

**Earned Value Management System (EVMS) and
Project Analysis
Standard Operating Procedure
(EPASOP)**

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Earned Value Management System (EVMS) and Project Analysis Standard Operating Procedure (EPASOP)

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- 1. PURPOSE.** This EVMS and Project Analysis Standard Operating Procedure (EPASOP) will serve as a primary reference for MA-631 when conducting project-level data analysis to support Monthly Project Assessments and other assessment needs. This SOP refers to several Project Assessment and Reporting System (PARS II) reports and provides instruction on interpretation of data to support project performance, predictive analysis, and identification of concerns with the contractor's EVMS. The results of the analysis and tools herein also support MA-632 EVMS Stage 1 surveillance (reference ESSOP), and any other project assessments where EVMS is contractually required.
- 2. APPLICABILITY.** This SOP applies to OAPM (MA-63) and is available for use outside MA-63.
- 3. RELEASABILITY – UNLIMITED.** This SOP is approved for public release.
- 4. EFFECTIVE DATE.** This SOP is effective immediately.

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1.0 INTRODUCTION

The Department of Energy performs three types of Earned Value Management System (EVMS) and project performance functions: System Compliance Reviews, System Surveillance, and Project Analysis. OAPM (MA-63) has developed a suite of procedures to define and standardize each of these functions. This EVMS & Project Analysis Standard Operating Procedure (EPASOP) is provided as a guide for conducting cost and schedule analysis in support of the aforementioned functions and other DOE reviews where project performance and/or EVMS knowledge and application are required.

An integral part of successful project management is reliable and accurate information. Project managers and their teams perform best when they are well informed. The goal of EVM project analysis is to provide consistent and timely insight to project status in order to enable timely, effective management decisions. In conjunction with conducting project analysis, the health of the contractor's EVMS is assessed through analysis of cost and schedule data. This SOP covers analysis both from a project-level and system-level perspective.

A primary reference used in the development of this SOP was the Department of Defense (DOD) Defense Contract Management Agency's (DCMA) Earned Value Management System Program Analysis Pamphlet (DCMA-EA PAM 200.1) issued July 12, 2012. Tailoring was required to connect portions of DCMA's pamphlet to DOE's Project Assessment and Reporting System (PARS II) reports. Additional guidance has been added in support of DOE-specific standard operating procedures based on government and industry best practices. Refer to Section 5.0 for a complete list of resources relating to this SOP.

2.0 PROJECT ASSESSMENT AND REPORTING SYSTEM (PARS II)

PARS II is the Department's official "System of Record" for capital asset project performance information. Because PARS II uses the same data maintained in our contractors' project management systems, everyone from the Federal Project Director's staff to the Secretary of Energy has easy access to the same data.

The PARS II software application is managed by the Office of Acquisition and Project Management (MA-63) and is used by federal and contractor personnel across the nation to record and track the progress of major construction and environmental cleanup projects. PARS II has the capability to provide various reports that are typically used for analysis and assessment purposes from both an EVMS prospective as well as for project-level performance. Those analysis reports are found in the SSS Reports Section, Shared Reports, in the Analysis Folder – Project Analysis SOP. The reports listed below are discussed in this EPASOP. The subfolders align to the recommended analysis plan. Where there is some duplication of reports among steps of the plan, each step identifies the area of focus in the following section. Reports may be added as necessary to accommodate analysis needs.

- Data Validity Check
 - EV Data Validity (WBS Level)
 - Retroactive Change Indicator (6-Mo, PMB Level)
- Schedule Health Assessment
 - Schedule Missing Logic (Activity Level)
 - Relationship Leads and Lags Report
 - Schedule Relationship Types (Activity Level)
 - Schedule Hard Constraints (Activity Level)
 - Schedule Total Float Analysis (Activity Level)
 - Schedule Duration Analysis (Activity Level)
 - Invalid Forecasts and Actual Dates (Activity Level)
 - Schedule Hit or Miss Report
- Variance Analysis
 - EV Project Summary (6-Mo, PMB Level)
 - Performance Analysis (WBS Level)
 - Variance Analysis Cumulative (WBS Level)

