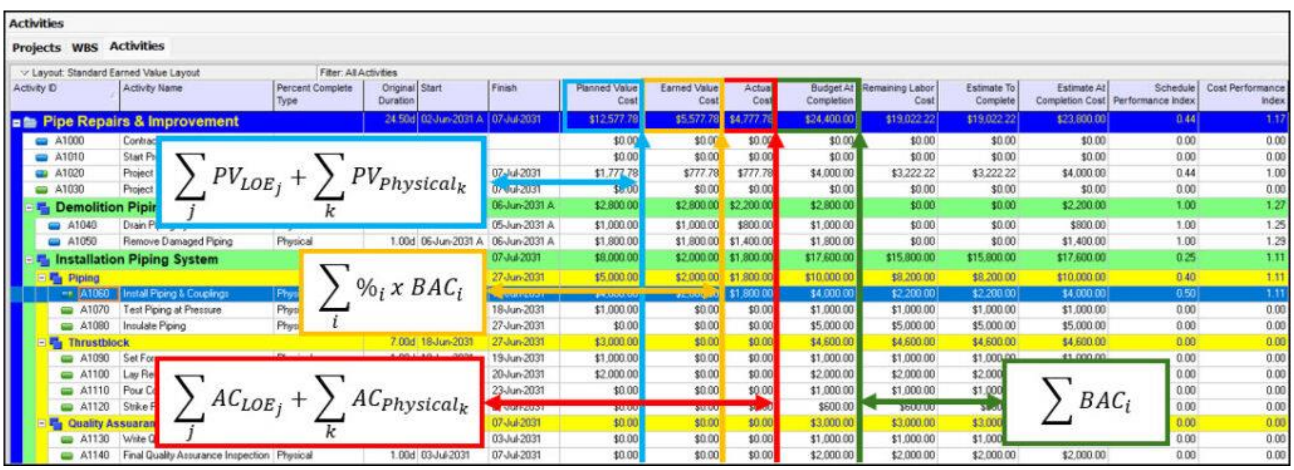


Figure 17

In our demo, the LOE is the sole Duration % task, so formulas use 'LOE' to represent both LOE and Duration % tasks. Figure 17 shows clean task-to-project rollups using these LOE summations.

a) Planned Value

The planned value represents the cost of work scheduled for completion by a specific date. It is calculated by multiplying the task's baseline-planned progress percentage by its total budget

$$PV_i = Schedule\ \%\ Complete \times BAC_{task}$$

Where Schedule % Complete is the progress that should have been made by the Data Date (DD) according to the baseline schedule.

The Duration % tasks labeled PV_{LOE} and the Physical % task labeled $PV_{Physical}$ sum cleanly to higher WBS elements and project levels.

$$PV_{Project} = \sum_j PV_{LOE_j} + \sum_k PV_{Physical_k}$$

PV at the project level is always the simple sum of PV values from all tasks, regardless of their type (Duration % (LOE), Physical %), since PV depends solely on the time-phased baseline schedule, not on actual progress measurement methods.

b) Earned Value

The EV for each percentage complete type is computed from the BAC for each task, BAC_{task}:

$$EV_{Duration\ \%} = Duration\ \% \times BAC_{task}$$

$$EV_{Physical\ \%} = Physical\ \% \times BAC_{task}$$

The EV for the project comes from the following summations:

$$EV_{Project} = EV_1 + EV_2 + \cdots = [(\%_1 \times BAC_1) + (\%_2 \times BAC_2) + \cdots] = \sum_i \%_i \times BAC_i$$

The percent-complete type only changes the % value used in the multiplication; BAC is identical for both methods (Duration % and Physical %) on the same task. Therefore:

$EV_{Project} = \sum(\%_{task} \times BAC_{task})$ regardless of the percentage complete type mix

And the EV values show no divergence between tasks and at the project level.

c) Actual Cost

As mentioned earlier, the AC of LOE (Duration % and LOE) differs from that of task-dependent tasks (Physical %):

$$AC_{LOE} = Duration\ \% \times BAC_{task}$$

Physical % complete, again, has two approaches:

1) Scheduler manually specifies (preferred)

2) Auto-calculated: $AC = \frac{OD-RD_{revised}}{OD} \times BC_{task}$

Then, for a single activity (task) i:

$$AC_i = sum\ of\ all\ costs\ incurred\ on\ task\ i$$

Remember that each task is a lump-sum cost loading, so each task has one AC_ . And for the project:

$$AC_{Project} = \sum_j AC_{LOE_j} + \sum_k AC_{Physical_k}$$

AC is always a clean bottom-up total of heterogeneous task AC values.

d) Budget At Completion

The BAC represents the total fixed budget baseline established at project outset.

$BAC_{Project} = \sum BAC_{task}$ (unaffected by the task percent complete type mix)

Where all task budgets sum regardless of how progress is later measured.

ii. Non-Clean Sums

Performance ratios exhibit non-clean aggregations of task metrics—they are calculated as ratios of the project totals, not as averages of task-level ratios.

a) Schedule Performance Index

SPI represents a non-clean sum where EV is divided by PV, calculated independently at each level.

$$SPI_{Task} = \frac{EV_i}{PV_i}$$

$$SPI_{Project} = \frac{EV_{project}}{PV_{project}} = \frac{\sum EV_i}{\sum PV_i} \neq \frac{\sum SPI_i}{n}$$

Figure 18 shows our SPI demonstration schedule with the non-clean sums; each level is independent of the others, ranging from the task level to the project level.

