Earned Value Management (EVM) Chart Analysis

Introduction
A key component of Earned Value Management (EVM) is analyzing EVM data, charts, and reports to assess cost and schedule performance trends as part of an integrated program management approach. EVM chart and report analysis provides insight into the accuracy of the performance measurement baseline (PMB) and is useful in determining whether a contractor’s estimate at completion (EAC) is reasonable, or needs to be explained and/or adjusted based on EVM data trends.

This job aid provides an overview of the following EVM charts and report:

- Cumulative Variance Trend chart
- Cost and To-Complete Performance Indexes (CPI/TCPI) chart
- Cost/Schedule Variance Trends chart
- Estimates at Completion (EAC) chart
- Six-Period Summary report
Cumulative Variance Chart

The Cumulative Variance chart shows the contractor’s predicted variance at completion (VAC), cumulative schedule variance (SV\textsubscript{CUM}), and cumulative cost variance (CV\textsubscript{CUM}), plotting time on the x-axis and dollars in millions on the y-axis. You can use this chart to compare a contractor’s predicted performance against their actual performance.

Sample Cumulative Variance Chart

<table>
<thead>
<tr>
<th>Month</th>
<th>COST (in Millions)</th>
<th>SCHED (in Millions)</th>
<th>VAC (in Millions)</th>
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<tbody>
<tr>
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<tr>
<td>11</td>
<td>-1.1</td>
<td>-1.2</td>
<td>2.3</td>
</tr>
</tbody>
</table>

\( VAC = \text{Variance contractor predicts at end of contract} \)  
\( VAC = BAC - EAC \)

\( 0.0 = \text{Exactly at budget and on schedule} \)

\( \text{COST (CV}_{\text{CUM}}) \) and \( \text{SCHED (SV}_{\text{CUM}}) = \text{Contractor data calculations of actual cost and schedule performance} \)

\( \text{Note:} \) This sample Cumulative Variance chart, and other charts in this job aid, display data in a slightly different way than Empower. Depending on the software tool used by your organization, the charts you see outside of the EVM 202 classroom may look different from what you see here or in Empower.
How to Analyze this Chart

The **VAC** is the cost variance the contractor predicts at the end of the contract. **SCHED (SVcum)** and **COST (CVcum)** are the contractor’s data calculations of actual schedule and cost performance. The 0 line is the point at which work is exactly at budget and on schedule.

If the **VAC** is positive, then the contractor is predicting an **underrun**; their EAC is less than the budget at completion (BAC). If the VAC is negative, then the contractor is predicting an **overrun**; their EAC is more than the BAC.

If the **SVcum** is positive, then the contractor has accomplished *more* work than planned. If the **SVcum** is negative, then the contractor has accomplished *less* work than planned. If the **SVcum** is trending down, (i.e., the **SVcum** line is sloping downward), then schedule performance is getting worse.

**Note:** Negative **SVcum** does *not* necessarily mean that the contract is behind schedule. You must look at the network schedule to determine if the tasks are on the critical path before making assumptions about schedule impact.

**Note:** At contract completion, **SVcum** will always be 0 because BCWS will equal BCWP.

If the **CVcum** is positive, then the contractor has spent *less* than planned to accomplish the work. If the **CVcum** is negative, then the contractor has spent *more* than planned to accomplish the work. If the **CVcum** is trending down, (i.e., the **CVcum** line is sloping downward), then cost performance is getting worse. In other words, the overrun is increasing or the underrun is decreasing.

To determine whether the contractor’s EAC is reasonable, compare the contractor’s VAC to the **CVcum**. Based on the **CVcum** trend data:

- If the VAC and **CVcum** are *approximately the same*, then the contractor’s EAC is reasonable.
- If the VAC is *more than the CVcum* and the trends are *diverging* (i.e., getting farther apart), then it is less likely the contractor can achieve their EAC. If the trends are *converging* (i.e., coming closer together), then the EAC is more likely achievable.

### Analysis in Action

In the previous sample Cumulative Variance chart, the contractor is predicting an underrun because the VAC is positive (2.3). However, the contractor’s EAC is unreasonable because the **CVcum** has consistently been much less than the VAC, and it is trending downward away from the VAC. In addition, the VAC and **CVcum** trends are diverging, which also indicates that the contractor’s EAC may be unreasonable.