- Trend Analysis
 - Baseline Volatility – Past and Near-Term (PMB Level)
 - EV Project Summary (6-Mo, PMB Level)
 - MR Balance v. CV, VAC, & EAC Trends
 - Management Reserve (MR) Log
 - Performance Index trends (WBS Level)
 - Variance Analysis Cumulative (WBS Level)
- EAC Reasonableness
 - CPI v. TCPI (PMB Level)
 - EV Data Validity (WBS Level)
 - Performance Index Trends (WBS Level)
- Predictive Analysis
 - Funding Status (Monthly at Project Level)
 - IEAC Analysis (WBS Level)

3.0 ANALYSIS PLAN

The Analysis Plan outlines steps taken when conducting basic project-level analysis. The analysis described in this plan is conducted on the project's Performance Measurement Baseline (PMB). The PMB is a time-phased budget plan for accomplishing work, against which project performance is measured. The PMB includes all effort as described in the Statement of Work (SOW) or Project Execution Plan (PEP), from CD-2 through Post CD-4 closeout effort. Post CD-4 activities are comprised of all activities chargeable against project costs including data deliverables, such as PARS II reporting, Lessons Learned, and Initial Closeout Report submittal (ref. DOE O 413.3B, Table 2.4).

By following this Analysis Plan, the Analyst can assess EVMS data validity, identify sources of current and past performance issues, determine if recent corrective actions were successful in improving performance, and assess baseline stability and reasonableness of the Estimate at Completion. The following notation indicates when the analysis results could also point to systemic issues possibly justifying Stage 2 surveillance, i.e. *Concerns in this area not only apply to Project performance but also to systemic concerns with the contractor's EVMS*. In these cases, the Analyst should alert the MA-632 EVM Specialists.

This process should be followed:

- Monthly by the Analyst to gain insight for use in the preparation of the monthly project assessments
- During the Stage 1 EVMS Surveillance to identify if systemic issues warrant a closer look at the contractor's EVMS
- Prior to any post CD-2 project review, such as Peer Review, EIR, etc.
- Prior to any EVMS-related or project-level briefing with focus on project performance

The steps of the plan include:

1. Assess data validity
2. Assess schedule health
3. Analyze variances
4. Analyze trends

5. Assess realism of contractor's EAC
6. Predict future performance and an IEAC

When conducting analysis, single occurrence non-compliance issues are important. However, we also need to know if there are multiple occurrences. This helps us identify the root cause, e.g. people, process, and tools associated with the contractor's EVMS.

3.1 ANALYSIS PLAN STEP 1: ASSESS DATA VALIDITY

Earned value data is ultimately used to manage the project and make informed decisions and projections. The first step of the Analysis Plan is to assess data accuracy and reliability. Data integrity indicators are metrics designed to provide confidence in the quality of the data being provided from the contractor's EVM System. Many of the other metrics described in this EPASOP are designed to provide insight into the performance of a project. If a contractor's data has one or more of the conditions being tested for by these metrics, the Analyst should investigate further and consider a Stage 2 Surveillance in accordance with MA-63's Earned Value Management Systems Surveillance Standard Operating Procedure (ESSOP).

PARS II automatically issues warnings upon contractor's upload if there are concerns with the validity of the data. The contractor may or may not take the opportunity to make corrections. The PARS II EV Data Validity (WBS Level) Report provides a concise and complete report of typical data integrity metrics to identify errors or issues. As the name suggests, these metrics determine the validity and accuracy of EVM data produced by the contractor for management decision making. *Concerns in this area not only apply to Project performance but also to systemic concerns with the contractor's EVMS.* These metrics reflect the trustworthiness of EVM-based reports.

The metrics listed below are discussed in detail in the following paragraphs:

- Negative BCWS, BCWP, or ACWP entries in current period
- Current period BCWS, BCWP, or ACWP greater than cumulative
- $BCWS_{CUM} > BAC$ and/or $BCWP_{CUM} > BAC$
- $ACWP_{CUM} > EAC$
- ACWP and/or EAC with no BAC

- BCWP with no ACWP
- Completed Work with ETC
- Incomplete Work with No ETC
- BCWS with no ACWP or BCWP

Two of the data indicators on the Data Validity (WBS Level) Report correspond to the accuracy and reasonableness of the contractor's Estimate at Completion. They are 1) CV_{CUM} more negative than VAC, and 2) $TCPI_{EAC}$ and CPI differ by more than 5%. These will be discussed in more detail later in this SOP when assessing EAC reasonableness.