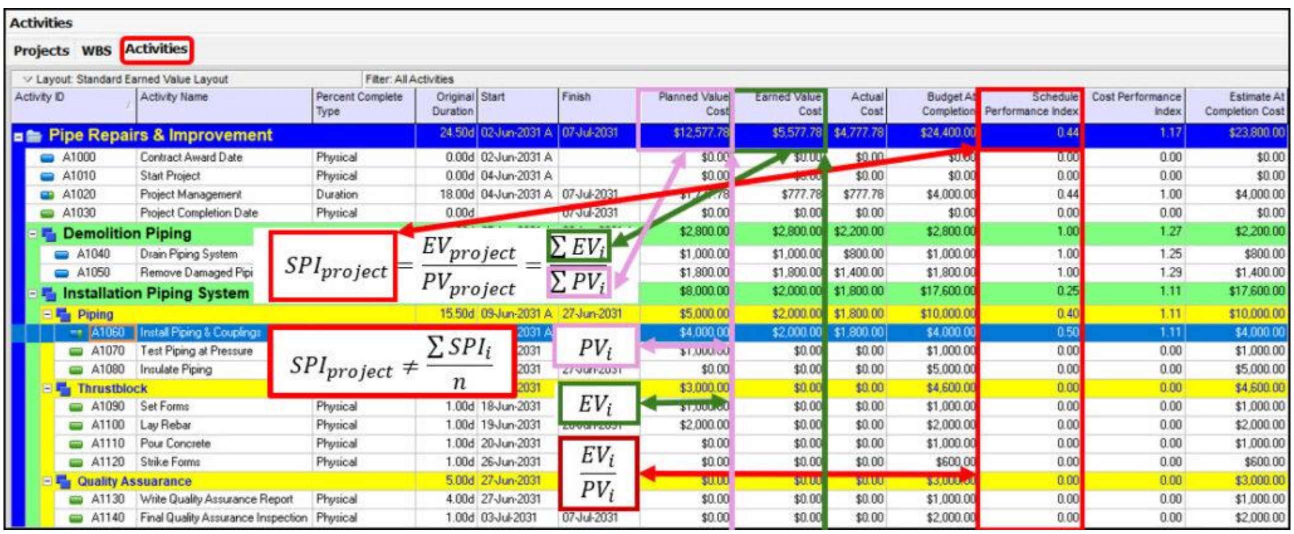


Figure 18

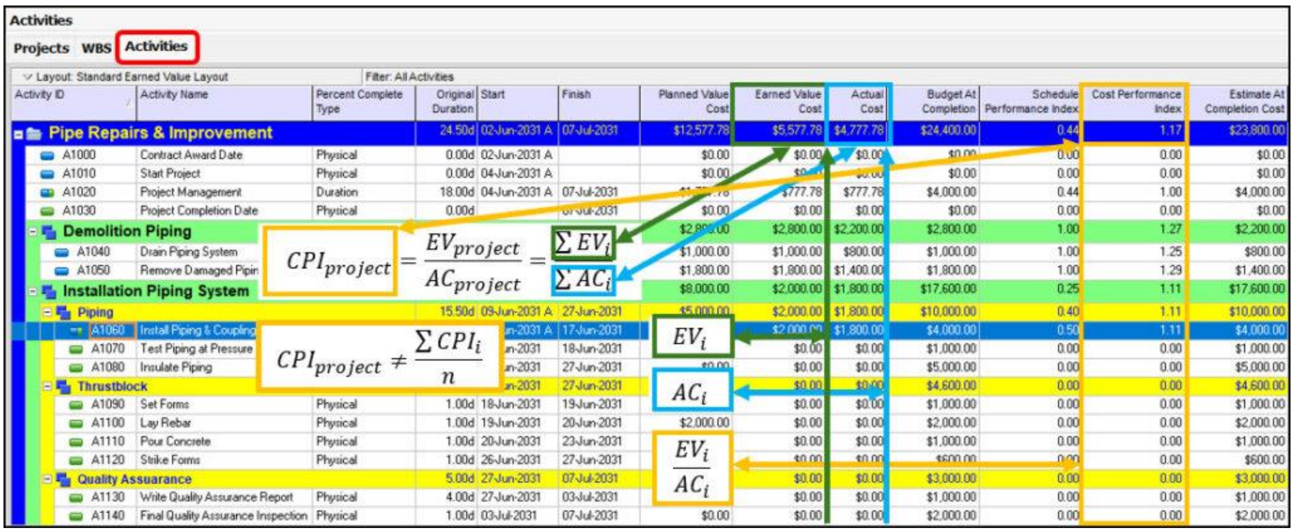
b) Cost Performance Index

CPI represents a non-clean sum where EV is divided by AC, calculated independently at each level.

$$CPI_{Task} = \frac{EV_i}{AC_i}$$

$$CPI_{Project} = \frac{EV_{project}}{AC_{project}} = \frac{\sum EV_i}{\sum AC_i} \neq \frac{\sum CPI_i}{n}$$

Figure 19 displays our demonstration schedule, again, this time including non-clean independent CPI values at the task-, deliverable-, and project-levels.



Activity ID	Activity Name	Percent Complete Type	Original Duration	Start	Finish	Planned Value Cost	Earned Value Cost	Actual Cost	Budget At Completion	Schedule Performance Index	Cost Performance Index	Estimate At Completion Cost
Pipe Repairs & Improvement			24.50d	02-Jun-2031 A	07-Jul-2031	$12,577.78	$5,577.78	$4,777.78	$24,400.00	0.44	1.17	$23,800.00
A1000	Contract Award Date	Physical	0.00d	02-Jun-2031 A		$0.00	$0.00	$0.00	$0.00	0.00	0.00	$0.00
A1010	Start Project	Physical	0.00d	04-Jun-2031 A		$0.00	[illegible]	[illegible]	$0.00	0.00	0.00	$0.00
A1020	Project Management	Duration	18.00d	04-Jun-2031 A	07-Jul-2031	[illegible]	$777.78	$777.78	$4,000.00	0.44	1.00	$4,000.00
A1030	Project Completion Date	Physical	0.00d		[illegible]	$0.00	$0.00	$0.00	$0.00	0.00	0.00	$0.00
Demolition Piping						[illegible]	$2,800.00	$2,200.00	$2,800.00	1.00	1.27	$2,200.00
A1040	Drain Piping System	[illegible]	[illegible]	[illegible]	[illegible]	$1,000.00	$1,000.00	$800.00	$1,000.00	1.00	1.25	$800.00
A1050	Remove Damaged Pipin	[illegible]	[illegible]	[illegible]	[illegible]	$1,800.00	$1,800.00	$1,400.00	$1,800.00	1.00	1.29	$1,400.00
Installation Piping System						$8,000.00	$2,000.00	$1,800.00	$17,600.00	0.25	1.11	$17,600.00
Piping			15.50d	09-Jun-2031 A	27-Jun-2031	[illegible]	$2,000.00	$1,800.00	$10,000.00	0.40	1.11	$10,000.00
A1060	Install Piping & Coupling	[illegible]	[illegible]	[illegible]	17-Jun-2031	[illegible]	[illegible]	$1,800.00	$4,000.00	0.50	1.11	$4,000.00
A1070	Test Piping at Pressure	[illegible]	[illegible]	[illegible]	18-Jun-2031	[illegible]	$0.00	$0.00	$1,000.00	0.00	0.00	$1,000.00
A1080	Insulate Piping	[illegible]	[illegible]	[illegible]	27-Jun-2031	[illegible]	$0.00	$0.00	$5,000.00	0.00	0.00	$5,000.00
Thrustblock			[illegible]	[illegible]	27-Jun-2031	[illegible]	[illegible]	[illegible]	$4,600.00	0.00	0.00	$4,600.00
A1090	Set Forms	Physical	1.00d	18-Jun-2031	19-Jun-2031	[illegible]	$0.00	$0.00	$1,000.00	0.00	0.00	$1,000.00
A1100	Lay Rebar	Physical	1.00d	19-Jun-2031	20-Jun-2031	$2,000.00	$0.00	$0.00	$2,000.00	0.00	0.00	$2,000.00
A1110	Pour Concrete	Physical	1.00d	20-Jun-2031	23-Jun-2031	[illegible]	$0.00	$0.00	$1,000.00	0.00	0.00	$1,000.00
A1120	Strike Forms	Physical	1.00d	26-Jun-2031	27-Jun-2031	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.00	$600.00
Quality Assurance			5.00d	27-Jun-2031	07-Jul-2031	[illegible]	$0.00	$0.00	$3,000.00	0.00	0.00	$3,000.00
A1130	Write Quality Assurance Report	Physical	4.00d	27-Jun-2031	03-Jul-2031	[illegible]	$0.00	$0.00	$1,000.00	0.00	0.00	$1,000.00
A1140	Final Quality Assurance Inspection	Physical	1.00d	03-Jul-2031	07-Jul-2031	$0.00	$0.00	$0.00	$2,000.00	0.00	0.00	$2,000.00

Figure 19

iii. Divergence – Estimate to Complete

Project ETC diverges from the bottom-up sum of task ETCs (ETC_{task}) in both the RC and PF formula methods.

a) Management ETC (Remaining Cost)

The remaining cost ETC—known as management ETC—uses this equation from project-level costs:

