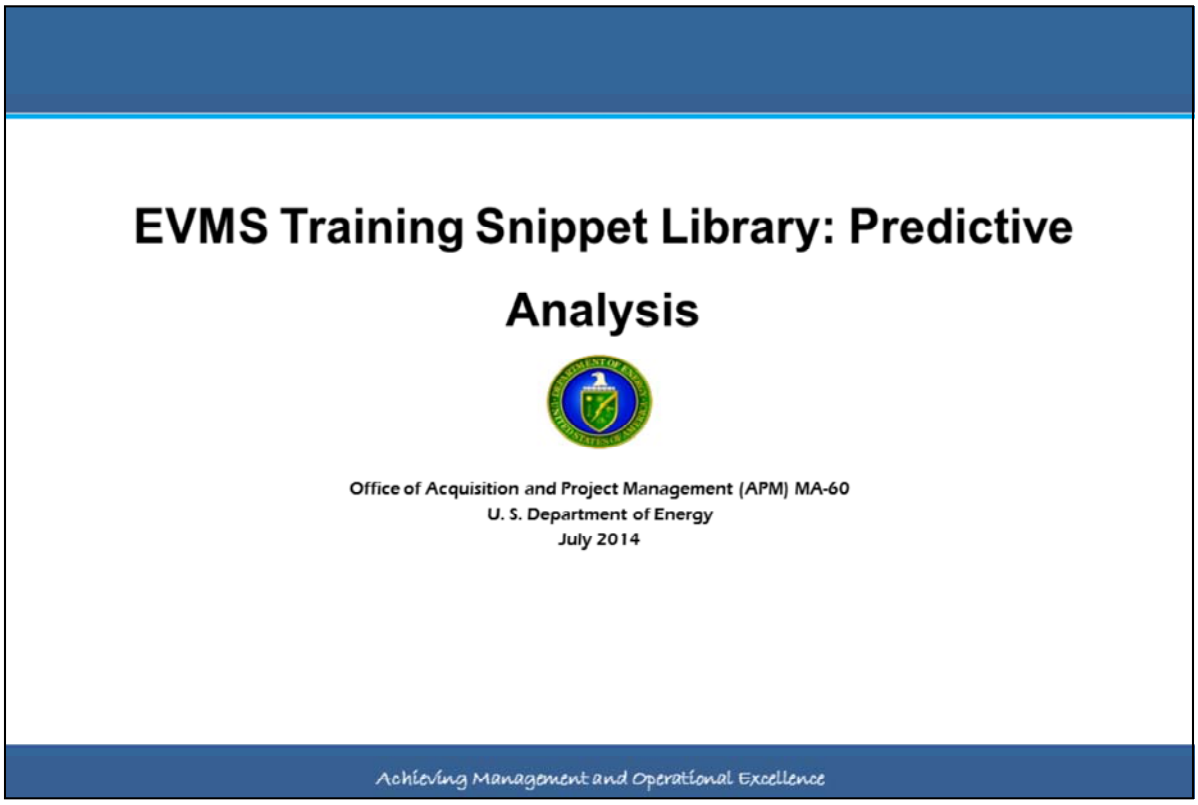
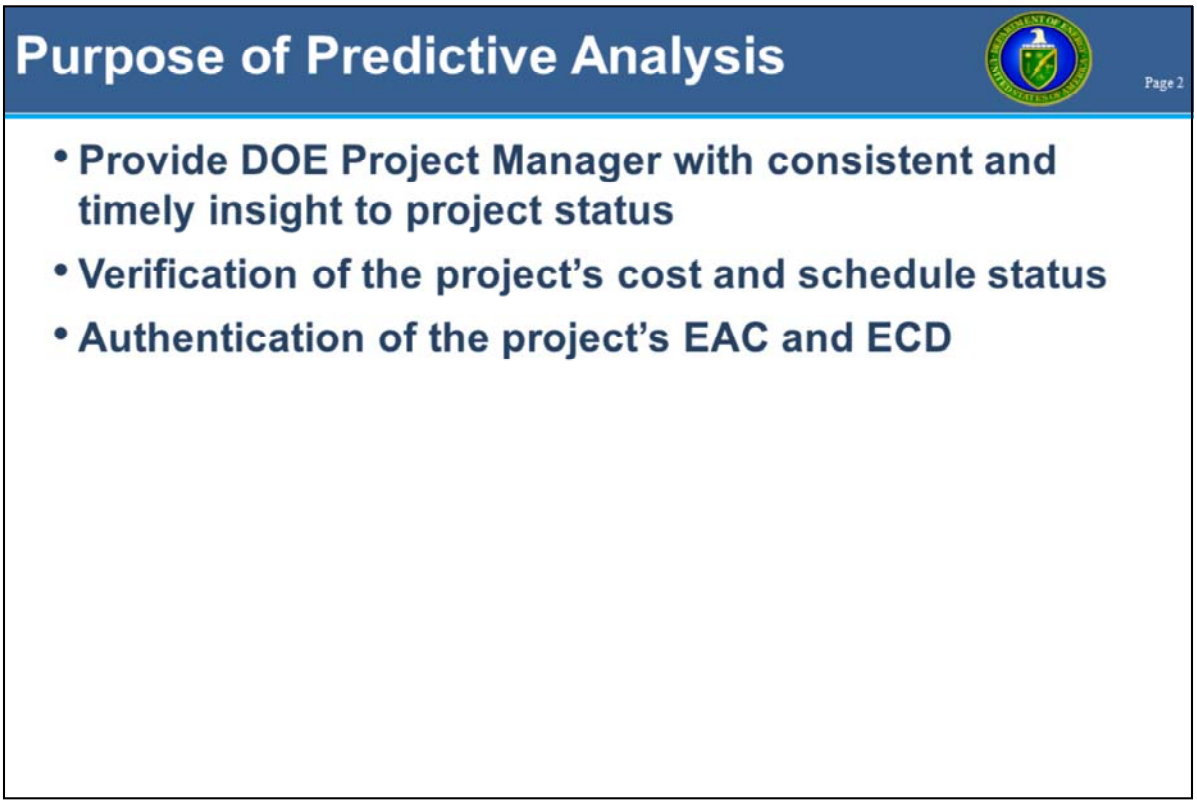


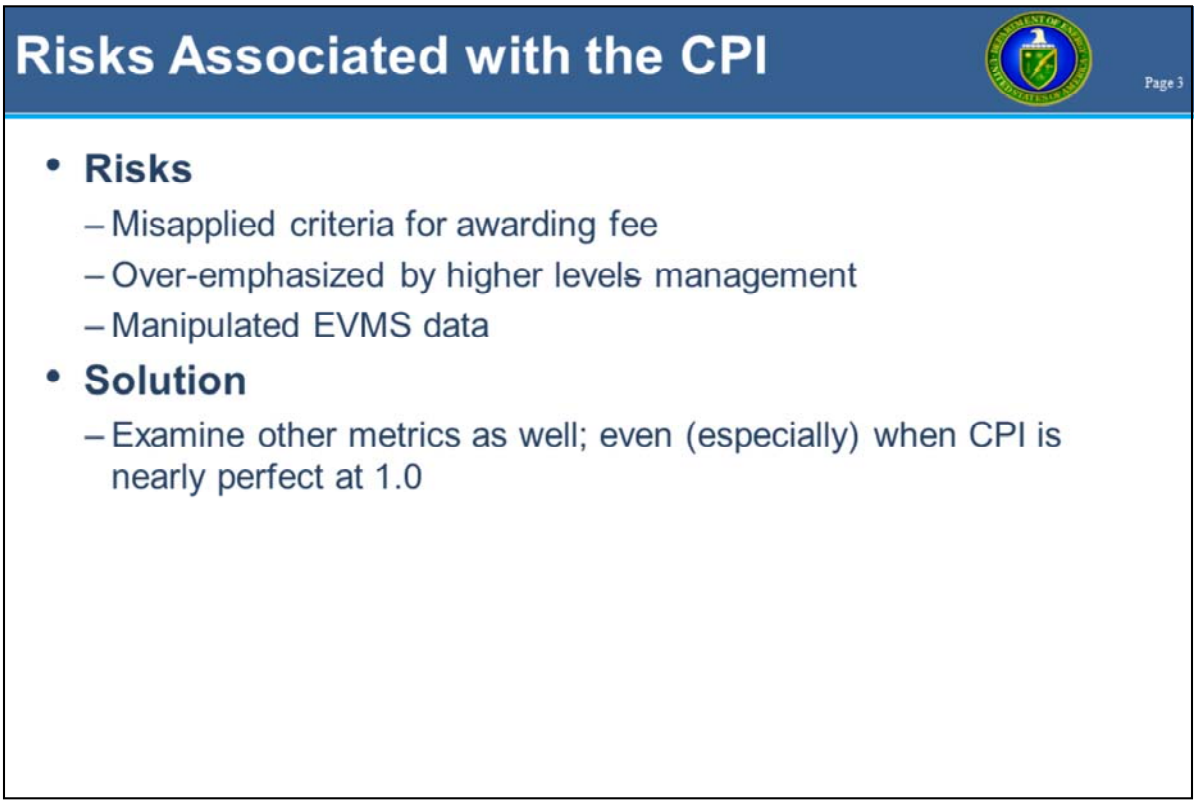
This EVMS Training Snippet, sponsored by the Office of Acquisition and Project Management (OAPM) discusses various methods to predict future performance. The focus is on the Federal management and oversight perspective of reviewing project performance when schedule and cost performance indices are near 1.0. Alternative indicators may be used to predict future cost or schedule growth when CPI and SPI appear favorable.



Predictive analysis involves much more than monthly reviews of the contractor's performance report's schedule and cost variances and variances at completion. It also involves reviewing and understanding the project's EVM data indices and reports to gain insight into the future of the project should the SPI and CPI appear to be nearly perfect.

One of the DOE FPD's primary responsibilities is keeping higher level managers well informed on the project's forecasted cost and project CD 4 date. Analysis techniques provide the DOE FPD with the needed insight into project status and, when properly done, verify that status as reported by the contractor is accurate.

A principal purpose of the analyses is authentication of the contractor's Estimate at Completion, the total funds, or 'how much' the project will cost, and the Estimated Completion Date for the project, the 'when' date.