3.1.1 NEGATIVE $BCWS_{CUR}$, $BCWP_{CUR}$, $ACWP_{CUR}$

The budgeted cost of work scheduled (BCWS) is the time-phased project budget. The summation of BCWS for all reporting periods equals the total project budget at completion. When the initial baseline is established there should be no instances of negative BCWS. However, as work progresses there may be legitimate reasons for re-planning of budget. Negative BCWP in the current period indicates that previously claimed performance is being backed out. While this might occur due to re-plan actions it should be explained. Negative ACWP in the current period indicates prior charges are being backed out. This may be due to routine accounting adjustments or correction of errors. Instances of current period negative values should be investigated further to determine the root cause.

While any negative values in the current period may be valid, they should be investigated. However, these corrections must always be reflected in the current period BCWS, BCWP, or ACWP – never made retroactively to previously reported periods. The PARS II Retroactive Change Indicator (6 mo; PMB Level) Report (discussed in greater detail in section 3.1.11) highlights when reported history was changed by comparing each monthly upload of data. The Retroactive Change Indicator report should be reviewed minimally every 6 months; although a review every 1 to 3 months is recommended to allow for real-time investigation and impacts to performance indices.

3.1.2 INCREMENTAL BCWS, BCWP, OR ACWP GREATER THAN CUMULATIVE

The $BCWS_{CUM}$, $BCWP_{CUM}$, and $ACWP_{CUM}$ are calculated by the sum of the current period values to date. Therefore, it is impossible for the $BCWS_{CUR}$, $BCWP_{CUR}$, and $ACWP_{CUR}$ to be greater than the cumulative. Should this occur, consider this an error in the EVMS data.

3.1.3 $BCWS_{CUM} > BAC$

The budgeted cost of work scheduled (BCWS) is the project budget time-phased over the period of performance. The summation of BCWS for all reporting periods should equal the budget at completion (BAC) for the same level. In other words, $BCWS_{CUM}$ should equal BAC on the month the project is planned to complete. Due to this relationship, the value of $BCWS_{CUM}$ should never exceed BAC. If $BCWS_{CUM}$ is greater than BAC, consider this an error in the EVMS data and pursue corrective action.

3.1.4 $BCWP_{CUM} > BAC$

The budgeted cost of work performed (BCWP) is the amount of BCWS earned by the completion of work to date. The $BCWP_{CUM}$ may not exceed the value of BAC. The project is considered complete when $BCWP_{CUM}$ equals BAC. If $BCWP_{CUM}$ is greater than the BAC, consider this an error.

3.1.5 $ACWP_{CUM} > EAC$

The Estimate at Completion (EAC) consists of two components, the actual costs incurred to date ($ACWP_{CUM}$) plus the estimate of future costs to be incurred or the estimate to completion (ETC). The $ACWP_{CUM}$ can only be greater than EAC if the ETC is negative; i.e. indicating that previously reported ACWP will be reduced. There may be limited cases that would require a negative ETC, although not the norm. If this condition exists, further investigation is required.

3.1.6 $ACWP_{CUM}$, $ACWP_{CUR}$, or EAC WITH NO BAC

The actual cost of work performed (ACWP) is the total dollars spent on labor, material, subcontracts, and other direct costs in the performance of the contract statement of work. These costs are controlled by the accounting general ledger and must reconcile between the accounting system and EVMS. Work should only be performed if there is a clear contractual requirement. If

there are Work Breakdown Structure (WBS) elements that contain EAC or ACWP but no BAC, consider this an issue that needs to be investigated.

3.1.7 BCWP WITH NO ACWP

Since work or materials must be paid for, it is not possible to earn BCWP without incurring ACWP. For material receipts not yet billed, the contractor is expected to use estimated actuals to report ACWP in the same period as the BCWP, thus avoiding false variances. This condition may also occur for elements using the Level of Effort (LOE) earned value technique. In this case, it would signify the support work that was planned to occur is not occurring due to some delay. The delay is likely in the work the LOE function would support. Either way, this condition should be further investigated to determine the root cause.