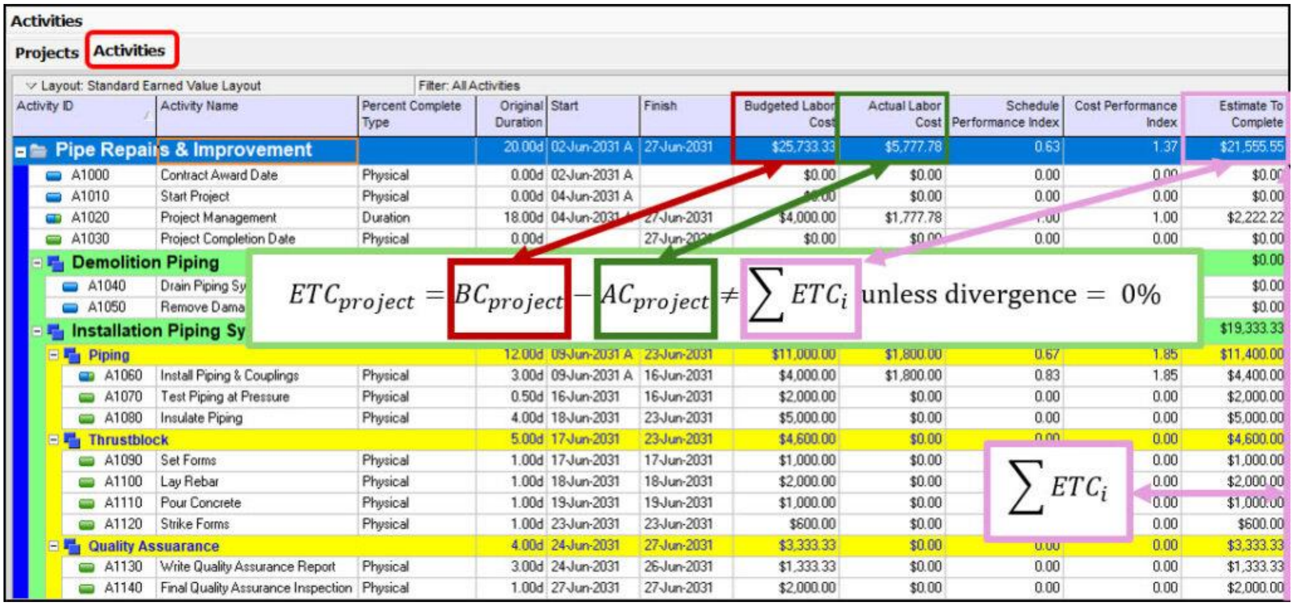
$$ETC_{Project} = BC_{project} - AC_{project}$$

This differs from the bottom-up sum:

$$ETC_{Project} \neq \sum ETC_i$$

(unless divergence = 0%)

Figure 20 displays the ETC project, by labor costs versus the $\sum ETC_{task}$.



Activities

Projects Activities

Layout: Standard Earned Value Layout | Filter: All Activities

Activity ID	Activity Name	Percent Complete Type	Original Duration	Start	Finish	Budgeted Labor Cost	Actual Labor Cost	Schedule Performance Index	Cost Performance Index	Estimate To Complete
Pipe Repairs & Improvement			20.00d	02-Jun-2031 A	27-Jun-2031	$25,733.33	$5,777.78	0.63	1.37	$21,555.55
A1000	Contract Award Date	Physical	0.00d	02-Jun-2031 A		$0.00	$0.00	0.00	0.00	$0.00
A1010	Start Project	Physical	0.00d	04-Jun-2031 A		[illegible]	$0.00	0.00	0.00	$0.00
A1020	Project Management	Duration	18.00d	04-Jun-2031 A	27-Jun-2031	$4,000.00	$1,777.78	[illegible]	1.00	$2,222.22
A1030	Project Completion Date	Physical	0.00d		27-Jun-2031	$0.00	$0.00	0.00	0.00	$0.00
Demolition Piping										$0.00
A1040	Drain Piping Sy									$0.00
A1050	Remove Dama									$0.00
Installation Piping Sy										$19,333.33
Piping			12.00d	09-Jun-2031 A	23-Jun-2031	$11,000.00	$1,800.00	0.67	1.85	$11,400.00
A1060	Install Piping & Couplings	Physical	3.00d	09-Jun-2031 A	16-Jun-2031	$4,000.00	$1,800.00	0.83	1.85	$4,400.00
A1070	Test Piping at Pressure	Physical	0.50d	16-Jun-2031	16-Jun-2031	$2,000.00	$0.00	0.00	0.00	$2,000.00
A1080	Insulate Piping	Physical	4.00d	18-Jun-2031	23-Jun-2031	$5,000.00	$0.00	0.00	0.00	$5,000.00
Thrustblock			5.00d	17-Jun-2031	23-Jun-2031	$4,600.00	$0.00	0.00	0.00	$4,600.00
A1090	Set Forms	Physical	1.00d	17-Jun-2031	17-Jun-2031	$1,000.00	$0.00		0.00	$1,000.00
A1100	Lay Rebar	Physical	1.00d	18-Jun-2031	18-Jun-2031	$2,000.00	$0.00		0.00	$2,000.00
A1110	Pour Concrete	Physical	1.00d	19-Jun-2031	19-Jun-2031	$1,000.00	$0.00		0.00	$1,000.00
A1120	Strike Forms	Physical	1.00d	23-Jun-2031	23-Jun-2031	$600.00	$0.00		0.00	$600.00
Quality Assurance			4.00d	24-Jun-2031	27-Jun-2031	$3,333.33	$0.00	0.00	0.00	$3,333.33
A1130	Write Quality Assurance Report	Physical	3.00d	24-Jun-2031	26-Jun-2031	$1,333.33	$0.00	0.00	0.00	$1,333.33
A1140	Final Quality Assurance Inspection	Physical	1.00d	27-Jun-2031	27-Jun-2031	$2,000.00	$0.00	0.00	0.00	$2,000.00

Figure 20

There are numerous reasons for the ($-1,600) divergence shown in Figure 20 ($25,733.33 – $5,777.78 versus $21,555.55). A likely explanation is that the scheduler specified At Completion Labor Costs (ACC), a practice often used in schedule-recovery scenarios.

b) Parametric Approaches (PF-Based)

Project-level parametric ETC versus task-level sum:

$$ETC_{Project} = PF \times \left(BAC_{project} - EV_{project}\right) \neq \sum ETC_i \text{ , } i = \text{task}$$

(Divergence occurs when PF ≠1 (1/CPI, 1/(CPI x SPI), or scheduler specified)

Figure 21 shows task-level ETC rollup versus project-level parametric ETC.