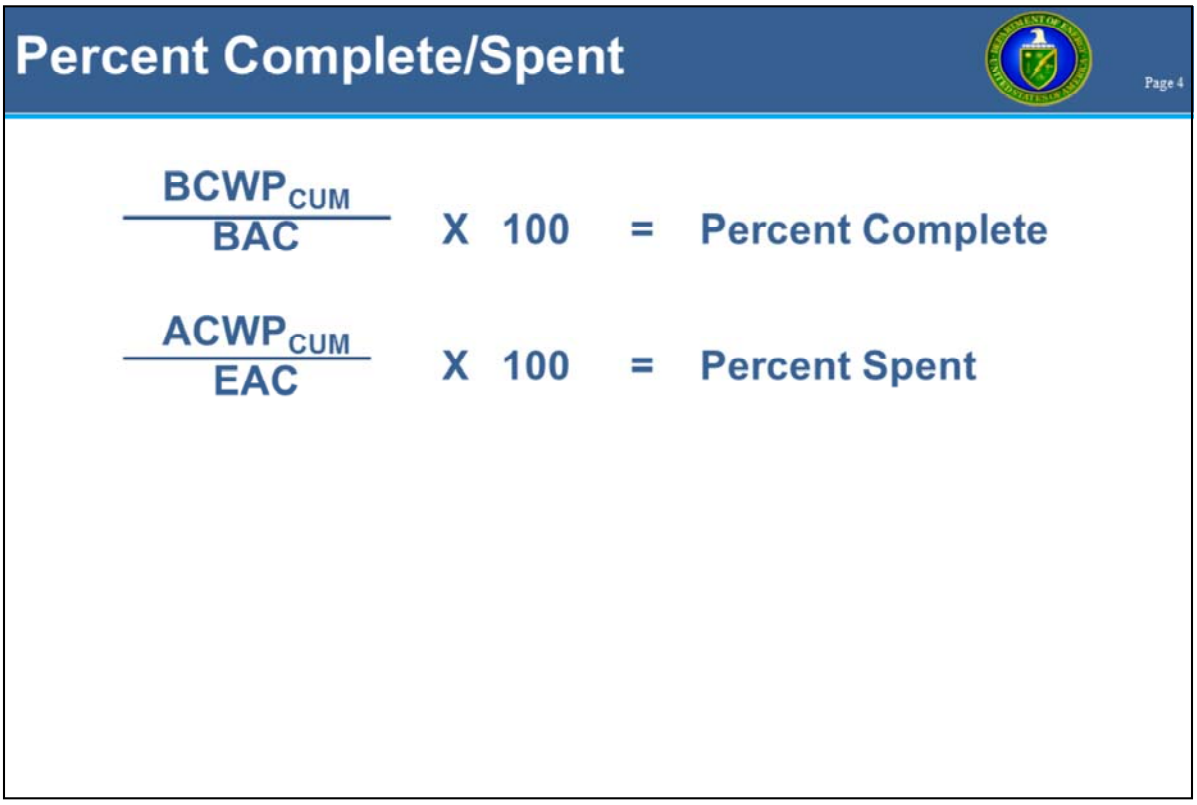
While the comfort factor on a project is often tied to the project's Cost Performance Index, only looking at the CPI is risky. Often, *CPI is misapplied as a primary factor in determining award fee on a* cost plus award fee type contract. This can over emphasize the importance of CPI by management if the expectation is that it needs to be near 1.0 in order to earn higher fee. Unfortunately, this can lead to decisions that impact cost and schedule data reliability and may result in invalidating the certification that a contractor's EVMS is compliant with ANSI/EIA-748

Because of this, the DOE is looking at other measures for award fee criteria.

The DOE FPD can influence a realistic CPI during the project's life cycle by regular use of the other indices we will cover in this Snippet. Reviewing the contractor's EVM data for budget shifting, very subjective earned value techniques, and being firm with the contractor about proper application of a compliant EVM system are positive steps for the DOE FPD to take with the contractor's project manager.

The EVM data are intended to be used by both the contractor PM and the DOE FPD to take early corrective actions when problems are indicated. An accurate CPI is extremely helpful; however, focusing only on CPI can lead to surprises.

Because of these risks, this snippet focuses on predictive analysis using other means beyond CPI or SPI. There are many other indices available that help to avoid surprises when the CPI or SPI may not be reliable while presenting an invalid assumption that everything is proceeding according to plan.



A good place to start analysis when looking at cost and schedule from different perspectives is with two simple metrics, that is percent complete versus percent spent. The project's percent complete calculation is the cumulative BCWP divided by the Budget at Completion, multiplied by 100. Many of the formulas presented can be applied at a Control Account level or at the project or contract level.

The second metric used for comparison is percent spent, the result of the cumulative ACWP divided by the EAC, then multiplied by 100. When the percent spent is less than the progress claimed, do not assume that the project is underrunning without conducting further analysis.

If the percent spent is greater than the percent complete, drill down to the control account or control accounts contributing to the difference. This may indicate an overrun or inefficiency. Before ensuring that the Estimate at Completion incudes the overrun, verify the results are not because of timing differences or anomalies. When comparing the percent complete to the percent spent at the control account level, examine the earned value technique or EVT for claiming progress. It could be that the Control Account Manager assumed the task would complete in the current period, and chose a 0/100 earned value technique. However, if the effort didn't complete in the current period, the CAM can only incur the actual costs charged to the effort, but can't earn any performance, i.e. BCWP, until the effort is 100 percent complete. The percent complete would lag the percent spent in this case. Therefore, the appearance that the control account is overrunning is false and temporary, and the perceived inefficiency may not be indicative of future performance.

In the opposite scenario, where the comparison shows the percent complete is greater than the percent spent, this may indicate an underrun or better than planned efficiency. Before ensuring the Estimate at Completion incorporates the underrun, verify the results are not because of time differences.

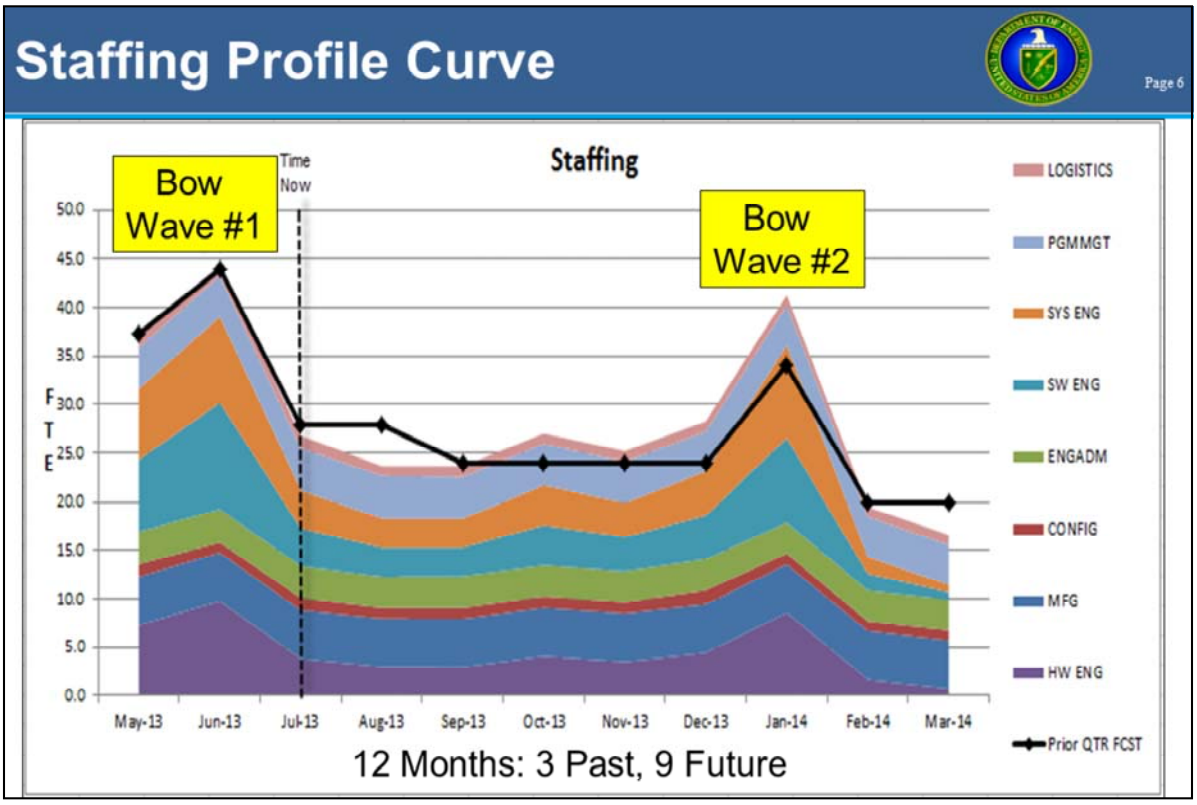
The ANSI/EIA-748 requires that actual costs be recorded in the same reporting period as performance is claimed. In both of these examples, that may not have happened, thus causing a false variance. The earned value technique chosen to measure progress should be one that will most accurately indicate progress and reflect the associated actual cost for any given reporting period. In the second example, estimated actuals may have been appropriate to avoid the false variance.

We have reviewed two situations where the percent complete and percent spent may be due to anomalies and timing differences. It is also likely the trends of percent complete and percent spent are indications that the EAC may be overstated, that is when the percent complete is greater than the percent spent, or understated, that is when the percent spent is greater than the percent complete. Note that these ratios will also be affected with changes to the EAC or BAC.