3.1.8 COMPLETED WORK WITH ETC

Work is considered complete when the Control Account (CA) or Work Package (WP) $BCWP_{CUM}$ equals BAC. The estimate to complete (ETC) is the to-go portion of the estimate at completion (EAC). The ETC should be zero if the work is complete, as there should be no projected future cost left to incur. This condition may exist if labor or material invoices are lagging behind and have not been paid yet which indicates improper use of estimated actuals. This situation requires investigation to determine the root cause and corrective action.

3.1.9 INCOMPLETE WORK WITHOUT ETC

This metric is the opposite of section 3.1.8 of this SOP. If work has not been completed, there should be a forecast of the remaining costs to be incurred. If this condition exists consider it an error that requires corrective action.

3.1.10 BCWS WITHOUT BCWP AND ACWP

This indicator identifies active open control accounts where work is scheduled in the current period; however, no performance or costs have been reported. This is not an error but may point to performance issues.

3.1.11 RETROACTIVE CHANGE

Another data point in determining accuracy of data is provided in the PARS II Retroactive Change Indicator (6-mos; PMB Level) Report. The purpose of the report is to highlight discrepancies in Earned Value data reporting based on the time-phased data reported in the last 6 reporting periods. The report identifies retroactive changes made to previously reported BCWS, BCWP, and ACWP data, as well as negative BCWS values that are planned for future periods. Since this report covers a 6 month window, it should be reviewed minimally every 6 months; although a review every 1 to 3 months is recommended to allow for real-time investigation.

The term ‘retroactive’ applies when previously reported BCWS, BCWP, or ACWP was erroneous and needs to be corrected. The process to make the change is to make it in the current period when the event causing the change happens. Previously reported data, i.e. history, is not changed and the cumulative effect of the change is shown in the current period. Examples of valid reasons to change previously reported data include:

- Negotiated indirect rates or overhead rate adjustments: While the impact of the rate changes may go back to the beginning of the fiscal year; the sum of the impact is reported in the ACWP for the reporting month that the customer negotiated and authorized the change.
- Clerical errors that effect BCWS, BCWP, and ACWP should be corrected as soon as discovered.
- Work/cost transfers occur when it is discovered that the work was erroneously assigned to an incorrect WBS.
- Work in process termination: When an open work is not to be completed, BCWS and BAC are set equal to the BCWP.
- Adjustments to previously reported ACWP when actual costs replace estimated actuals.

While these kinds of changes are acceptable, an excessive amount may indicate the system lacks discipline. Questions to ask when changes have been identified include:

1. Why was budget removed? Was scope removed?
2. Does the rationale meet Guideline 30, e.g. correction of errors, routine accounting adjustments, effects of customer or management directed changes, or to improve the baseline integrity and accuracy of performance measurement data?
3. Why was the change made to history rather than in current period?

3.2 ANALYSIS PLAN STEP 2: ASSESS SCHEDULE HEALTH

As stated in the ANSI/EIA-748 (current version), the project schedule and budget are an integrated time-oriented plan for accomplishment of work scope requirements on a project. Schedule planning and control, budget planning and control, work scope definition, and project risk handling are necessary prerequisites for basic and effective project management control. Therefore, step 2 of the analysis plan is to assess the health of the schedule by performing some diagnostics. This step may also be done in preparation for EVMS review, review of a major schedule restructure, and whenever schedule health is a concern. Two references used for this section are the portion of DCMA's Program Analysis Pamphlet section 4.0 and the GAO (Government Accountability Office) Scheduling Best Practices May 2012 exposure draft. Note that until the GAO Schedule Assessment Guide is issued as 'final' following resolution of public comments, it is not recommended as a primary reference.