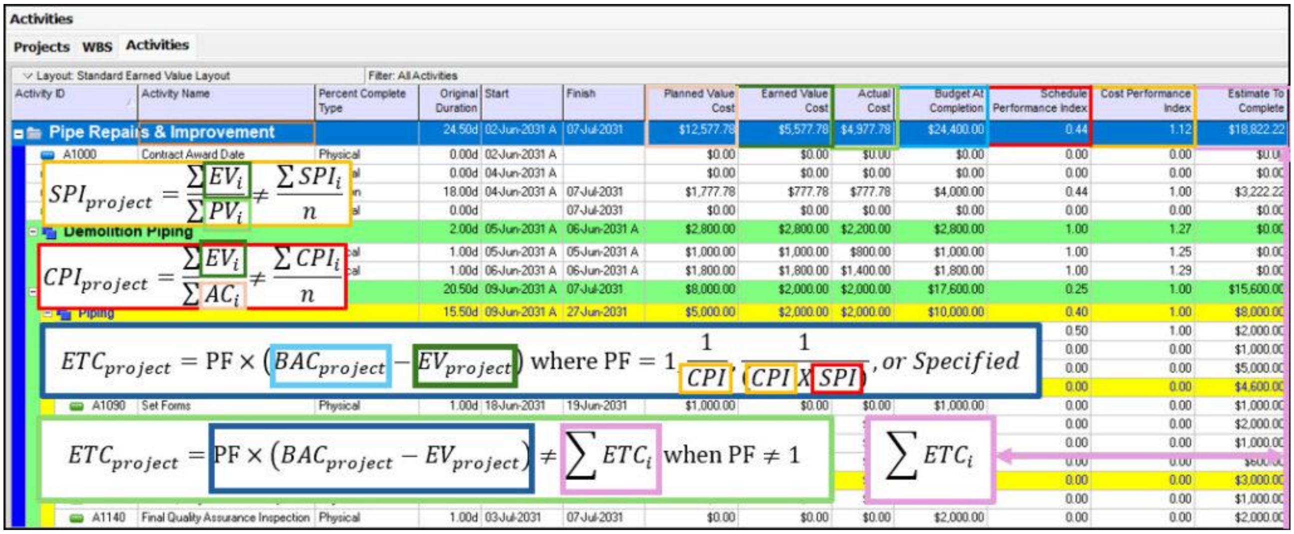


Figure 21

Figure 21 confirms that when PF ≠ 1, task-level parametric ETC rollups diverge from the project-level ETC.

5. Cumulative and Forecast Performance

We aim to assess the cumulative status of our schedule, then select an ETC setting that best aligns with our progress to forecast the remaining budget and the cost efficiency required to complete the work.

A. Cumulative Performance

Figure 22 displays the EV data needed to assess the to-date cumulative performance of our schedule.

Activity ID	Activity Name	Original Duration	Remaining Duration	Start	Finish	Planned Value Cost	Earned Value Cost	Actual Cost	Budget At Completion	Schedule Performance Index	Cost Performance Index
Pipe Repairs & Improvement		24.50d	14.50d	02-Jun-2031 A	07-Jul-2031	$12,577.78	$5,577.78	$4,777.78	$24,400.00	0.44	1.17
A1000	Contract Award Date	0.00d	0.00d	02-Jun-2031 A		$0.00	$0.00	$0.00	$0.00	0.00	0.00
A1010	Start Project	0.00d	0.00d	04-Jun-2031 A		$0.00	$0.00	$0.00	$0.00	0.00	0.00
A1020	Project Management	18.00d	14.50d	04-Jun-2031 A	07-Jul-2031	$1,777.78	$777.78	$777.78	$4,000.00	0.44	1.00
A1030	Project Completion Date	0.00d	0.00d		07-Jul-2031	$0.00	$0.00	$0.00	$0.00	0.00	0.00
Demolition Piping		2.00d	0.00d	05-Jun-2031 A	06-Jun-2031 A	$2,800.00	$2,800.00	$2,200.00	$2,800.00	1.00	1.27
A1040	Drain Piping System	1.00d	0.00d	05-Jun-2031 A	05-Jun-2031 A	$1,000.00	$1,000.00	$800.00	$1,000.00	1.00	1.25
A1050	Remove Damaged Piping	1.00d	0.00d	06-Jun-2031 A	06-Jun-2031 A	$1,800.00	$1,800.00	$1,400.00	$1,800.00	1.00	1.29
Installation Piping System		20.50d	14.50d	09-Jun-2031 A	07-Jul-2031	$8,000.00	$2,000.00	$1,800.00	$17,600.00	0.25	1.11
Piping		15.50d	9.50d	09-Jun-2031 A	27-Jun-2031	$5,000.00	$2,000.00	$1,800.00	$10,000.00	0.40	1.11
A1060	Install Piping & Couplings	3.00d	1.50d	09-Jun-2031 A	17-Jun-2031	$4,000.00	$2,000.00	$1,800.00	$4,000.00	0.50	1.11
A1070	Test Piping at Pressure	1.00d	1.00d	17-Jun-2031	18-Jun-2031	$1,000.00	$0.00	$0.00	$1,000.00	0.00	0.00
A1080	Insulate Piping	4.00d	4.00d	23-Jun-2031	27-Jun-2031	$0.00	$0.00	$0.00	$5,000.00	0.00	0.00
Thrustblock		7.00d	7.00d	18-Jun-2031	27-Jun-2031	$3,000.00	$0.00	$0.00	$4,600.00	0.00	0.00
A1090	Set Forms	1.00d	1.00d	18-Jun-2031	19-Jun-2031	$1,000.00	$0.00	$0.00	$1,000.00	0.00	0.00
A1100	Lay Rebar	1.00d	1.00d	19-Jun-2031	20-Jun-2031	$2,000.00	$0.00	$0.00	$2,000.00	0.00	0.00
A1110	Pour Concrete	1.00d	1.00d	20-Jun-2031	23-Jun-2031	$0.00	$0.00	$0.00	$1,000.00	0.00	0.00
A1120	Strike Forms	1.00d	1.00d	26-Jun-2031	27-Jun-2031	$0.00	$0.00	$0.00	$600.00	0.00	0.00
Quality Assurance		5.00d	5.00d	27-Jun-2031	07-Jul-2031	$0.00	$0.00	$0.00	$3,000.00	0.00	0.00
A1130	Write Quality Assurance Report	4.00d	4.00d	27-Jun-2031	03-Jul-2031	$0.00	$0.00	$0.00	$1,000.00	0.00	0.00
A1140	Final Quality Assurance Inspection	1.00d	1.00d	03-Jul-2031	07-Jul-2031	$0.00	$0.00	$0.00	$2,000.00	0.00	0.00

Figure 22

Figure 22: has CPI 1.17 (efficient spending) but SPI 0.44 (severe distress). Students from one company reported that SPI < 0.95 triggers recovery plans and SPI < 0.85 risks contract termination. Our demo (SPI<<1) is in serious trouble.

B. Forecast Performance

We must decide which ETC setting to use when forecasting. Remember that P6 Professional computes the TCPI using EAC.

$$TCPI_{P6} = \frac{BAC - EV}{EAC - AC}$$

The equation for EAC is AC + ETC, so EAC is driven by ETC. The question becomes which ETC setting we should use to forecast our schedule's ETC and, therefore, EAC?

A CPI > 1 indicates good cost efficiency; TCPI uses BAC because the budget remains achievable. However, reasonable spending yielded an SPI of 0.44 (compared with the student-reported 0.85 contract-removal threshold), indicating schedule failure despite cost control.

Before deciding on our ETC technique, we should first assess the status of construction completion. Figure 23 lists the Physical %, Duration %, Activity % and Schedule % Complete.