Staffing Profile

- Timing is everything
- Resources without commitments invite trouble
- Having the right skills available at the right time is key

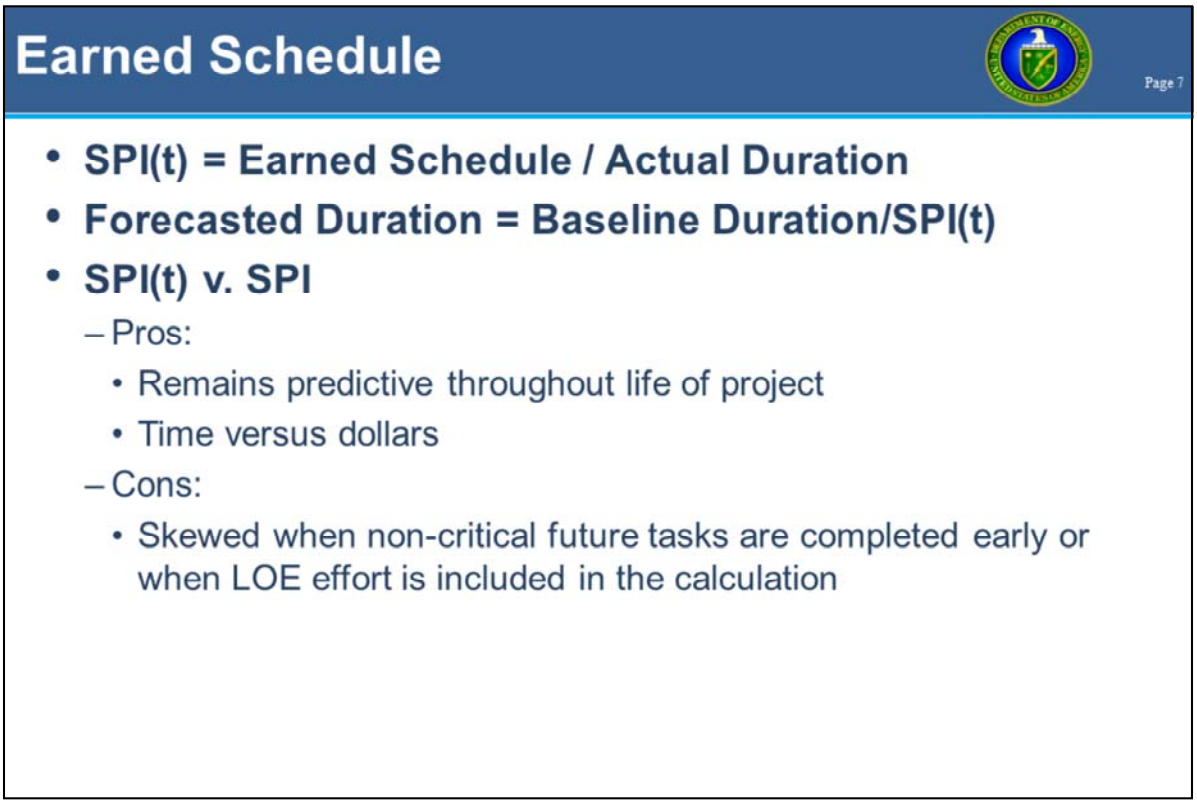
Identifying and obtaining the right resources at the right time is critical to a project's success. The Control Account Manager should not start executing without commitments from the Staffing Resource Managers. The earlier in the lifecycle of the project that the staffing requirements are identified and conveyed, the better the project will be able to ensure that the correct staffing profile is established to successfully execute the project.



A time-phased, 12-month rolling full-time equivalent (FTE) headcount by product, organizational, or functional area of individuals required on the project comprises the staffing profile. This type of information is often required on EVMS projects via the CPR or IPMR Format 4. However, if Format 4 is not required, the DOE requires a resource loaded schedule. Most scheduling tools can generate this information. It should include the number of actual months and forecasted (demand) months. The example shows 3 months of actuals and 9 months of forecast by labor type.

Forecasted data indicate the project's staffing needs. Analysis of data and interacting with staffing/resource managers is essential to ensure staffing availability. Look for indicators such as ramp up needs, noted on the graph as bow wave number 1 and number 2. Also conduct work rate analysis; that is how much work must be accomplished each month for the remainder of the project to finish on schedule. Do we have the number of resources and resource mix required? Significant changes to the forecasted staffing needs require active management to ensure that either insufficient staffing conditions or excessive staffing conditions are resolved in a timely manner.

Also compare manpower usage to CPI trends. Manpower is a leading indicator of future cost growth. Current actuals to plan may indicate there is not enough staff to maintain the schedule. Unrealistic ramp ups/down in the future may indicate unrealistic ability to maintain the schedule. Schedule drives cost and so more analysis and scrutiny may be necessary for successful project implementation regardless of the current CPI status.



This next analysis tool is called Earned Schedule, based on the concept of earning 'time'. The metric presented here is SPI(t) which is the time-based schedule performance index. It is the result of dividing the earned schedule by the actual duration. Earned schedule is the amount of time that was originally planned (based on BCWS duration) to reach the current period BCWP. Actual duration is the amount of time that has elapsed on the project to date.

Similar to the SPI, an SPI(t) less than 1.0 indicates the effort, on average, is being accomplished at a slower rate than planned. An SPI(t) greater than 1.0 means that the effort, on average, is being accomplished at a faster rate than planned.

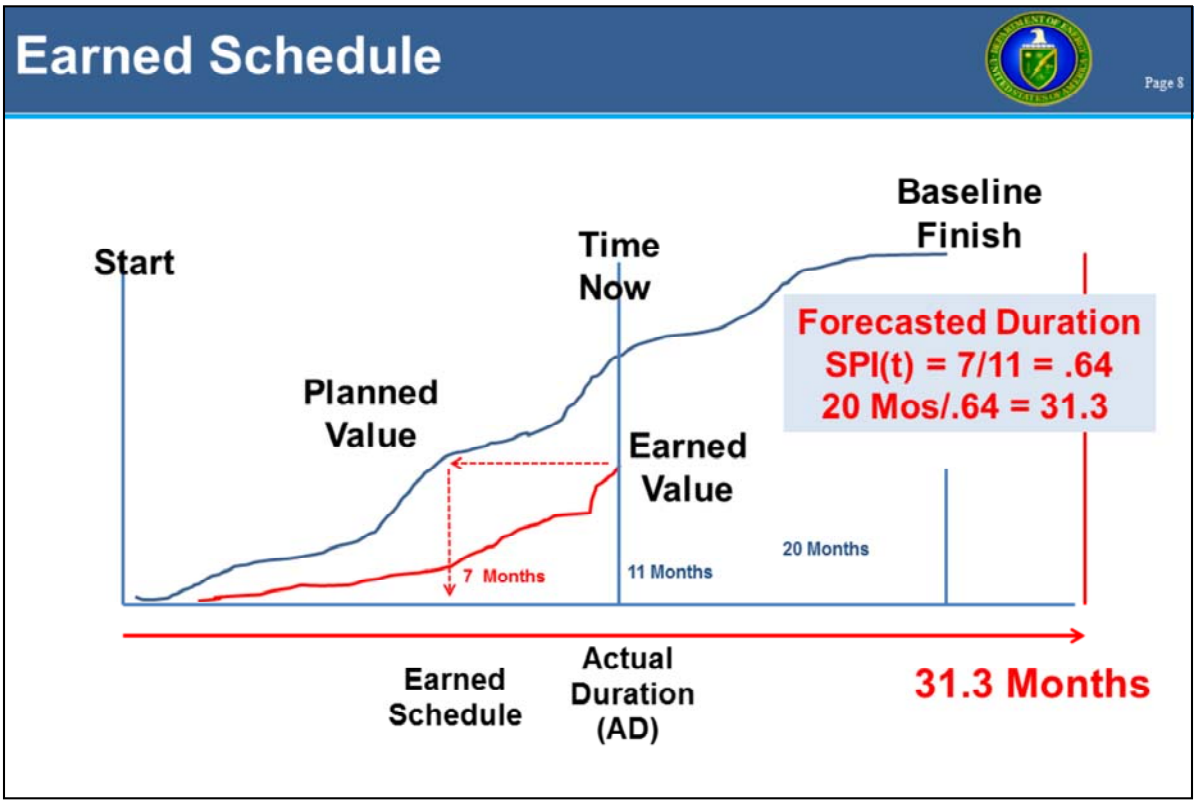
The forecasted duration can then be calculated by dividing the baseline duration by the SPI(t). An advantage of using SPI(t) versus SPI is that it maintains its mathematical integrity over the entire project whereas SPI loses effectiveness in the last third of the project because SPI returns to 1.0 at the completion of every project whether it was completed on time or late.

The result of SPI(t) is in units of time rather than SPI which is in units of dollars. Using time units more clearly shows the impact to the planned schedule.

The cautions when using SPI(t) are the same as when using the SPI. Both indices can be manipulated or skewed when non-critical future tasks are completed early. LOE effort can also skew the predictive value so they should be calculated for discrete effort only.

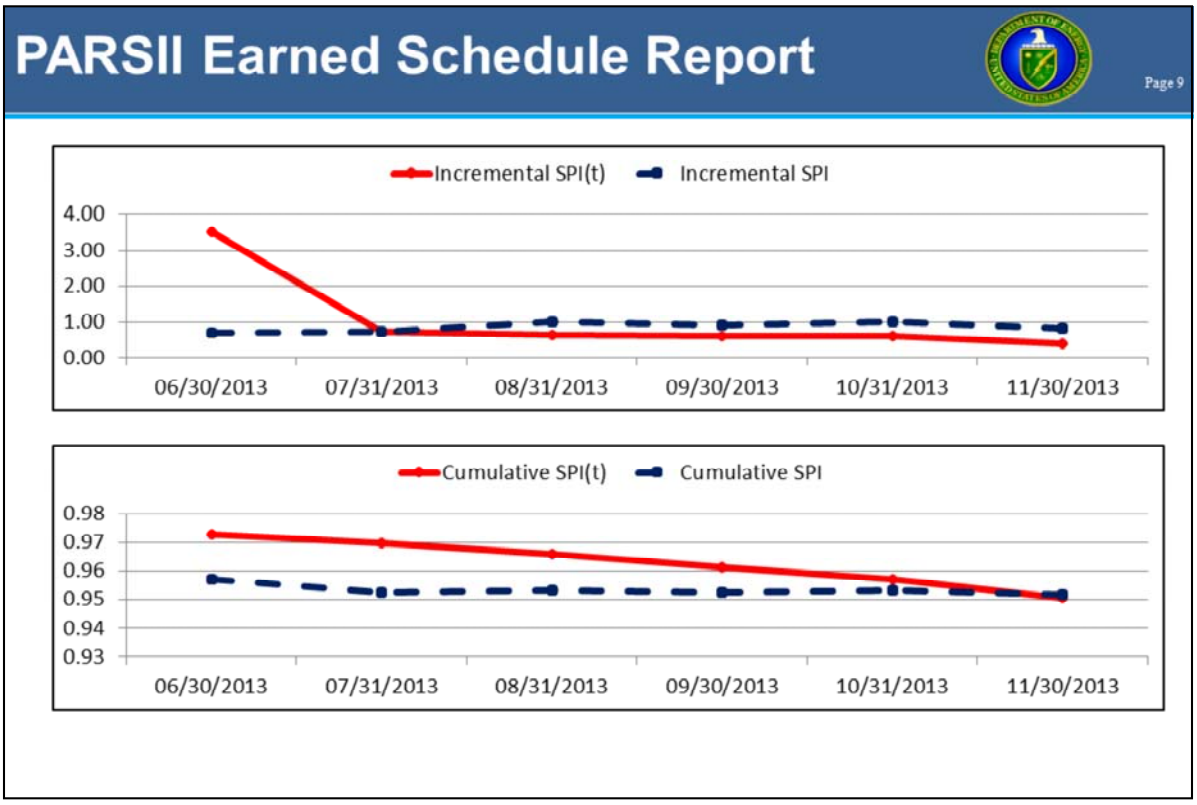
Statistics have shown that despite the anomalies, earned schedule calculated at the total

project level has shown good predictability of schedule performance and is a useful metric to consider.