OAPM (MA-63) currently uses Acumen Fuse ® software to identify potential problem areas with a contractor's schedule. *Concerns in this area not only apply to Project performance but also to systemic concerns with the contractor's EVMS.* The following metrics provide the analyst with a framework for asking educated questions and performing follow-up research. The identification of a triggered metric is not in and of itself synonymous with failure but rather an indicator or a catalyst to dig deeper in the analysis for understanding the reason for the situation. Consequently, correction of that metric is not necessarily required but it should be understood. -

3.2.1 LOGIC

Logic, used in the scheduling sense, is the relationship tasks have to each other. The objective of this metric is to ensure each task has at least one predecessor and successor link, i.e. logic links. Discrete tasks must be linked (have predecessors and successors) in order to properly calculate the Total Float in the project. If the logic is missing, the true critical path for the project is unknown. Even if links exist, the logic still needs to be verified to ensure that the links make sense. Incomplete tasks missing predecessors and/or successors are included in this metric. If this metric yields the result of greater than 5%, it should be considered a flag and further investigation of

contractor schedule is required to understand which activities are missing logic ties in the schedule and why. The formulas for calculating this metric follow.

To calculate the numerator:

$$[(\# \text{ missing predecessors}) + (\# \text{ missing successors}) - (\# \text{ missing both})] = \# \text{ of tasks missing logic}$$

To calculate the percentage:

$$[\# \text{ Tasks Missing Logic} / \text{Incomplete Task Count}] \times 100 \leq 5\%$$

PARS II replicates this metric in the Schedule Missing Logic (Activity Level) report. However this metric calculation is based only on discrete tasks which mean they do not include any LOE tasks that may be in the schedule. PARS II currently does not distinguish between discrete and LOE tasks, so all tasks are included in this report. Therefore, the high risk rating identified in the PARS II report is anything equal to or greater than 15% instead of the 5% when using the discrete tasks only.

3.2.2 LEADS

A lead, also called a negative lag, refers to a relationship whereby the successor activity is scheduled to begin before the predecessor activity has completed. For example, say Task 1 and Task 2 have a Finish-Start relationship, so when Task 1 finishes, Task 2 can start. If when Task 2 is planned, a Lag of -1 is added to the predecessor relationship between Task 1 and Task 2, the schedule would then show that Task 2 must start 1 day prior to the last day Task 1 finished. The negative lag is called a lead. When tasks are logically linked, it is important to determine if any leads exist because the critical path and any subsequent analysis can be adversely affected by using leads. The use of leads distorts the total float in the schedule and may cause resource conflicts. In some cases, these leads are used to artificially compress the schedule which results in distorted total float values which is discussed later in this section. The reason for using leads should be documented and have proper justification (preferably in a “notes” column of the schedule).

This metric identifies the number of logic links with a lead in predecessor relationships for incomplete tasks. The critical path and any subsequent analysis can be adversely affected by using

leads. The use of leads distorts the total float in the schedule and may cause resource conflicts. The goal for this metric is 0. PARS II replicates this metric in the Relationship Leads and Lags (Activity Level) report.

First, calculate the numerator by counting the number of logic links with leads. Next, calculate the denominator, i.e. the number of logic links (sometimes referred to as the Relationship Count) or Logic Links, by counting the number of each of the four relationship types (FS, SS, FF, SF) in the predecessor OR successor column (but not both to avoid double-counting). Then calculate the percentage of leads as follows:

$$[\textit{# of logic links with Leads} / \textit{# of logic links}] = 0\%$$

3.2.3 LAGS

Lag refers to a relationship whereby the successor activity cannot start right after the end of its predecessor. The objective of this metric is to ensure that lags are not being used to artificially constrain the schedule. The critical path and any subsequent analysis can be adversely affected by using lags. In many cases, these lag values are appropriately used by the CAMs to represent wait times for government review, waiting for “paint to dry”, etc.

The critical path and any subsequent analysis can be adversely affected by using lags. Lags should not be used to manipulate float/slack or to restrain the schedule. If lags are used to force a task to start/finish on a certain date, the schedule is being artificially restrained and this should be considered an instance of non-compliance during surveillance. The reason for using a lag should be documented and have proper justification (preferably in a “notes” column of the schedule) to discern whether or not the lag is being used in an appropriate manner.

The calculation is based on examining the incomplete tasks, and determining the number of logic links with lags. The denominator is the number of incomplete tasks with logic links. The number relationships with lags should not exceed 5%.

$$[\textit{# of logic links with Lags} / \textit{# of logic links}] \leq 5\%$$

3.2.4 RELATIONSHIP TYPES

The metric provides a count of incomplete tasks containing each type of logic link.