TENSIX®

Activities

Projects WBS **Activities**

Layout: Standard Percent Layout | Filter: All Activities

Activity ID	Activity Name	Original Duration	Remaining Duration	Start	Finish	Schedule % Complete	Activity % Complete	Duration % Complete	Physical % Complete
Pipe Repairs & Improvement		24.50d	14.50d	02-Jun-2031 A	07-Jul-2031	51.55%		40.82%	
A1000	Contract Award Date	0.00d	0.00d	02-Jun-2031 A		100%	100%	100%	100%
A1010	Start Project	0.00d	0.00d	04-Jun-2031 A		100%	100%	100%	100%
A1020	Project Management	18.00d	14.50d	04-Jun-2031 A	07-Jul-2031	44.44%	19.44%	19.44%	0%
A1030	Project Completion Date	0.00d	0.00d		07-Jul-2031	0%	0%	0%	0%
Demolition Piping		2.00d	0.00d	05-Jun-2031 A	06-Jun-2031 A	100%		100%	
A1040	Drain Piping System	1.00d	0.00d	05-Jun-2031 A	05-Jun-2031 A	100%	100%	100%	100%
A1050	Remove Damaged Piping	1.00d	0.00d	06-Jun-2031 A	06-Jun-2031 A	100%	100%	100%	100%
Installation Piping System		20.50d	14.50d	09-Jun-2031 A	07-Jul-2031	45.45%		29.27%	
Piping		15.50d	9.50d	09-Jun-2031 A	27-Jun-2031	50%		38.71%	
A1060	Install Piping & Couplings	3.00d	1.50d	09-Jun-2031 A	17-Jun-2031	100%	50%	50%	50%
A1070	Test Piping at Pressure	1.00d	1.00d	17-Jun-2031	18-Jun-2031	100%	0%	0%	0%
A1080	Insulate Piping	4.00d	4.00d	23-Jun-2031	27-Jun-2031	0%	0%	0%	0%
Thrustblock		7.00d	7.00d	18-Jun-2031	27-Jun-2031	65.22%		0%	
A1090	Set Forms	1.00d	1.00d	18-Jun-2031	19-Jun-2031	100%	0%	0%	0%
A1100	Lay Rebar	1.00d	1.00d	19-Jun-2031	20-Jun-2031	100%	0%	0%	0%
A1110	Pour Concrete	1.00d	1.00d	20-Jun-2031	23-Jun-2031	0%	0%	0%	0%
A1120	Strike Forms	1.00d	1.00d	26-Jun-2031	27-Jun-2031	0%	0%	0%	0%
Quality Assurance		5.00d	5.00d	27-Jun-2031	07-Jul-2031	0%		0%	
A1130	Write Quality Assurance Report	4.00d	4.00d	27-Jun-2031	03-Jul-2031	0%	0%	0%	0%
A1140	Final Quality Assurance Inspection	1.00d	1.00d	03-Jul-2031	07-Jul-2031	0%	0%	0%	0%

Figure 23

Activity % Complete is either Duration % or Physical %, depending on the Percent Complete Type of the task assignment.

Figure 23 shows 51.55% Schedule % Complete versus 40.82% project-level Duration % complete—indicating a true 40% construction progress. (Note that Physical % and Activity % do not tabulate at the deliverable-levels.) The cumulative CPI after 40% should be considered a stable indicator going forward.

Thus, our schedule scenario is a lump-cost-loaded, progressed schedule with SPI << 1, CPI > 1, 40% construction complete and Technique for Computing Performance Percent Complete: Activity % Complete.

Our project shows CPI > 1 but SPI << 1, requiring ETC = Remaining Cost. Table 3's Scenario 8 (CPI>, SPI<) is the closest match for our cost-efficient yet schedule-distressed state. Scenario 8's forward view: baseline cost is reasonable; schedule is optimistic. But our SPI<<1 signals worse distress. We require guidance that is more specific to our situation.

Table 4 validates ETC techniques for our scenario (40% complete, SPI << 1, CPI > 1).

Table 4 – Validity of ETC Technique for SPI <<1, CPI > 1, 40% Construction Complete

#	ETC Technique	Acceptable	Reasoning
1	Remaining Cost	Yes	Honors at completion cost override while activity % complete drives EV correctly. Manual duration/cost schedule recovery achieved at the new EAC.
2	PF = 1.0	No	Does not recover the schedule, and the formula recalculates from BAC, regardless of the manual at-completion cost override.
3	PF = 1/CPI	No	Past CPI efficiency is stable but cannot accommodate schedule recovery from SPI << 1, and the formula recalculates from BAC regardless of the manual at completion cost override.
4	PF = 1/(CPI x SPI)	No	No schedule recovery, it blends SPI and CPI trends, but SPI << 1 skews PF; the manual at-completion cost override is also overwritten
5	PF scheduler specified	No	No schedule recovery and the manual at-completion cost override is also overwritten.

Table 4 shows that only (1) ETC = Remaining Cost is viable for time-constrained recovery. All (2-5) alternatives compute ETC with schedule slippage. Further, (2-5) ETC techniques use formulaic overrides:

$$ETC = PF \times (BAC - EV)$$

These recompute your manual ETC from increased recovery costs. Management-directed recovery requires preserving the specified ACC.

For a non-time-constrained schedule: PF=1 (optimistic), PF=1/CPI (most likely), and a scheduler-specified option (Project Manager confidence required) merit consideration. Eliminate PF = 1/(CPI × SPI) when SPI << 1, as this disproportionately skews the PF. All (2-5) accept schedule slippage versus ETC, remaining cost recovery. Weigh divergence rollup error % for final selection.

Conclusion: ETC = Remaining Cost (1) is our primary choice because it honors the manual EAC override and enables schedule recovery. Secondary options are PF backups (2-5), calculated prior to recovery implementation. Recovery testing will confirm (1) as preferred, then rank (2-5) by rollup error, EAC, and cost forecast.

C. Manual Schedule Recovery

Our overarching schedule recovery plan is to shorten key critical-path tasks, which are Physical % and Fixed Duration and Units. This surgical compression should reduce project duration while requiring a proportionate adjustment to the ACC for each compressed task. After manual entry, we will recalculate the schedule, keeping the DD on June 16, 2031, at 8:00 AM.

Figure 24 displays the schedule recovery plan for (40% complete, SPI << 1, and CPI > 1 conditions)

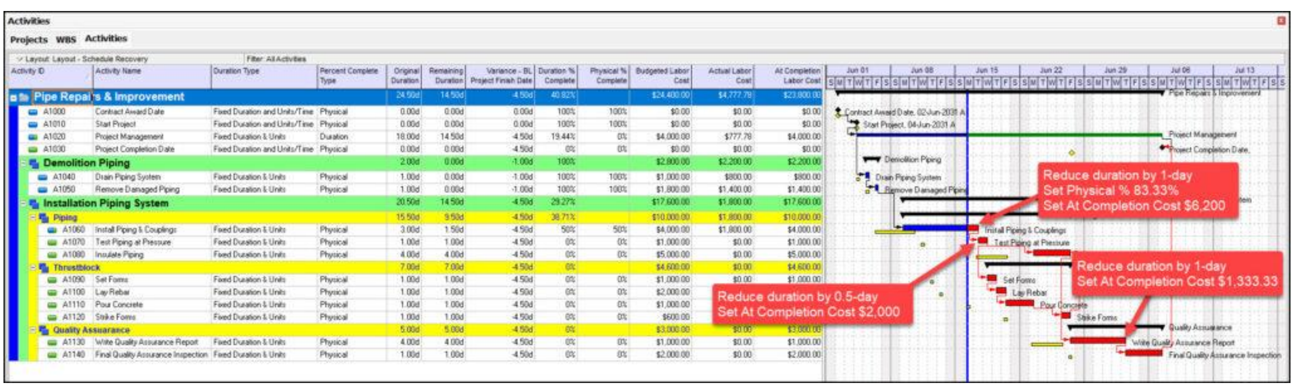


Figure 24

i. Pre-Schedule Recovery

Before recovery, verify that the project-level ETC equals the Remaining Cost. In the WBS tab, select the top-level project WBS element and confirm that ETC =

Remaining Cost (BAC – EV). (Refer to Figure10: WBS tab, bottom details, Earned Value tab).

ii. Schedule Recovery Steps

Apply task changes:

- Install Piping & Couplings: reduce duration by 1 day, Physical % = 83.33%.
- Test Piping at Pressure: reduce duration by 0.5 days.
- Write Quality Assurance Report: reduce duration by 1 day.