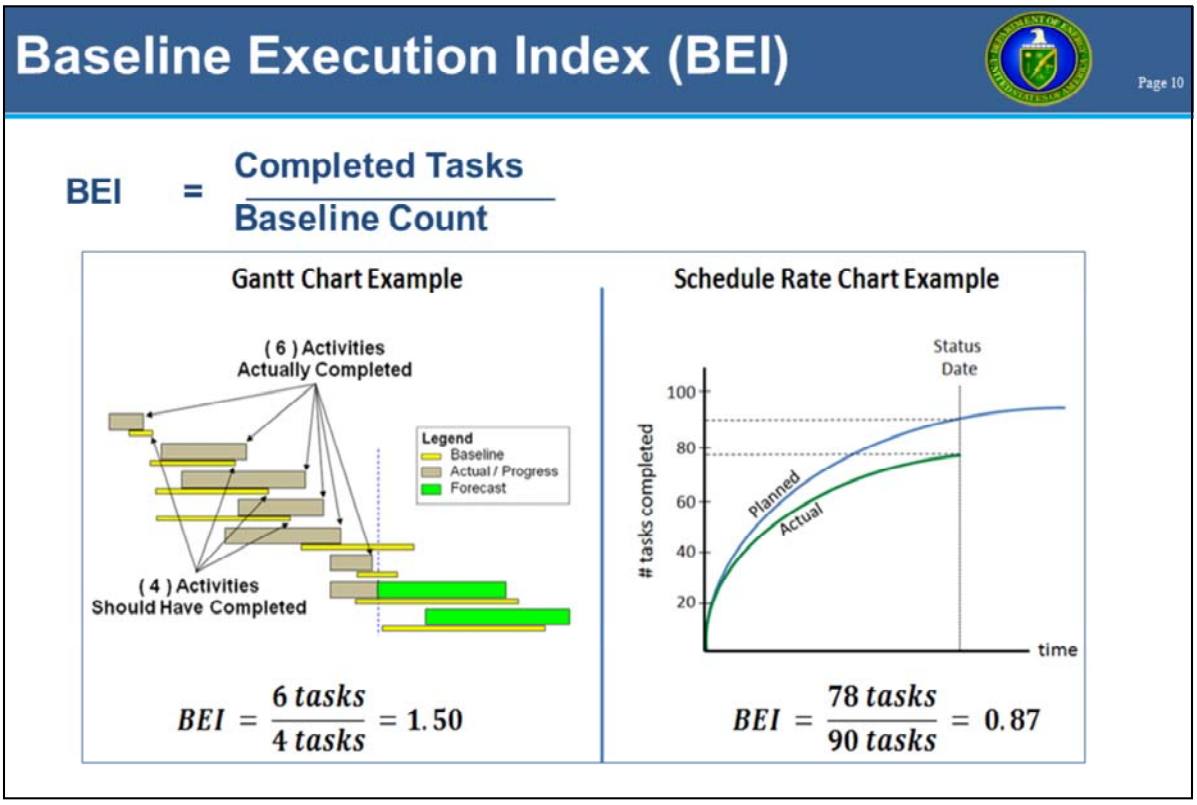


Earned schedule is the amount of time that was originally planned to reach the current level of BCWP. For the current period (time now), we see the earned schedule is 7 months. The actual duration is 11 months. Stated differently, it has taken 11 months to complete 7 months of the project. Therefore the SPI(t) is .64.

The Forecasted Duration then takes the efficiency and provides the prediction of when the project will complete. In this example, the baseline duration was 20 months, so the forecasted duration becomes 31.3 months – quite a difference from the baseline.



A PARS II report is available to compare the schedule performance index in terms of earned time, the letter 't' in parentheses, to the actual schedule performance index. The top graph compares them as incremental/current periods while the bottom graph compares them in terms of cumulative values at the end of each period. Remember that the comparison differs because SPI is based on dollars or hours while the SPI(t) is based on time.



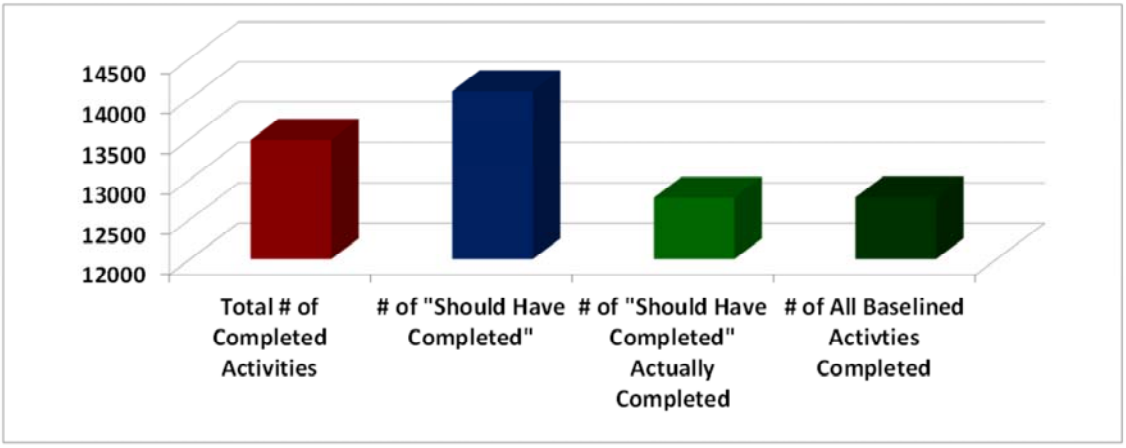
Another current schedule metric is the Baseline Execution Index, or BEI. The objective and purpose of the BEI is to measure the number of tasks that were completed as a ratio to those tasks that should have been completed to date, according to the original baseline plan. Think of it as the "execution pace" for a project which provides an early warning of increased risk to on-time completion.

The BEI calculation is simply the completed tasks divided by the baseline count with the following parameters: The numerator in the equation is any task with an actual finish on or before the status date. The denominator is any task that has a baseline finish date on or before the status date. The pictures show two examples: The first is a Gantt chart example where four activities were baselined to have completed by the status date; however, six were actually completed. The BEI is 1.50. The Schedule Rate Chart example shows that 90 tasks were baselined to have been completed, yet only 78 actually were completed. The BEI is 0.87.

PARSII Schedule Baseline Execution Index Report, Summary Tab

Total Count		Total # of Completed Activities	# of "Should Have Completed"	# of "Should Have Completed" Actually Completed	# of All Baselined Activties Completed	BEI		% of Baseline Completed		
Baseline	Current					Should Have Completed	Baselined Completed	Planned	Actual	Actual less Accelerated
14287	17023	13483	14093	12769	12774	0.91	0.91	98.64%	89.37%	89.41%

* Target BEI is >= 0.95. Any value below 0.95 is considered failure on the assessment scale.



A PARS II report is available to show the Baseline Execution Index, available in bar chart format as seen on this slide, and as a time-phased trend chart as shown on the next slide. Note that the BEI on this report is calculated two ways to provide comparison information.

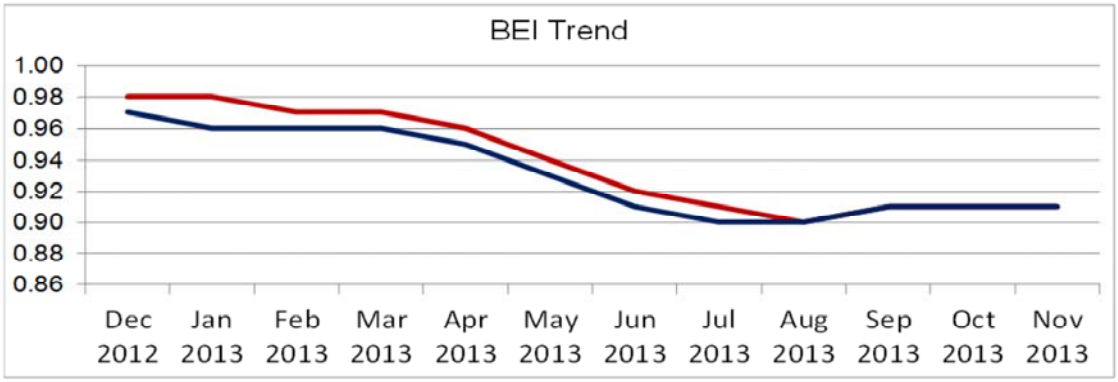
The first BEI calculation is a little different from what we explained earlier in that it looks at only the number of completed tasks that should have completed by now divided by the total that should have been completed by now. This gives us some insight into how well the project is executing what was supposed to be done.

The second BEI calculation is for all completed tasks to date, just like on the examples from prior slides. That is, the number of completed tasks divided by the number of activities that Should Have Completed as of time now. The second calculation when compared to the first will show how much ‘cherry picking’ may be going on. If the second calculation is greater than the first, then we know the contractor is working on some tasks that aren’t due yet. This could be good use of resources but it could also be an effort to mask the fact that tasks due now are not being completed.

PARSII Schedule Baseline Execution Index Report, Trend Tab

	Dec 2012	Jan 2013	Feb 2013	Mar 2013	Apr 2013	May 2013	Jun 2013	Jul 2013	Aug 2013	Sep 2013	Oct 2013	Nov 2013
BEI (All Baselined)	0.98	0.98	0.97	0.97	0.96	0.94	0.92	0.91	0.90	0.91	0.91	0.91
BEI (BEF < Status)	0.97	0.96	0.96	0.96	0.95	0.93	0.91	0.90	0.90	0.91	0.91	0.91