The Finish-to-Start (FS) relationship type (“once the predecessor is finished, the successor can start”) provides a logical path through the project and should account for at least 90% of the relationship types being used. The Start-to-Finish (SF) relationship type is counter-intuitive (“the successor can’t finish until the predecessor starts”) and should only be used very rarely and with detailed justification. By counting the number of Start-to-Start (SS), Finish-to-Finish (FF), and Start-to-Finish (SF) relationship types, the % of Finish-to-Start (FS) relationship types can be calculated.

$$[\# \text{ of FS Relationships} / \text{Relationship Count}] \geq 90\%$$

PARS II replicates this metric in the Schedule Relationship Types (Activity Level) report.

However this metric calculation is based only on discrete tasks which mean they do not include any LOE tasks that may be in the schedule. Since PARS II does not distinguish between discrete or LOE tasks, this report includes all tasks. The REPORT tab shows the relationship types in a histogram.

The histogram bars are positioned to allow for easy view of the trend from baseline to current period. Variances can be used to identify if there is a trend of schedule logic shifting from FS type relationship to FF or SS type relationship. Consistently decreasing number of FS type relationships coupled with continuously increasing number of SS and/or FF type relationships may be an indicator of activity relationships that are used to manipulate critical path and mask schedule delays. Significant fluctuations in relationship types may be an indicator of unstable baseline and work reshuffling.

3.2.5 HARD CONSTRAINTS

Schedule constraints inflict a restriction on either the start or end date of a discrete task and/or milestone. Hard constraints anchor a schedule or task in time to a specific date regardless of predecessor logic, i.e. dependencies. Soft constraints anchor a task’s start or finish date but they respect predecessor logic, thus allowing the schedule end date to move to the right should a slip

occur. Because hard constraints restrict the schedule, they must be minimized to allow the network schedule to update properly and reflect current status.

The calculation used to determine schedule health regarding the use of hard constraints is based on a count of incomplete tasks with hard constraints in use. Hard constraints include: Must-Finish-On (MFO), Must-Start-On (MSO), Start-No-Later-Than (SNLT), & Finish-No-Later-Than (FNLT). Soft constraints such as As-Soon-As-Possible (ASAP), As Late As Possible (ALAP), Start-No-Earlier-Than (SNET), and Finish-No-Earlier-Than (FNET) .

Divide the total number of hard constraints by the number of incomplete tasks. The number of tasks with hard constraints should not exceed 5%.

$$\text{Hard Constraint \%} = \frac{\text{Total \# of incomplete discrete tasks with hard constraints}}{\text{Total \# of incomplete discrete tasks}} \times 100$$

PARSII replicates this metric in the Schedule Hard Constraints (Activity Level) report. However this metric calculation is based only using only discrete tasks. Since PARSII does not distinguish discrete from LOE tasks, this report includes all incomplete tasks.

3.2.6 FLOAT ANALYSIS

Float is the amount of time a predecessor activity can be delayed without impacting its successor. Total Float is the amount of time an activity can be delayed or extended before it impacts the project end date. The highest risk to schedule completion includes those activities with the lowest float values. Conversely, activities with unreasonably high amounts of total float indicate missing activities, missing or incomplete logic, and date constraints. When these things occur, the high total float gives a false sense of a cushion toward meeting the project completion date. The schedule should identify reasonable float, sometimes called slack, so that the schedule's flexibility can be determined and monitored.

When evaluating float values is it important to understand:

- Float/total float should always be greater than or equal to zero.
- Negative float indicates a problem with the schedule’s achievability.
- Excessive float usually indicates there is a problem with the logic connections.

The two key metrics to focus on when conducting schedule analysis are discussed in the next two paragraphs, i.e. High Total Float and Negative Float. PARSII replicates these metrics in the Schedule Total Float Analysis (Activity Level) report. However this metric calculation is based only using only discrete tasks. Since PARSII does not distinguish discrete from LOE tasks, this report includes all incomplete tasks.