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**Key EVM Formulas**

- **VAC** = BAC − EAC
  - Positive VAC = Underrun
  - Negative VAC = Overrun
- **SV** = BCWP − BCWS
  - Positive SV = Finished more work than planned
  - Negative SV = Finished less work than planned
- **CV** = BCWP − ACWP
  - Positive CV = Underrunning
  - Negative CV = Overrunning
Cost and To-Complete Performance Indexes Chart

The Cost and To-Complete Performance Indexes (CPI/TCPI) chart shows the contractor’s cumulative and current cost performance indexes (CPI\text{CUM} and CPI\text{CUR}), and the to-complete performance index for the BAC and contractor’s EAC (TCPI\text{BAC} and TCPI\text{EAC}). The chart plots time on the x-axis and index of dollars on the y-axis. You can use this chart to compare a contractor’s demonstrated efficiency with the efficiency needed to meet a cost target.

Sample CPI/TCPI Chart

How to Analyze this Chart

The CPI\text{CUM} and CPI\text{CUR} reflect the contractor’s demonstrated efficiency. The CPI\text{CUM} is the contractor’s cumulative cost efficiency, while the CPI\text{CUR} is their monthly cost efficiency. The CPI\text{CUR} tends to be volatile so it is not a good measure of total performance.

The TCPI\text{BAC} and TCPI\text{EAC} reflect the efficiency the contractor needs to achieve the BAC and their EAC, starting Day 1 of the next month.

- **Note:** With regards to TCPI, the *smaller* the BAC or EAC, the *greater* the efficiency needed to achieve it.

- **Note:** In the TCPI\text{EAC} formula, you may use the contractor’s EAC or the Government EAC to determine the TCPI for that specific EAC.

**Key EVM Formulas**

\[
\text{CPI} = \frac{\text{BWCP}}{\text{ACWP}}
\]

\[
\text{TCPI}_{\text{BAC}} = \frac{\text{Work Remaining}}{\text{Budget Remaining}} = \frac{\text{BAC} - \text{BCWP}_{\text{CUM}}}{\text{BAC} - \text{ACWP}_{\text{CUM}}}
\]

\[
\text{TCPI}_{\text{EAC}} = \frac{\text{Work Remaining}}{\text{Budget Remaining}} = \frac{\text{BAC} - \text{BCWP}_{\text{CUM}}}{\text{EAC} - \text{ACWP}_{\text{CUM}}}
\]
If the $CPI_{\text{CUM}}$ is 1.00, then the contractor’s cost efficiency is as planned. If it is greater than 1.00, the contractor is more than 100% efficient, or more efficient than budgeted. If the $CPI_{\text{CUM}}$ is less than 1.00, the contractor is less than 100% efficient, or less efficient than budgeted. If the $CPI_{\text{CUM}}$ is trending down (i.e., the $CPI_{\text{CUM}}$ line is sloping downward), the contractor’s efficiency is getting worse. If the $CPI_{\text{CUM}}$ is trending up (i.e., the $CPI_{\text{CUM}}$ line is sloping upward), their efficiency is improving.

To determine whether the contractor’s EAC is reasonable, compare the $CPI_{\text{CUM}}$ (efficiency demonstrated) to the TCPI required to achieve the BAC or EAC (efficiency needed).

- If the contractor’s $CPI_{\text{CUM}}$ is greater than the TCPI, then they are more likely to achieve the cost target because they are more efficient than what is needed to meet that target.
- If the contractor’s $CPI_{\text{CUM}}$ is less than the TCPI, then they are less likely to achieve the cost target because they are less efficient than what is needed to meet that target.
- If the trends for $CPI_{\text{CUM}}$ and TCPI are *diverging* (i.e., getting farther apart), then the likelihood of the contractor achieving the cost target is decreasing because the gap between the efficiency demonstrated and the efficiency needed is increasing.
- If the trends for $CPI_{\text{CUM}}$ and TCPI are *converging* (i.e., coming closer together), then the likelihood of the contractor achieving the cost target is increasing because the gap between the efficiency demonstrated and the efficiency needed is decreasing.
- A delta of 10% or more between TCPI and $CPI_{\text{CUM}}$ is used as an early warning indication that the targeted budget could be unrealistic.