Run Schedule Tool (F9): Set DD to June 16, 2031, 8:00 AM and recalculate:

- Verify Current Finish reflects June 27, 2031, 4:00 PM
- Confirm Project Completion matches the BL Project Finish column.
- Note Install Piping & Couplings task auto-resets to 1,800 h; Actual Units to 3,333 h.

iii. Post-Schedule Recovery

Manual Units Entry:

- Install Piping & Couplings: reset AU to 1,800h ($1,800 AC) and set At Completion Units (ACU) to 6,200h ($6,200 ACC)
- Test Piping at Pressure: set to 2,000h ACU ($2,000 ACC)
- Write Quality Assurance Report: set to 1,333h ACU ($1,333 ACC)
- F9 Recalculate Schedule and confirm units/costs hold.

iv. Schedule Recovery Duration/Cost Results

Figure 25 displays the recovered project.

Activity ID	Activity Name	Duration Type	Original Duration	Remaining Duration	Physical % Complete	Variance - BL Project Finish Date	Budgeted Labor Cost	Actual Labor Cost	At Completion Labor Cost	Estimate To Complete	Estimate At Completion Cost
Pipe Repairs & Improvement			20.00d	10.00d		0.00d	$25,733.33	$5,777.78	$27,333.33	$21,555.55	$27,333.33
A1000	Contract Award Date	Fixed Duration and Units/Time	0.00d	0.00d	100%	0.00d	$0.00	$0.00	$0.00	$0.00	$0.00
A1010	Start Project	Fixed Duration and Units/Time	0.00d	0.00d	100%	0.00d	$0.00	$0.00	$0.00	$0.00	$0.00
A1020	Project Management	Fixed Duration & Units	18.00d	10.00d	0%	0.00d	$4,000.00	$1,777.78	$4,000.00	$2,222.22	$4,000.00
A1030	Project Completion Date	Fixed Duration and Units/Time	0.00d	0.00d	0%	0.00d	$0.00	$0.00	$0.00	$0.00	$0.00
Demolition Piping			2.00d	0.00d		-1.00d	$2,800.00	$2,200.00	$2,200.00	$0.00	$2,200.00
A1040	Drain Piping System	Fixed Duration & Units	1.00d	0.00d	100%	-1.00d	$1,000.00	$800.00	$800.00	$0.00	$800.00
A1050	Remove Damaged Piping	Fixed Duration & Units	1.00d	0.00d	100%	-1.00d	$1,800.00	$1,400.00	$1,400.00	$0.00	$1,400.00
Installation Piping System			16.00d	10.00d		0.00d	$18,933.33	$1,800.00	$21,133.33	$19,333.33	$21,133.33
Piping			12.00d	6.00d		-1.00d	$11,000.00	$1,800.00	$13,200.00	$11,400.00	$13,200.00
A1060	Install Piping & Couplings	Fixed Duration & Units	3.00d	0.50d	83.33%	-3.50d	$4,000.00	$1,800.00	$6,200.00	$4,400.00	$6,200.00
A1070	Test Piping at Pressure	Fixed Duration & Units	0.50d	0.50d	0%	-3.00d	$2,000.00	$0.00	$2,000.00	$2,000.00	$2,000.00
A1080	Insulate Piping	Fixed Duration & Units	4.00d	4.00d	0%	-1.00d	$5,000.00	$0.00	$5,000.00	$5,000.00	$5,000.00
Thrustblock			5.00d	5.00d		-1.00d	$4,600.00	$0.00	$4,600.00	$4,600.00	$4,600.00
A1090	Set Forms	Fixed Duration & Units	1.00d	1.00d	0%	-3.00d	$1,000.00	$0.00	$1,000.00	$1,000.00	$1,000.00
A1100	Lay Rebar	Fixed Duration & Units	1.00d	1.00d	0%	-3.00d	$2,000.00	$0.00	$2,000.00	$2,000.00	$2,000.00
A1110	Pour Concrete	Fixed Duration & Units	1.00d	1.00d	0%	-3.00d	$1,000.00	$0.00	$1,000.00	$1,000.00	$1,000.00
A1120	Strike Forms	Fixed Duration & Units	1.00d	1.00d	0%	-1.00d	$600.00	$0.00	$600.00	$600.00	$600.00
Quality Assurance			4.00d	4.00d		0.00d	$3,333.33	$0.00	$3,333.33	$3,333.33	$3,333.33
A1130	Write Quality Assurance Report	Fixed Duration & Units	3.00d	3.00d	0%	0.00d	$1,333.33	$0.00	$1,333.33	$1,333.33	$1,333.33
A1140	Final Quality Assurance Inspection	Fixed Duration & Units	1.00d	1.00d	0%	0.00d	$2,000.00	$0.00	$2,000.00	$2,000.00	$2,000.00

Figure 25

As verified in the Schedule Recovery Steps, the project meets the baseline end date. AC and ACC values: Install Piping & Couplings ($1,800/ $6,200), Test Piping at Pressure ($2,000) and Write Quality Assurance Report ($1,333).

D. Preliminary EAC and TCPI Results

We present the base schedule for the primary schedule-recovery ETC = Remaining Cost scenario (1) and the base non-recovered schedule for secondary scenarios (2-5). We then present preliminary EAC/TCPI results for scenario (1), followed by scenario (2), which is representative of the computations for follow-on scenarios (3-5).

i. Recovered Schedule – ETC Setting 1

The recovered schedule EV data is shown in Figure 26.

Activities

Projects WBS Activities

Layout: Standard Recovery Layout Filter: All Activities

Activity ID	Activity Name	Original Duration	Remaining Duration	Planned Value Cost	Earned Value Cost	Actual Cost	Budget At Completion	Estimate To Complete	Estimate At Completion Cost	Schedule Performance Index	Cost Performance Index	To Complete Performance Index
Pipe Repairs & Improvement		20.00d	10.00d	$12,577.78	$7,911.11	$5,777.78	$24,400.00	$21,555.55	$27,333.33	0.63	1.37	0.76
A1000	Contract Award Date	0.00d	0.00d	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	0.00	0.00	0.00
A1010	Start Project	0.00d	0.00d	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	0.00	0.00	0.00
A1020	Project Management	18.00d	10.00d	$1,777.78	$1,777.78	$1,777.78	$4,000.00	$2,222.22	$4,000.00	1.00	1.00	1.00
A1030	Project Completion Date	0.00d	0.00d	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	0.00	0.00	0.00
Demolition Piping		2.00d	0.00d	$2,800.00	$2,800.00	$2,200.00	$2,800.00	$0.00	$2,200.00	1.00	1.27	0.00
A1040	Drain Piping System	1.00d	0.00d	$1,000.00	$1,000.00	$800.00	$1,000.00	$0.00	$800.00	1.00	1.25	0.00
A1050	Remove Damaged Piping	1.00d	0.00d	$1,800.00	$1,800.00	$1,400.00	$1,800.00	$0.00	$1,400.00	1.00	1.29	0.00
Installation Piping System		16.00d	10.00d	$8,000.00	$3,333.33	$1,800.00	$17,600.00	$19,333.33	$21,133.33	0.42	1.85	0.74
Piping		12.00d	6.00d	$5,000.00	$3,333.33	$1,800.00	$10,000.00	$11,400.00	$13,200.00	0.67	1.85	0.58
A1060	Install Piping & Couplings	3.00d	0.50d	$4,000.00	$3,333.33	$1,800.00	$4,000.00	$4,400.00	$6,200.00	0.83	1.85	0.15
A1070	Test Piping at Pressure	0.50d	0.50d	$1,000.00	$0.00	$0.00	$1,000.00	$2,000.00	$2,000.00	0.00	0.00	0.50
A1080	Insulate Piping	4.00d	4.00d	$0.00	$0.00	$0.00	$5,000.00	$5,000.00	$5,000.00	0.00	0.00	1.00
Thrustblock		5.00d	5.00d	$3,000.00	$0.00	$0.00	$4,600.00	$4,600.00	$4,600.00	0.00	0.00	1.00
A1090	Set Forms	1.00d	1.00d	$1,000.00	$0.00	$0.00	$1,000.00	$1,000.00	$1,000.00	0.00	0.00	1.00
A1100	Lay Rebar	1.00d	1.00d	$2,000.00	$0.00	$0.00	$2,000.00	$2,000.00	$2,000.00	0.00	0.00	1.00
A1110	Pour Concrete	1.00d	1.00d	$0.00	$0.00	$0.00	$1,000.00	$1,000.00	$1,000.00	0.00	0.00	1.00
A1120	Strike Forms	1.00d	1.00d	$0.00	$0.00	$0.00	$600.00	$600.00	$600.00	0.00	0.00	1.00
Quality Assurance		4.00d	4.00d	$0.00	$0.00	$0.00	$3,000.00	$3,333.33	$3,333.33	0.00	0.00	0.90
A1130	Write Quality Assurance Report	3.00d	3.00d	$0.00	$0.00	$0.00	$1,000.00	$1,333.33	$1,333.33	0.00	0.00	0.75
A1140	Final Quality Assurance Inspection	1.00d	1.00d	$0.00	$0.00	$0.00	$2,000.00	$2,000.00	$2,000.00	0.00	0.00	1.00