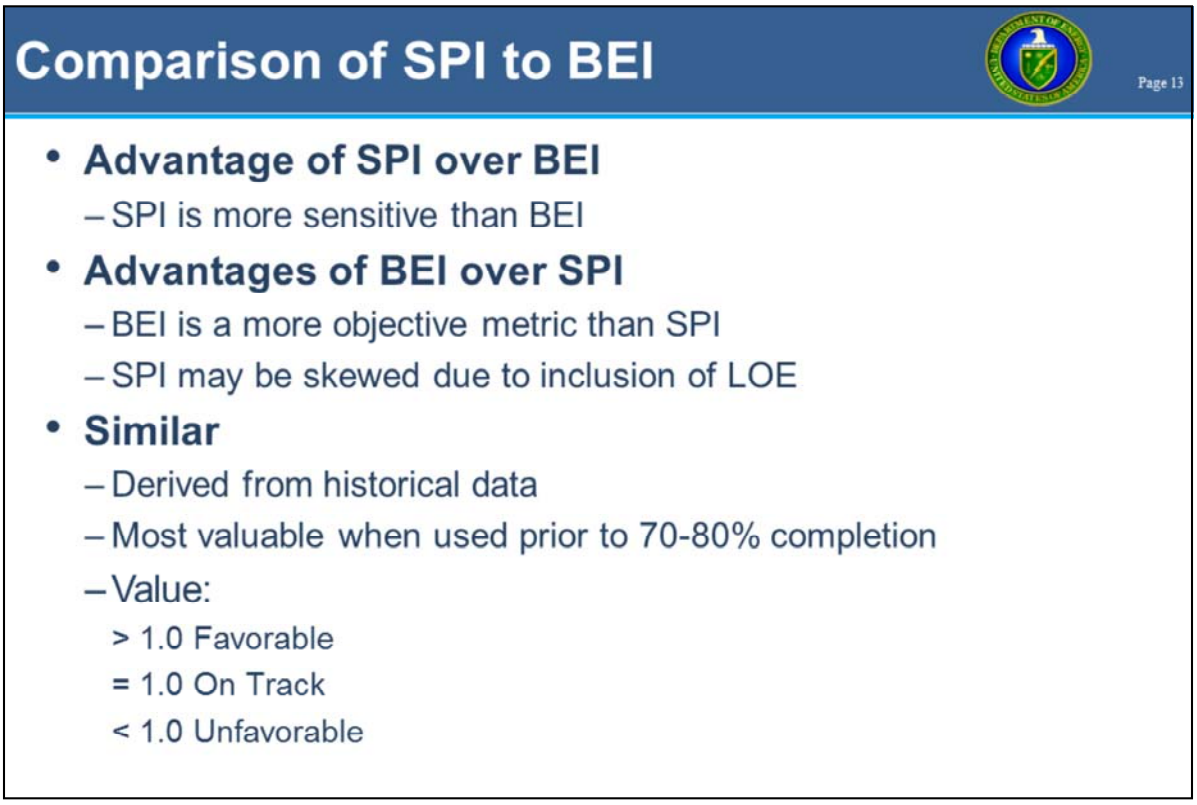
* Target BEI is >= 0.95. Any value below 0.95 is considered failure on the assessment scale.



Selecting the Trend tab of the PARS II Schedule BEI Report shows the BEI changing over time.

Questions to ask when analyzing the BEI include

- Is the BEI in line with performance on the critical path? If not, why is the critical path different from the rest of the project on average?
- Are current period BEI calculations trending up or down? If so, what are the key drivers?
- If BEI < *1.0*, what is the recovery plan? Is it realistic given the available resources?
- Is the BEI demonstrated to date in line with other estimations of future performance? If not, what is the cause of the expected change in performance?
- Is BEI being inflated by “cherry picking” easier downstream tasks? Were they completed out of sequence? And if so, why?



What are the advantages of using SPI over BEI, and vice versa?
Considered an advantage, SPI is more sensitive than BEI. BEI places equal weight on all activities; that is each one is counted. SPI weights activities by their planned resource loading, usually in dollars, sometimes in hours. Therefore, activities that require more effort will have a greater effect on the SPI calculation.

BEI advantages over SPI can be explained simply in terms of objectivity and potency. Project managers consider BEI an objective assessment since it is based on the planned and actual completion of activities. SPI has at least some degree of embedded subjectivity due to the earned value assessments made on in-progress effort.

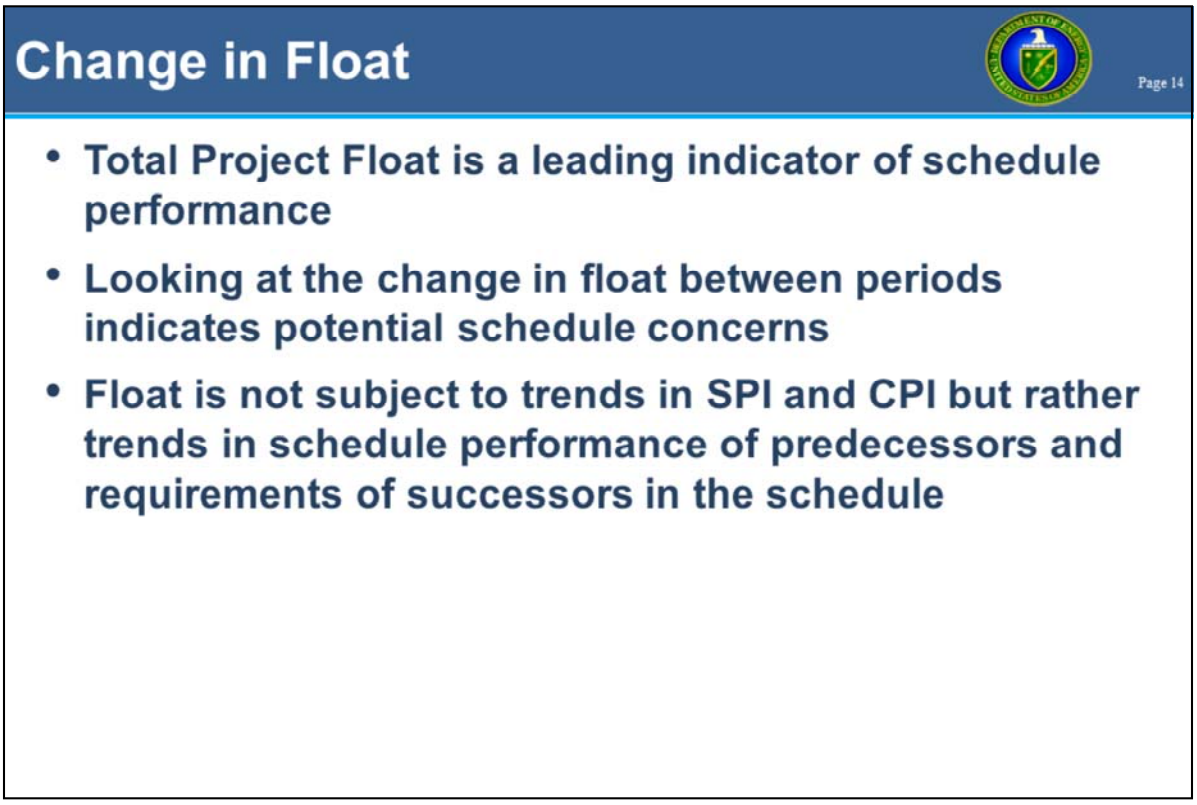
SPI may be a more "watered down" index than BEI. LOE tasks skew BEI and SPI calculations toward 1.0, and thus can mask the true state of the project. LOE is generally *included* in the calculation of a project's SPI. LOE is typically *excluded* from BEI calculations.

Like SPI, BEI is fundamentally a backward-looking index. Because it is derived entirely from historical data, a project's BEI calculation is completely independent of the remaining effort in the IMS. However, BEI can be used in a predictive manner as a quick and easy gauge of future project execution risk and as a historical basis to compare forecasted schedule efficiency.

Also like SPI, no matter how early or late a project completes, BEI calculations will eventually equal 1.0. This is because the BEI formula breaks down over the final third of the project. During this time, BEI trends will always skew toward 1.0 regardless of how the

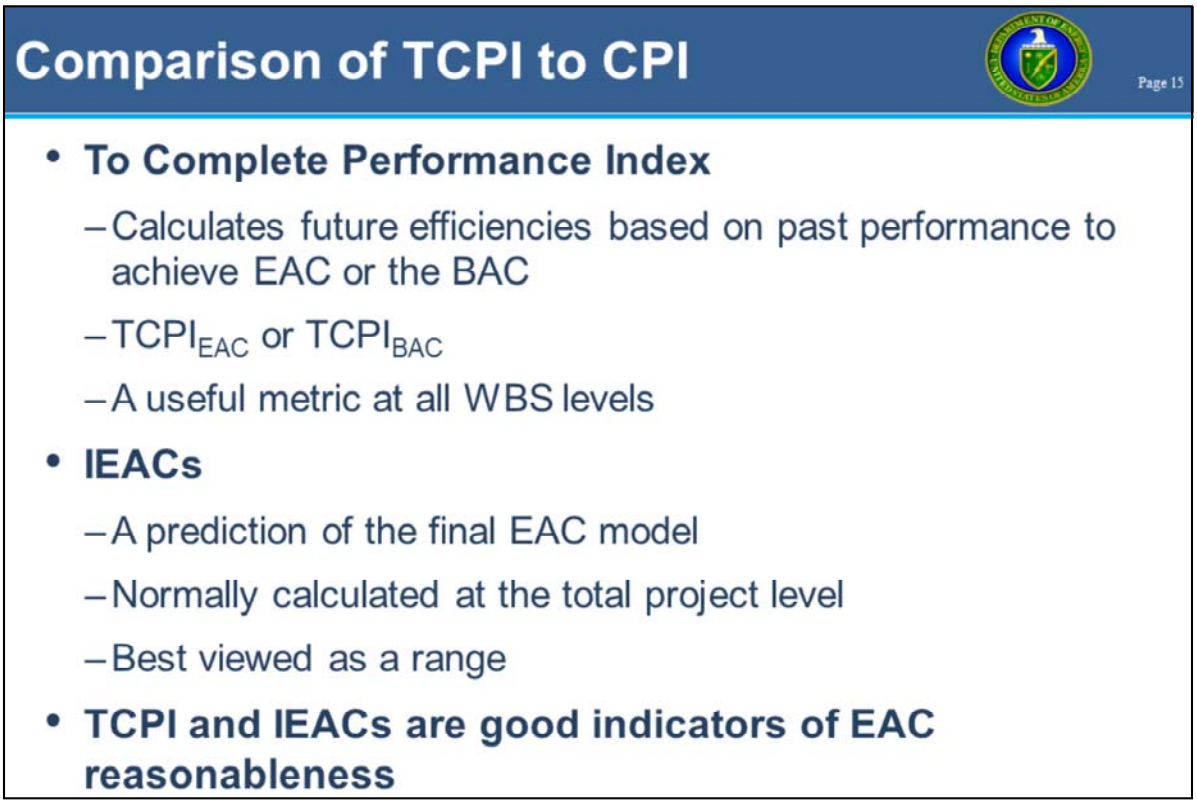
project is actually progressing, rendering the metric less effective as the project nears completion.

Lastly, the BEI gauges the ‘efficiency of contractor performance to plan’ or execution pace where an efficiency ratio greater than 1.0 is favorable, less than 1.0 is unfavorable. When the metric is less than 0.95, then investigate schedule performance.



Total Project Float in the critical and near critical paths is a forward indicator of schedule performance. Float is calculated as the difference between the early finish and late finish dates of a task. The early date is based on schedule performance and remaining duration and the late date is based on the requirement expressed in a constraint downstream in the schedule. Therefore changes in float mean performance is better (increases) or worse (decreasing) than expected last period.