**Analysis in Action**

In the previous sample CPI/TCPI chart, the contractor’s $CPI_{\text{CUM}}$ is 0.929. In other words, for every $1 spent (ACWP), $0.929 worth of work was accomplished (BCWP). The contractor’s EAC is unreasonable because the $CPI_{\text{CUM}}$ is less than the TCPI_{EAC} (1.072) and TCPI_{BAC} (1.022). In addition, the difference between the $CPI_{\text{CUM}}$ and TCPI_{EAC} is more than 10% (14.3%), and the difference for the TCPI_{BAC} is nearly 10% (9.3%), which also indicates that the contractor’s EAC may be unreasonable.
Cost/Schedule Variance Trends Chart

The Cost/Schedule Variance Trends chart, also known as the cone chart, shows the contract start and completion dates, the contractor’s SV$_{CUM}$ and CV$_{CUM}$, the ±10% threshold bands, the contractor and Joint Program Office (JPO) VACs, and management reserve (MR). The chart plots time on the x-axis and dollars in millions on the y-axis. You can use this chart to compare cost and schedule performance trends to the JPO’s and contractor’s VAC.

Sample Cost/Schedule Variance Trends Chart
How to Analyze this Chart

Similar to the Cumulative Variance chart, if the VAC is positive for either the JPO or the contractor, then that entity is predicting an *underrun*; their EAC is less than the BAC. If their VAC is negative, then they are predicting an *overrun*; their EAC is more than the BAC.

If the CV_{CUM} is positive, then the contractor has spent *less* than budgeted to accomplish the work. If it is negative, then the contractor has spent *more* than budgeted to accomplish the work. If the CV_{CUM} is trending down, (i.e., the CV_{CUM} line is sloping downward), then performance is getting worse. In other words, the overrun is increasing or the underrun is decreasing.

If the SV_{CUM} is positive, then the contractor has accomplished *more* work than planned. If it is negative, then the contractor has accomplished *less* work than planned. If the SV_{CUM} is trending down, (i.e., the SV_{CUM} line is sloping downward), then schedule performance is getting worse.

- **Note:** Negative SV_{CUM} does not necessarily mean that the contract is behind schedule. You must look at the network schedule to determine if the tasks are on the critical path before making assumptions about schedule impact.

- **Note:** If the contractor has a large number of 50/50 work packages, a positive SV_{CUM} could result from the contractor opening work packages early.

To determine whether the contractor's EAC is reasonable, compare the cost and schedule performance trends to the trend required to reach the JPO and contractor estimates (i.e., the VACs) and look for changes in trends.

- A negative SV_{CUM} trend is often followed by a negative CV_{CUM} trend.
- Normally, the best a contractor can do is to flatten the CV_{CUM} trend, meaning there are no additional overruns. However, when the CV_{CUM} trend to date is negative, it is rare for a contractor to spend less than planned in the future to cause the trend to improve, or track up. For this reason, if the CV_{CUM} trend needs to improve drastically to reach the JPO or contractor VAC, the contractor would need a good explanation for how this change could occur.
- Remember: The SV_{CUM} will always trend back to 0 when work is complete because BCWP will equal BCWS. This does not mean work will be completed according to the original schedule, only that all work will eventually be completed and earned value (EV) will be achieved.
- Use of MR is also something to track; early MR use is often an indication of planning problems.
• The ±10% threshold bands are based upon ±10% of BCWP and provide perspective on the relative significance of the cost and schedule variances. The goal is to stay within this cone.

Analysis in Action
In previous sample Cost/Schedule Variance Trends chart, the contractor is predicting an underrun because their VAC is positive. However, the contractor’s EAC is unreasonable because both CV_{CUM} and SV_{CUM} have consistently trended downward, and show no sign of improving. Moreover, the change required in the CV_{CUM} trend to reach the JPO and contractor VACs is significant, which makes this change unlikely.
Estimates at Completion Chart

The Estimates at Completion (EAC) chart shows the BAC, the contractor’s EAC, and one or more formula-based EACs, plotting time on the x-axis and dollars in millions on the y-axis. This chart is used to compare a contractor’s EAC to formula-based EAC(s) to determine if the contractor’s EAC is reasonable.