3.2.6.1 HIGH TOTAL FLOAT

An incomplete task with total float greater than 44 working days (2 months) is counted in this metric. A task with total float over 44 working days may be a result of missing predecessors and/or successors. If the percentage of tasks with excessive total float exceeds 5%, the network may be unstable and may not be logic-driven.

$$\text{High Total Float \%} = \frac{\text{Total \# of incomplete tasks with high total float}}{\text{Total \# of incomplete tasks}} \times 100$$

3.2.6.2 NEGATIVE FLOAT

An incomplete task with total float less than 0 working days is included in this metric. It helps identify tasks that are delaying completion of one or more milestones. Negative float also may be an indicator of a constrained activity completion date or activities completed out of sequence. Tasks with negative float should have an explanation and a corrective action plan to mitigate the negative float. Divide the total number of tasks with negative float by the number of incomplete tasks. Ideally, there should not be any negative float in the schedule.

$$\text{Negative Total Float \%} = \frac{\text{Total \# of incomplete tasks with negative total float}}{\text{Total \# of incomplete tasks}} \times 100$$

3.2.7 HIGH DURATION

Duration is the estimated amount of time to complete a task. The purpose of monitoring durations is to ensure that baseline durations are realistic and manageable. The rationale behind this metric is that a task with baseline duration greater than 44 working days should be analyzed to determine whether or not it can be broken into two or more discrete tasks rather than one. By breaking down the tasks into smaller pieces, it is likely that the tasks will be more manageable and provide better insight into cost and schedule performance. However, care should be taken not to break larger tasks into smaller tasks simply to meet a threshold.

Divide the number of incomplete tasks with high duration tasks by the total number of incomplete tasks. The number of tasks with high duration should not exceed 5%.

$$\text{High Duration} = \frac{\text{Total \# of incomplete tasks with high duration}}{\text{Total \# of incomplete tasks}} \times 100$$

Note: rather than 44 days, the customer may specify a different value. Therefore, the goal may vary from project to project. This goal should be consistent with accepted system description. In absence of detailed guidance regarding durations of work correlating with EVM techniques, the default is 44 days.

PARSII replicates these metrics in the Schedule Duration Analysis (Activity Level) report. However this metric calculation is based only using only discrete tasks. Since PARSII does not distinguish discrete from LOE tasks, this report includes all incomplete tasks.

3.2.8 INVALID DATES

This metric is designed to identify issues relative to invalid forecast dates and invalid actual dates. Neither should exist so the goal is 0%. PARSII replicates these metrics in the Invalid Forecast and Actual Dates (Activity Level) report. However this metric calculation is based only using only discrete tasks. Since PARSII does not distinguish discrete from LOE tasks, this report includes all incomplete tasks.

3.2.8.1 INVALID FORECAST DATES

The objective of this metric is to ensure that forecast start and forecast finish dates are being updated for incomplete tasks. A task should have forecast start and forecast finish dates that are in the future relative to the status date (sometimes called the data date) of the IMS. Tasks that have forecast start and/or finish dates that do not meet the criteria are invalid and indicate that the IMS has not been properly stated. Accurate and updated forecast dates are necessary for good project management, for calculating a valid critical path, and for EVMS compliance in general.

There should be zero tasks with invalid forecast start and/or finish dates. The formula is:

$$[\# \text{ of tasks with Invalid Forecast Dates} / (\text{Incomplete Tasks Count} \times 2)] = 0\%$$

3.2.8.2 INVALID ACTUAL DATES

The objective of this metric is to ensure that actual start and actual finish dates are valid. A task should not have actual start and actual finish dates that are in the future relative to the status date of the IMS. Tasks that have actual start and/or actual finish dates that meet the criteria are invalid and indicate that the IMS has not been properly stated. Accurate and updated actual start and actual finish dates are necessary for good project management and for calculating a valid critical path. Additionally, invalid actual dates adversely affect “out of sequence tasks” and ultimately affect meeting the correct forecasting required to be EVMS compliant.

There should be zero tasks with invalid actual start and/or actual finish dates. The formula is:

$$[\# \text{ of tasks with Invalid Actual Dates} / (\text{Incomplete Tasks Count} \times 2)] = 0\%$$

3.2.9 RESOURCES

This metric provides verification that resources (hours and dollars) are properly loaded into the schedule. All tasks included as part of the Performance Measurement Baseline (PMB) should have resources assigned. DOE O 413.3B, Attachment 1, paragraph 5 states “a critical path schedule and a resource-loaded schedule must be developed and maintained for the project”.