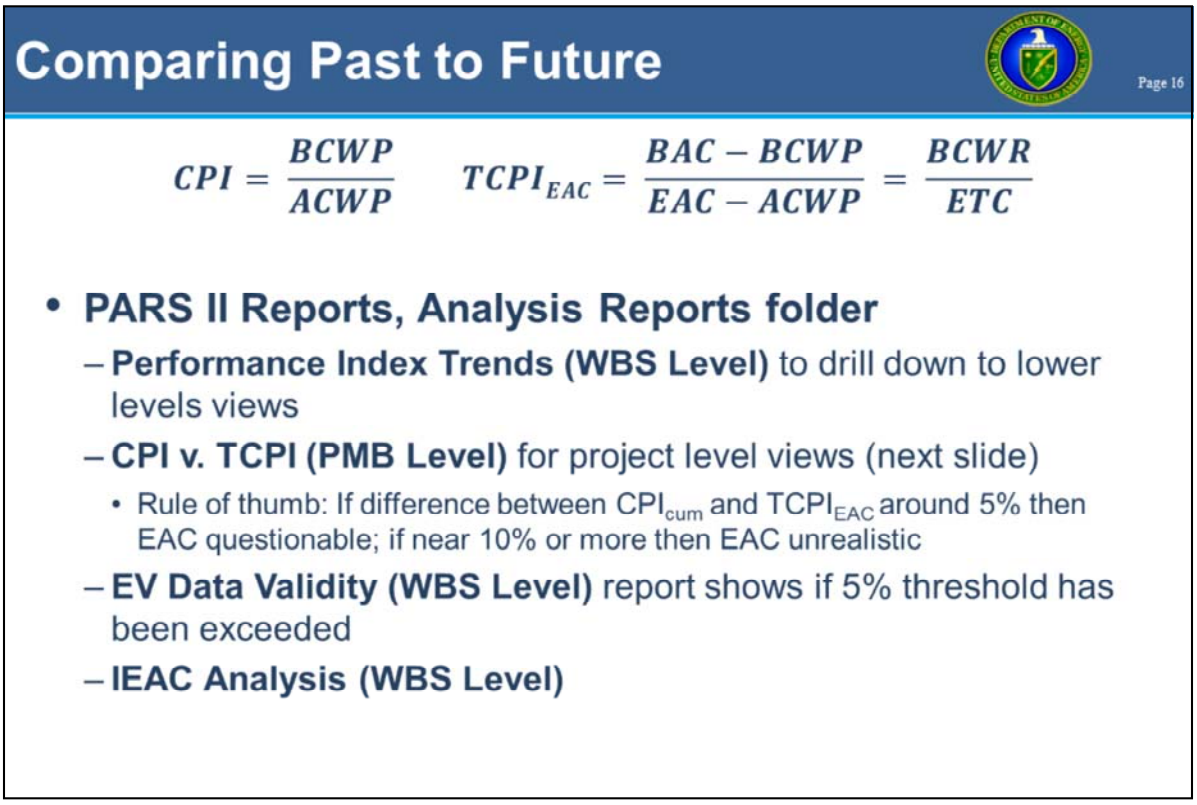
See the IMS Monthly Review Snippet for more discussion about analysis using schedule float.



The To Complete Performance Index (TCPI) can be calculated based on either the Estimate at Completion (EAC) or the Budget at Completion (BAC). These terms are expressed as $TCPI_{EAC}$ and $TCPI_{BAC}$. The TCPI looks at past performance and the future efficiencies required to achieve the EAC. Its advantage is that it is equally valid at any cost level. Its disadvantage is that it does not by itself provide the magnitude of a concern. However, comparing the $TCPI_{EAC}$, which indicates the future efficiency required to complete within the EAC, to the CPI, which indicates the past efficiency, can indicate problems. For instance, if the $TCPI_{EAC}$ were 1.2 and the CPI were 0.8, the indication is that future work cannot be completed for the current EAC. The question would be how will the projected increase in efficiency be accomplished? When there is a significant difference between the $TCPI_{EAC}$ and CPI, the EAC should be questioned.

Independent Estimates at Completion (IEACs) are a calculated prediction of the final EAC model. They are normally calculated at the total project level, and best viewed as a range. We will view some examples in later slides.

The TCPI and IEACs are used as tools to assess EAC reasonableness.

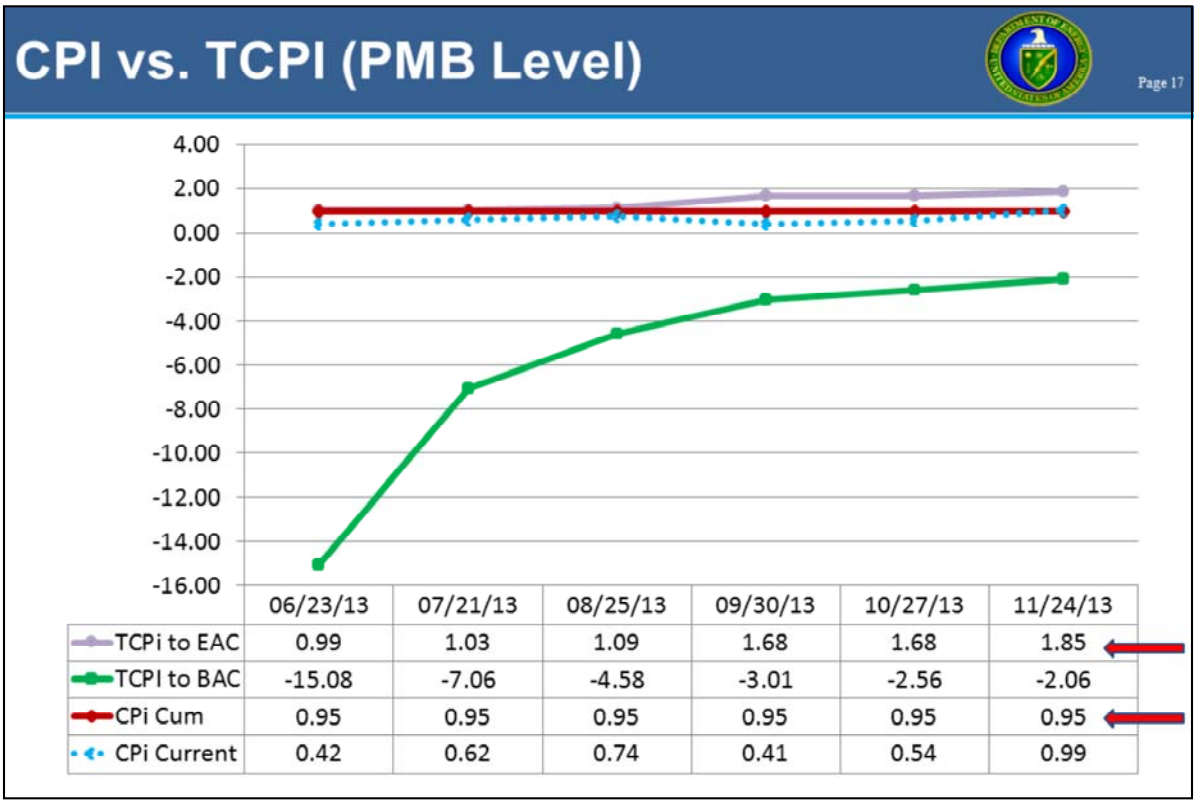


The Cost Performance Index, CPI, is the cost efficiency for a project that has been demonstrated to date. The To Complete Performance Index based on the contractor's estimate at completion, $TCPI_{EAC}$, is the average future cost efficiency that must be maintained going forward in order to achieve a project's EAC. For a typical project, future efficiency will likely be similar to past efficiency. By comparing CPI and $TCPI_{EAC,}$ assessments can be made about the risk associated with achieving a project's EAC.

A CPI of 0.95 indicates that, to date, $0.95 of work was accomplished for every dollar spent on the project. Similarly, a $TCPI_{EAC}$ of 1.85 indicates that $1.85 worth of work must be accomplished for every dollar spent to meet the current EAC. Does this sound possible?

Typically a difference of 5 percent is cause for concern. If the difference is 10 percent, the Estimate at Completion is probably not achievable. These thresholds are a guide, so ask questions to understand the difference before making assumptions. For example, if process improvements have been put in place that are expected to dramatically reduce costs, it might be reasonable to believe that efficiency going forward can improve performance significantly; however, if a substantial one-time expediting fee was paid to a vendor (unplanned), sustained efficiency improvements going forward should not be assumed. Under normal circumstances, CPI and $TCPI_{EAC}$ should be expected to be similar, but when they are not, there should be specific, identifiable causes to help explain the change in future performance.

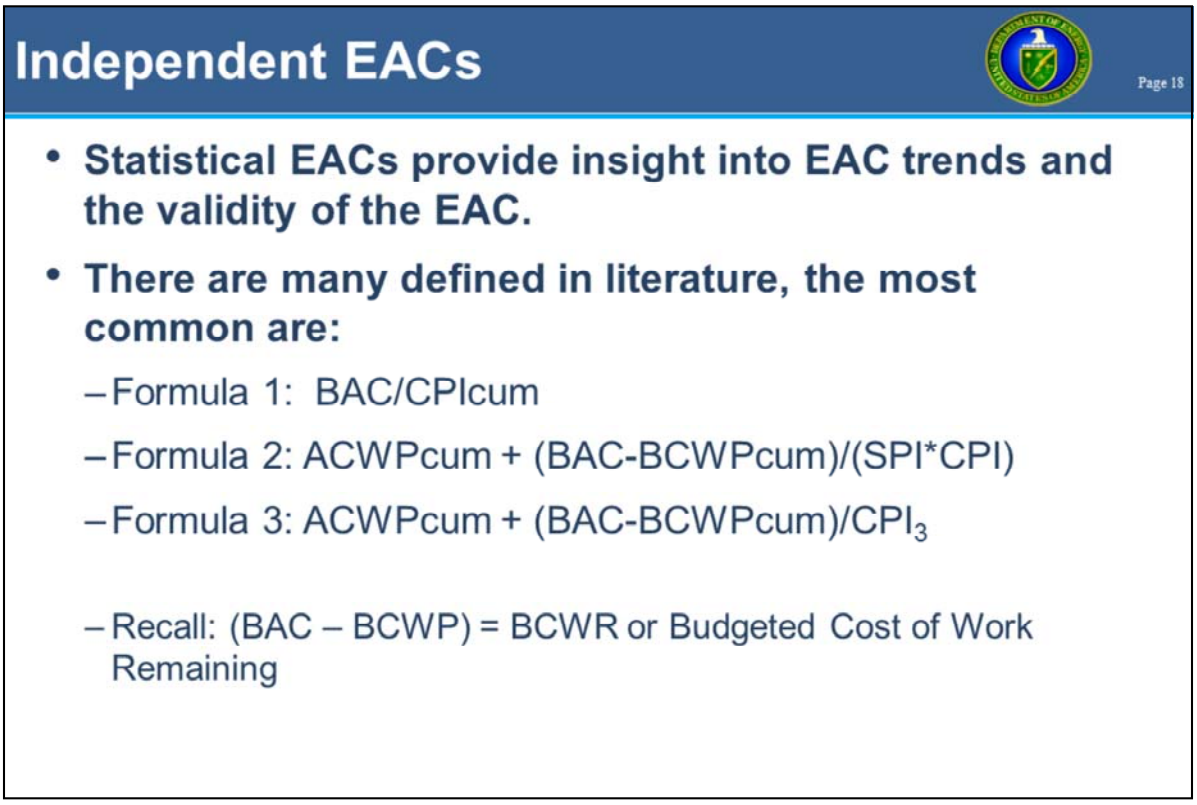
In the Analysis Reports folder there are several PARS II reports that provide this information, from the lowest WBS levels to the project level. Refer to Snippet series 5.0 for information on each PARS II report.