Sample EAC Chart

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<tr>
<th>Month</th>
<th>BAC</th>
<th>EAC</th>
<th>CUM CPI</th>
</tr>
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<td>62.4</td>
<td>69.7</td>
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**Note:** This sample chart displays one formula-based EAC: $\text{EAC}_{\text{CPI}}$ (also known as the *floor EAC*), which uses $\text{CPI}_{\text{CUM}}$ as the performance factor. Other charts may display additional EACs, such as the *ceiling EAC* ($\text{EAC}_{\text{Composite}}$), which uses $\text{CPI} \times \text{SPI}$ as the performance factor.

*See the next section for more information about formula-based EACs and performance factors.*
How to Analyze this Chart

The contractor's EAC is one way to determine what the contract may cost compared to the original plan.

Formula-based EACs are another way to determine what the contract may cost. EACs may be calculated by using different performance factors (PFs).

To calculate a formula-based EAC, substitute an efficiency factor (e.g., CPI_{CUM} or CPI_{CUM} \cdot SPI_{CUM}) for the PF. No one factor is better than another. Choose an efficiency factor based on program history, current trends, technical performance, and other programmatic information.

The Six Period Summary report pre-calculates several formula-based EACs. See the Six Period Summary Report subsection at the end of this job aid for more information.

EACs are used to assist management decision-making and planning. They are frequently included in reports, such as budget documents, submitted to upper levels of management. If the calculated EACs differ greatly from the BAC and/or contractor EAC, then the contractor and/or the Program Management Office (PMO) should be prepared to explain why.

Analysis in Action

In the previous Sample Estimates at Completion (EAC) chart, the contractor is predicting an underrun because their EAC is less than the BAC. However, the contractor's EAC is unreasonable because, it is below the formula-based EAC that uses CPI_{CUM} as the PF, otherwise known as the *floor*.

### Key EVM Formulas

<table>
<thead>
<tr>
<th>Formula</th>
<th>Description</th>
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<tr>
<td>VAC = BAC − EAC</td>
<td>Vacant Amount Cost</td>
</tr>
<tr>
<td>( VAC = BAC − EAC )</td>
<td>Vacant Amount Cost</td>
</tr>
<tr>
<td>Positive VAC = Underrun</td>
<td></td>
</tr>
<tr>
<td>Negative VAC = Overrun</td>
<td></td>
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<tr>
<td>( EAC_{PF} = ACWP + \frac{BAC − BCWP_{CUM}}{Performance Factor} )</td>
<td>EAC with Performance Factor</td>
</tr>
<tr>
<td>( EAC_{CPI_{CUM}} = ACWP + \frac{BAC − BCWP_{CUM}}{CPI_{CUM}} )</td>
<td>EAC with CPI_{CUM}</td>
</tr>
<tr>
<td>( EAC_{Composite} = ACWP + \frac{BAC − BCWP_{CUM}}{CPI_{CUM} \cdot SPI_{CUM}} )</td>
<td>Composite EAC with CPI_{CUM} * SPI_{CUM}</td>
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Six Period Summary Report

The Six Period Summary report provides current, cumulative, and completion data at the work breakdown structure (WBS) level for the most recent six periods, ending with the current period. The last section of this report provides statistical forecasts and independent EACs (i.e., formula-based EACs).

![EVM Chart Analysis](Image)
Statistical Forecasts and Independent EACs

Most of the forecasts calculated in this section use the EAC formula and a PF:

\[ \text{EAC}_{PF} = \text{ACWP} + \frac{\text{BAC} - \text{BCWP}_{CUM}}{\text{Performance Factor}} \]

Similar to the EAC chart, the choice of PF is based on program history, current trends, technical performance, and other programmatic information.

Calculations that do not use the EAC formula include the User Entered EAC and JPO Entered EAC. The User Entered EAC is a bottoms-up calculation generated by identifying an EAC method at lower WBS levels that gets summarized to the total level. The JPO Entered EAC is also a user input at the total contract level.