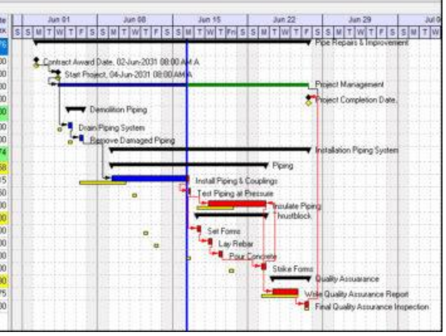


Figure 26

Figure 24 shows the schedule completed as originally planned. We shortened three critical tasks to achieve the end date. The schedule has a new EAC of $27,333, SPI of 0.63 and CPI of 1.37. The TCPI is computed as follows:

$$TCPI_{P6} = \frac{BAC - EV}{EAC - AC} = \frac{\$24{,}400 - \$7{,}911}{\$27{,}333 - 5{,}778} = \frac{\$16{,}489}{\$21{,}555} = 0.76$$

The TCPI of 0.76 indicates we can complete the project according to the schedule recovery plan's $27,333 EAC while maintaining a CPI of 0.76—providing a reassuring spending buffer.

ii. Non-Recovered Schedule – ETC Settings 2-5

These scenarios miss the end date but offer alternative EAC budgets and cost efficiencies. Decision-makers may accept a slight delay if the project is not strictly time-constrained. Include one of these alternative scenarios alongside the recovery plan in the final report.

Figure 27 shows the schedule progress without schedule recovery (scenario 2), which is representative of scenarios 3-5.


Activities

Projects WBS Activities

Layout: Layout Decision-Making_1 Filter: All Activities

Activity ID	Activity Name	Original Duration	Remaining Duration	Variance - BL Project Finish Date	Planned Value Cost	Earned Value Cost	Actual Cost	Budget At Completion	Estimate To Complete	Estimate At Completion Cost	Schedule Performance Index	Cost Performance Index	To Complete Performance Index
Pipe Repairs & Improvement		24.50d	14.50d	-4.50d	$12,577.78	$5,577.78	$4,777.78	$24,400.00	$18,822.22	$23,600.00	0.44	1.17	1.00
A1000	Contract Award Date	0.00d	0.00d	0.00d	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	0.00	0.00	0.00
A1010	Start Project	0.00d	0.00d	0.00d	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	0.00	0.00	0.00
A1020	Project Management	18.00d	14.50d	-4.50d	$1,777.78	$777.78	$777.78	$4,000.00	$3,222.22	$4,000.00	0.44	1.00	1.00
A1030	Project Completion Date	0.00d	0.00d	-4.50d	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	0.00	0.00	0.00
Demolition Piping		2.00d	0.00d	-1.00d	$2,800.00	$2,800.00	$2,200.00	$2,800.00	$0.00	$2,200.00	1.00	1.27	0.00
A1040	Drain Piping System	1.00d	0.00d	-1.00d	$1,000.00	$1,000.00	$800.00	$1,000.00	$0.00	$800.00	1.00	1.25	0.00
A1050	Remove Damaged Piping	1.00d	0.00d	-1.00d	$1,800.00	$1,800.00	$1,400.00	$1,800.00	$0.00	$1,400.00	1.00	1.29	0.00
Installation Piping System		20.50d	14.50d	-4.50d	$8,000.00	$2,000.00	$1,800.00	$17,600.00	$15,600.00	$17,400.00	0.25	1.11	1.00
Piping		15.50d	9.50d	-4.50d	$5,000.00	$2,000.00	$1,800.00	$10,000.00	$8,000.00	$9,800.00	0.40	1.11	1.00
A1060	Install Piping & Couplings	3.00d	1.50d	-4.50d	$4,000.00	$2,000.00	$1,800.00	$4,000.00	$2,000.00	$3,800.00	0.50	1.11	1.00
A1070	Test Piping at Pressure	1.00d	1.00d	-4.50d	$1,000.00	$0.00	$0.00	$1,000.00	$1,000.00	$1,000.00	0.00	0.00	1.00
A1080	Insulate Piping	4.00d	4.00d	-4.50d	$0.00	$0.00	$0.00	$5,000.00	$5,000.00	$5,000.00	0.00	0.00	1.00
Thrustblock		7.00d	7.00d	-4.50d	$3,000.00	$0.00	$0.00	$4,600.00	$4,600.00	$4,600.00	0.00	0.00	1.00
A1090	Set Forms	1.00d	1.00d	-4.50d	$1,000.00	$0.00	$0.00	$1,000.00	$1,000.00	$1,000.00	0.00	0.00	1.00
A1100	Lay Rebar	1.00d	1.00d	-4.50d	$2,000.00	$0.00	$0.00	$2,000.00	$2,000.00	$2,000.00	0.00	0.00	1.00
A1110	Pour Concrete	1.00d	1.00d	-4.50d	$0.00	$0.00	$0.00	$1,000.00	$1,000.00	$1,000.00	0.00	0.00	1.00
A1120	Strike Forms	1.00d	1.00d	-4.50d	$0.00	$0.00	$0.00	$600.00	$600.00	$600.00	0.00	0.00	1.00
Quality Assurance		5.00d	5.00d	-4.50d	$0.00	$0.00	$0.00	$3,000.00	$3,000.00	$3,000.00	0.00	0.00	1.00
A1130	Write Quality Assurance Report	4.00d	4.00d	-4.50d	$0.00	$0.00	$0.00	$1,000.00	$1,000.00	$1,000.00	0.00	0.00	1.00
A1140	Final Quality Assurance Inspection	1.00d	1.00d	-4.50d	$0.00	$0.00	$0.00	$2,000.00	$2,000.00	$2,000.00	0.00	0.00	1.00

Figure 27

This schedule forms the basis for investigating ETC approaches 2 through 5. To match the project-level TCPI in Figure 27, first confirm that PF = 1. Note TCPI computes for each PF setting: 1, 1/CPI, 1/(CPI × SPI, and scheduler-specified.