This graph compares the following trends: TCPI based on achieving the EAC, TCPI based on achieving the BAC, cumulative CPI, and current period CPI. As of 11/24/13, the cumulative CPI is 0.95. These are the cost efficiencies achieved to date. To complete this project within the estimate at completion, the future cost efficiency would have to be 1.85.

Questions to ask:

- Are CPI and $TCPI_{EAC}$ diverging (indicating an unrealistic EAC)? The answer is yes.
- If so, what factors might be causing future cost efficiency to differ from what has been demonstrated to date? Change in resources/staffing? Change in facilities or capacity? Change in technology? Change in plan? Is there an over target baseline and/or over target schedule?
- Next, Has the CPI been trending up or down? In this example, the cumulative CPI has remained steady. Does the $TCPI_{EAC}$ more closely resemble the current period CPI values? No, The $TCPI_{EAC}$ keeps increasing, meaning that future work must be completed with almost double the efficiency.
- Next, Is $TCPI_{EAC}$ very close to 1.0? In this case no, but if it was, you would still want to determine if it is an accurate representation of the future effort, or are downstream tasks simply being ignored?
- Lastly, If CPI < 1.0 and $TCPI_{EAC}$ > 1.0, are future ETCs being reduced to artificially project meeting the BAC target?



Independent estimates at completion provide a point estimate or to establish a range that the contractor's EAC can be compared against. They are based on earned value data and therefore more subject to CPI and SPI trends. Also note that if the SPI and CPI are questionable or invalid, then so are any IEAC values based on these indices. However they may provide some warning that the EAC may be out of bounds to the current trends. They are of most value in the middle of the project life cycle between 30-90 percent complete. Let's walk through the three more common IEAC formulas.

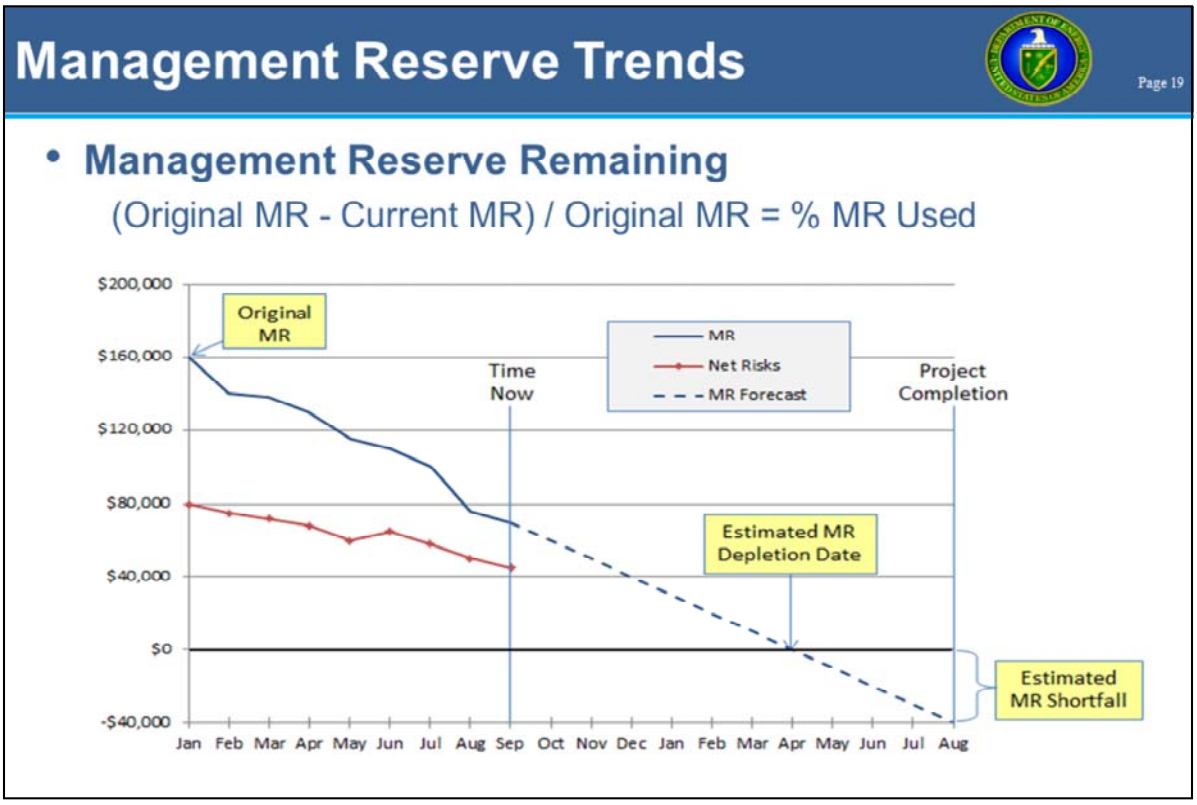
In Formula 1, the BAC is divided by the cumulative CPI. This calculation is based on the premise that the efficiencies experienced to date will be equal to the efficiencies while completing the work remaining.

Formulas 2 and 3 use the common approach of adding the actual cost of work performance to date plus the efficiency factor applied to the budgeted cost for work remaining, or BAC minus BCWP. In Formula 2, the efficiency factor applied to the budgeted cost for work remaining is calculated by multiplying the SPIcum and CPIcum. This formula becomes invalid in the last 25 percent complete of the project when SPI trends to 1.0.

In Formula 3, we see the efficiency factor applied to the budgeted cost of work remaining is based on the past three months CPI. This formula is most useful between 50 percent and 100 percent when the cumulative CPI to date could be misleading. This ratio is based on the premise that current trends are more meaningful for future performance than cumulative trends. This ratio can also be calculated for six month CPI denominators as well if the past six months of performance is more indicative of future performance.

Where the SPI is below 1.0, Formula 1 usually generates the minimum EAC and Formula 3 typically generates the maximum expected EAC.

For more information on CPI, TCPI, and EAC reasonableness, refer to Snippet 5.6.

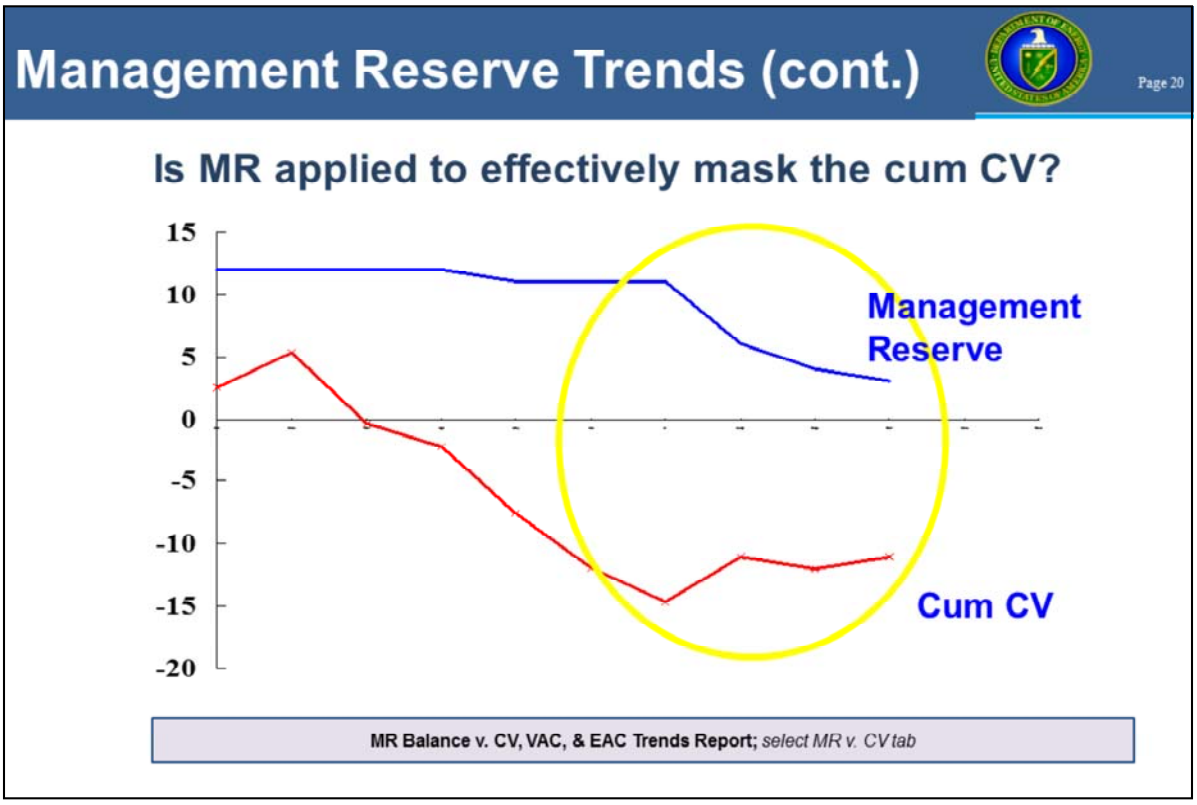


At a minimum, calculate the percentage of MR used. Compare that to the project level of percent complete. By plotting historic and forecasted management reserve, an estimation of the MR at project CD-4 can be made. If the actual MR burn down rate (solid blue line) has been too steep, the date at which MR is completely depleted can be estimated (blue dashed line). Adding a plot of the net risk exposure to date, i.e. the risk exposure minus the opportunity potential represented in red on the graph, provides additional insight into the adequacy of MR to cover known risks.

From this information, three key areas can be assessed:
First, assess the MR Adequacy. The value of the MR Forecast plot at the time of project completion will provide an estimate of MR adequacy. If management knows of a risk to MR coverage earlier, then more time is available to implement mitigation plans.

Next, estimate the Estimated MR Depletion Date. In the event of a projected MR shortfall (this will show as negative MR on the chart), an estimate of the date at which MR is depleted can be made.

Lastly, compare whether Risks are greater than MR. Available MR should always be more than the net risk exposure. If the net risk exposure is more than the MR (or expected to be in the future), management must expedite risk reduction measures and/or explore additional opportunities to offset the risks. If not, the EAC should incorporate the increased risk exposure in the most likely, worst, or best case scenarios.

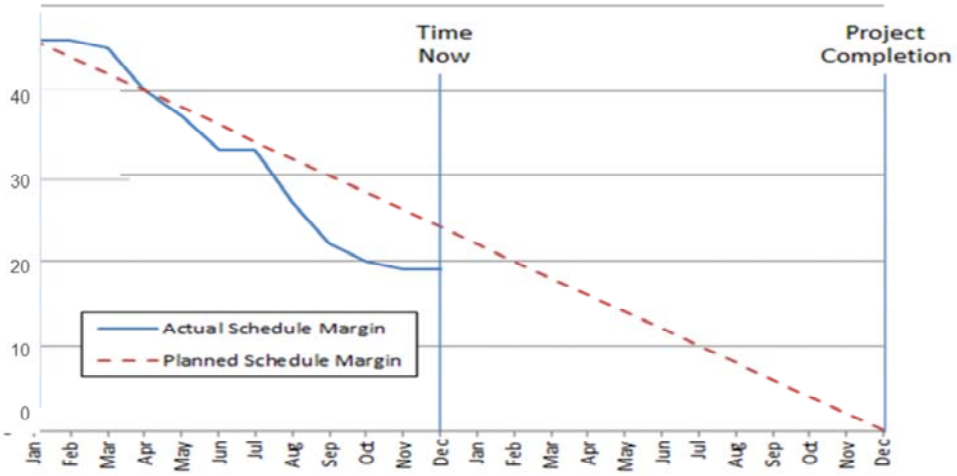


Open The PARS II Analysis Report titled “MR Balance versus CV, VAC, & EAC Trends Report”, and then select the MR versus CV tab to show how MR usage tracks with the cumulative cost variance. Notice the activity within the yellow oval. As the MR balance is consumed, the cumulative Cost Variance is improving. This is an indication that the contractor may be using MR to offset the overrun. This is not compliant with ANSI/EIA-748.

Schedule Margin

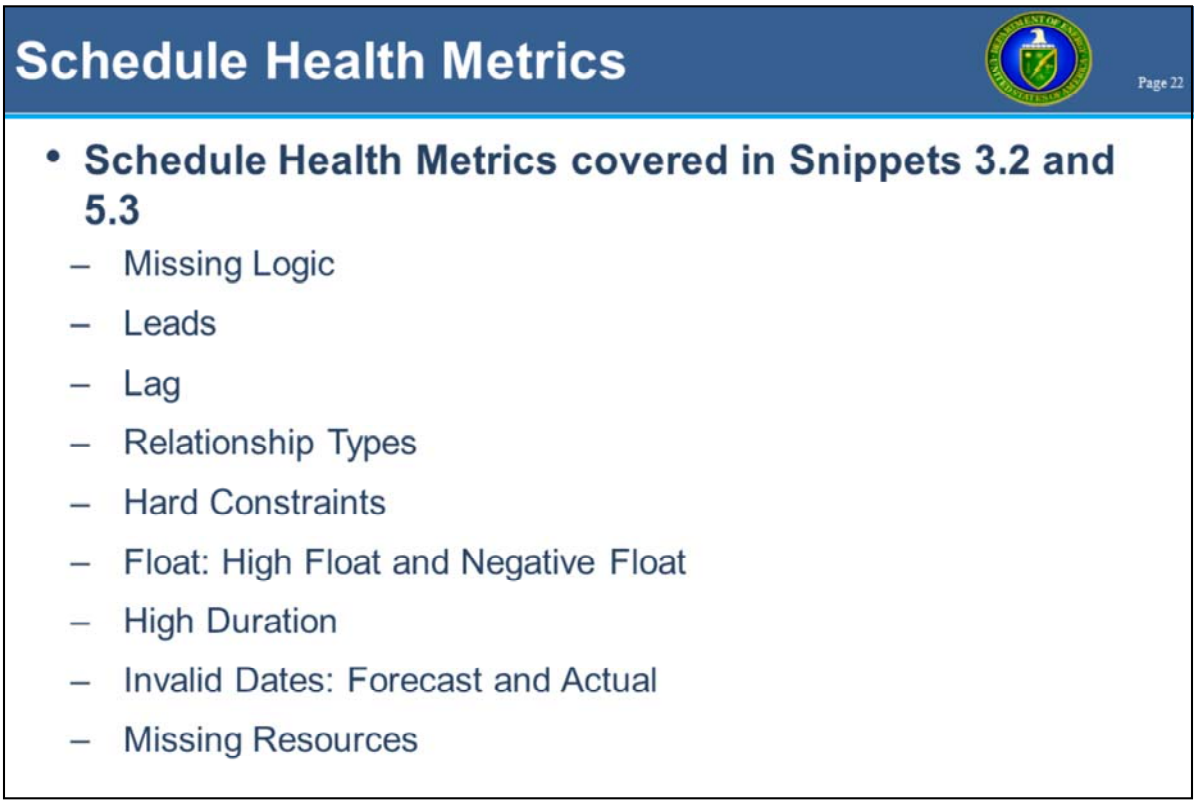
- **Schedule Margin Remaining**

  (Planned Schedule Margin - Actual Schedule Margin) / Planned Schedule Margin = % Schedule Margin Used



Another possible reserve to assess is the schedule margin remaining. If identified, schedule margin is a duration buffer prior to an end-item deliverable or any contract event. As a project progresses, the length of the schedule margin task is re-evaluated and adjusted as needed to protect the deliverable from risks that arise from natural variances in duration.

Shown here is a Schedule Margin Burn Down graphical display of schedule margin over time. When the actual schedule margin (the blue line) is above the planned schedule margin (red dashed line) at time now, the schedule margin is appears to be adequate. When the actual schedule margin is below the planned schedule margin, then schedule margin is being burned at an excessive rate and may impact completion.



The credibility of the schedule must be established before many of these metrics will work. The basics for determining schedule credibility are contained in the Schedule Health Metrics covered in Snippets 3.2 and 5.3. They cover:

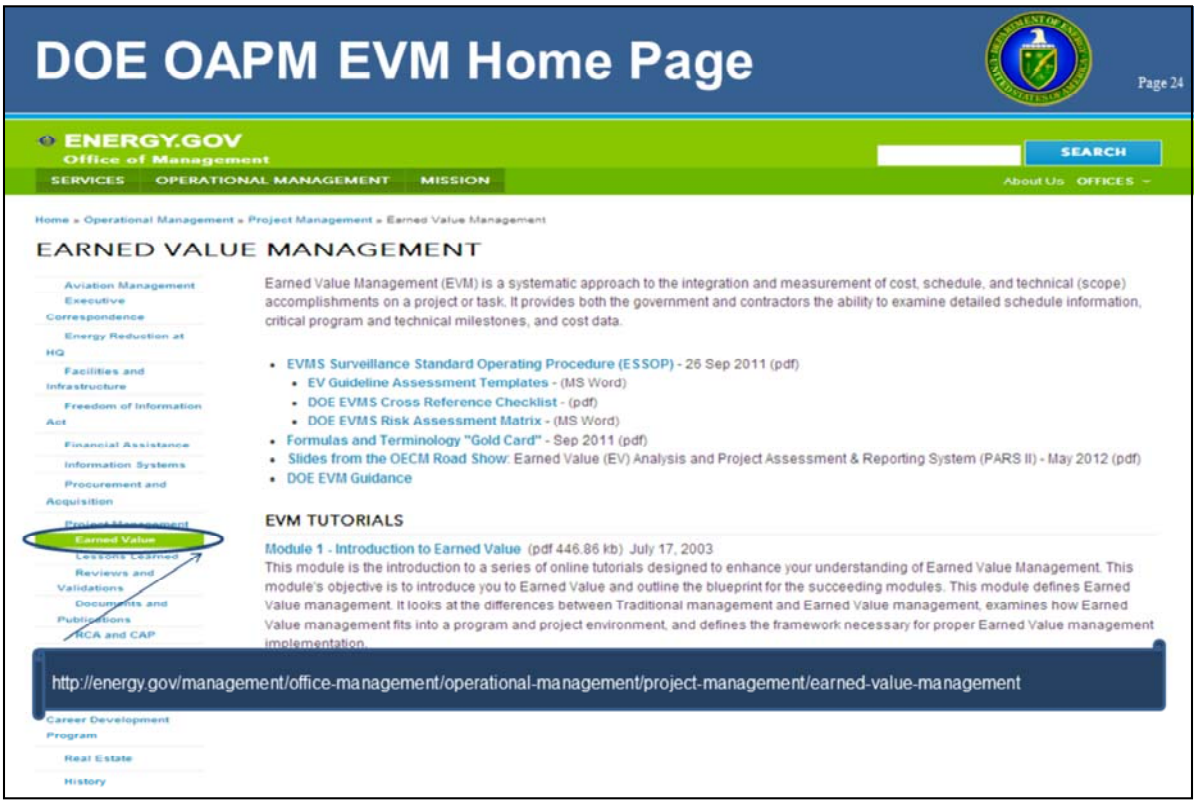
- Missing Logic
- Leads
- Lag
- Relationship Types
- Hard Constraints
- Float: High Float and Negative Float
- High Duration
- Invalid Dates: Forecast and Actual
- Missing Resources

To wrap up this snippet, here is a quick summary of the points discussed:

Always check other indices and trends – don't rely solely on SPI and CPI. When SPI and CPI are steady at 1.0, observe other indices to help predict future performance. If it sounds too good to be true, it probably is.

The Indices covered include:

- Percent Complete and Percent Spent
- Staffing Profiles
- Earned Schedule
- Baseline Execution Index
- Changes in project schedule float
- To Complete Performance Index
- Independent Estimates at Completion
- Management Reserve and
- Schedule Margin Reserves



For information relative to EVMS procedures, templates, helpful references, and training materials, please refer to OAPM's EVM Home page. Check back periodically for updated or new information.

Thank you