Scenario 2: This non-recovered schedule (PF = 1) has a new EAC of $23,600, SPI of 0.44 and CPI of 1.17. The TCPI is computed as follows:

$$TCPI_{P6} = \frac{BAC - EV}{EAC - AC} = \frac{\$24,400 - \$5,578}{\$23,600 - 5,778} = \frac{\$18,822}{\$18,222} = 1.00$$

The TCPI of 1.00 indicates we can complete the project with slippage and a reduced EAC budget of $23,600, while maintaining a CPI of 1.00—no cost buffer.

Scenarios (3-5): computed similarly but with distinct PFs: results to follow.

e. Final EAC and TCPI Results

Results for all scenarios (1-5) are tabulated together for comparison.

i. Decision Matrix EV Calculation Inputs

Table 5 lists the EV data inputs for all ETC techniques; again, (1) Remaining Cost denotes the only schedule-recovery scenario.

Table 5 – Inputs

#	ETC Technique	PF	CPI_prj	SPI_prj	Budgeted Labor Cost	Actual Labor Cost	BAC	EV
1	Remaining Cost	NA	1.37	0.63	$25,733	$5,778	NA	NA
2	PF = 1	1.00	NA	NA	NA	NA	$24,400	$5,578
3	PF = 1/CPI	0.85	1.17	NA	NA	NA	$24,400	$5,578
4	PF = 1/(CPI x SPI)	1.92	1.17	0.44	NA	NA	$24,400	$5,578
5	PF = 1.25	1.25	0.8	NA	NA	NA	$24,400	$5,578

From Table 5, (ETC Technique 1):

- Budgeted Labor Cost: $25,733 (post schedule recovery budget).
- Actual Labor Cost: $5,778 (schedule recovery funds spent per DD).

Project Management AC is higher due to a compressed schedule (versus non-compressed inputs for other ETCs). Fixed funding and shorter duration equate to larger AC.

Install Piping and Couplings EV:

$$EV_{Physical\,\%} = Physical\,\% \times BAC_{task}$$

Compressed RD_revised increases Physical % complete in the above equation and EV amount.

ii. Reliability/Decision Matrix Results

Table 6 tabulates the ETC and divergence for each ETC Technique, along with an assessment of the acceptability of the results.

Table 6 – Divergence and Acceptability

#	ETC Technique	BAC	ETC_project Computation	ETC_project Sum ETC_task	Rollup Error	Acceptability	Rationale
1	Remaining Cost	$24,400	$19,956	$21,556	-7%	Acceptable	Common for baseline schedules, LOE-driven, documented
2	PF = 1	$24,400	$18,822	$19,022	-1%	Excellent	Validity confirmed
3	PF = 1/CPI	$24,400	$16,087	$18,622	-14%	Warning	Exceeds 10%, CPI rollup distortion apparent
4	PF = 1/(CPI x SPI)	$24,400	$36,562	$24,565	49%	Unacceptable	Aggregation error
5	PF = 1.25	$24,400	$23,528	$23,528	0%	Perfect	Validity confirmed

Table 7 summarizes each range and required actions.

Table 7 – ETC Divergence Tolerance Levels

Range	Status	Action
0-5%	Excellent	No action required
5-10%	Acceptable	Document drivers, continue monitoring
10-20%	Warning	Investigate causes, consider bottom-up only
>20%	Unacceptable	Use bottom up ∑ETC_task exclusively

Reviewing Tables 6 and 7 together, the overall results look agreeable. Schedule Recovery Scenario (-7% rollup not-great-but-acceptable range): We need to document the cause of this rollup error. Investigating, we follow the logic:

ETC = BAC – EV

$$EV_{Project} = BAC_{Project} - ETC_{Project} = \$24{,}400 - \$19{,}956 = \$4{,}444$$

$$\sum EV_{Task} = BAC_{Project} - \sum ETC_{Task} = \$24{,}400 - \$21{,}556 = \$2{,}844$$

$$EV_{Gap} = EV_{Project} - \sum EV_{Task} = \$4{,}444 - \$2{,}844 = \$1{,}600$$

The Project Management LOE overweights progress; it is EV = PV, while the Install Piping and Couplings task has EV < PV. The accomplishment (EV) of Project Management is not compatible with the schedule slippage of the other tasks. It is the driver of the CPI divergence:

$$\mathrm{CPI_{project}} = \frac{\sum \mathrm{EV_i}}{\sum \mathrm{AC_i}} \neq \frac{\sum \mathrm{CPI_i}}{\mathrm{n}}$$

The -7% rollup error stems from:

• EV vs. AC gap (document as primary cause)

• Project Management LOE task EV overweight (key driver)

ETC Senarios:

- PF = 1, 1.25: Valid results confirmed
- PF = 1/CPI: Warning range → investigate + consider sole use of bottom-up analysis
- PF = 1/(CPI×SPI): Aggregation errors → use bottom-up ETC_task sum only

Having assessed the reliability of our output, Table 8 presents the decision-making results.

Table 8 – Reliability/Decision Matrix

#	ETC Technique	ETC_project Computation	ETC_project Sum ETC_task	Rollup Error	Variance BL Project Finish (Days)	BAC	EAC	TCPI
1	Remaining Cost	$19,956	$21,556	-7%	0	$24,400	$27,333	0.76
2	PF = 1	$18,822	$19,022	-1%	-4.5	$24,400	$23,600	1.00
3	PF = 1/CPI	$16,087	$18,622	-14%	-4.5	$24,400	$23,400	1.01
4	PF = 1/(CPI x SPI)	$36,562	$24,565	49%	-4.5	$24,400	$27,743	0.77
5	PF = 1.25	$23,528	$23,528	0%	-4.5	$24,400	$23,528	0.80

The last four columns in Table 8 present leadership data, including the number of days from baseline finish variance, the BAC (baseline budget) relative to the EAC (forecasted total cost), and the required cost efficiency for each scenario to achieve the EAC.

F. Demonstration – Summary

ETC Technique (1) Remaining Cost has zero variance; (1) meets the schedule. Its schedule recovery was successful. Furthermore, its forecast is trustworthy; it has a -7% divergence rollup error, which is acceptable if its drivers' EV vs. AC gap is documented. Based on this documentation, we conclude that scenario (1) achieves schedule conformance at a cost of $2,933 and a TCPI buffer of

0.76. Scenario (5) saves $872 with a TCPI buffer of 0.80 and accepts a schedule slip.

Based on the EV data and metrics, two promising scenarios emerge: (1) meets the schedule at a new budget with a conservative required cost efficiency; (5) accepts slippage for a reduced budget with similar efficiency.

6. Conclusion

Proper EAC/TCPI forecasting requires schedulers to first understand schedule progress measurement, EVM fundamentals and ETC techniques.

PV, AC, BAC and EV aggregate as clean sums; CPI/SPI exhibit non-clean aggregation. Additionally, there is a rollup divergence between the bottom-up task ETC sum and the project-level formulas.

For the most accurate funding forecast, utilize the bottom-up ETC method. This approach is more accurate than project-level formulas because it aggregates individual task estimates.

Compute both methods and the % rollup error. Reasonable rollup errors, such as the -7% schedule recovery (with a documented LOE driver), confirm bottom-up reliability; larger unexplained errors require a fully documented bottom-up approach.

Effective forecasting yields a realistic EAC with TCPI<1 cost buffer, which is what you want.

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