PARSII does not currently have the information needed to calculate this metric. The recommended method for calculating this metric is to coordinate with Federal Project Director (FPD) a request for the Project's Planner/Master Scheduler to create a filter in P6 (or another scheduling system used by the contractor) and then discuss the results with to ensure complete understanding of the results. The filter would find tasks with baseline durations of one or more days that do not have allocated resources (hours and/or dollars). It is important to remember that projects may code their resource columns differently. Therefore, it is very important that the project scheduler is involved to determine which columns contain the resources should the Project Analyst create the filter.

If tasks without resources are found, coordinate with the Federal Project Director (FPD) to make the Control Account Manager (CAM) and project scheduler available in order to find out why this condition exists. Investigate the type of work being done, labor versus material, subcontractor or external tasks, Government Furnished Equipment / Information / Material (GFE/I/M).

The metric is calculated by dividing the number of incomplete tasks without dollars/hours assigned by the total number of incomplete tasks. The goal is 0%.

$$\left[\frac{\text{\# of incomplete tasks with missing resources}}{\text{Incomplete Tasks Count}} \right] * 100 = \text{Missing Resource \%}$$

3.2.10 MISSED TASKS

A task is included in this metric if it is supposed to be completed already (baseline finish date on or before the status date) and the actual finish date or forecast finish date (early finish date) is after the baseline finish date or the Finish Variance (Early Finish minus Baseline Finish) is greater than zero. This metric helps identify how well or poorly the schedule is meeting the baseline plan. An excessive amount of missed tasks indicates that the project is performing poorly to the baseline plan due to lack of adequate resources, unrealistic planning, etc., or just poor project management in general. As a result, it is very likely that the project will not complete on time.

The Slip Severity tab of the PARSII Schedule Hit or Miss Report provides a better understanding of the severity of the schedule slip on slipped activities. Large number of slipped activities associated with significantly lower number of slipped milestones may be an indication that project

is encountering schedule issues in certain areas of the project that have not yet impacted other areas. Large number of slips in both activities and milestones may be an indicator of:

- a) Severe schedule problems across the entire project
- b) Baseline no longer represents true project environment and may need to be reviewed

To calculate this metric, divide the number of missed tasks by the baseline count which does not include the number of tasks missing baseline start or finish dates. The number of missed tasks should not exceed 5%.

$$\text{Missed \%} = \frac{\text{\# of tasks with actual/forecast finish date past baseline date}}{\text{\# of tasks with baseline finish dates on or before status date}} \times 100$$

3.2.11 CRITICAL PATH TEST

The purpose is to test the integrity of the overall network logic and, in particular, the critical path. If the project completion date (or other milestone) is not delayed in direct proportion (assuming zero float) to the amount of intentional slip that is introduced into the schedule as part of this test, then there is broken logic somewhere in the network. Broken logic is the result of missing predecessors and/or successors on tasks where they are needed. The schedule passes the Critical Path Test if the project completion date (or other task/milestone) show a negative total float number or a revised Early Finish date that is in direct proportion (assuming zero float) to the amount of intentional slip applied. Currently, this test can only be performed within contractor native scheduling system such as Primavera P6. This is a complex test and the analyst should coordinate with the Federal Project Director (FPD) to ensure the contractor performs the test and provides the results to the analyst.

3.3 ANALYSIS PLAN STEP 3: ANALYZE VARIANCES

The next step in conducting EVMS data analysis is to identify and investigate variances. This is the point where all the effort put in to developing an approved baseline plan and determining the status against that plan serves its purpose, i.e. to identify significant variances and analyze causes so corrective actions can be determined and implemented. Variance Analysis is the identification and explanation of the top cost and schedule drivers and typically involves cumulative information. Variance analysis employing current data may also be useful in identifying emerging trends that may signal concern. The WBS elements that significantly contribute to the project cost and schedule variance should be considered in the monthly assessment.

Three reports are helpful in this step. The PARS II EV Project Summary (6-Mo, PMB Level) Report provides variances at the project level. The PARS II Performance Analysis (WBS Level) Report and the PARS II Variance Analysis Cumulative (WBS Level) Report provides data shown at the lowest level reported (at least to the Control Account level, some even lower). Because all PARS II reports export into Excel, the Analyst can sort on the variance columns to see which WBS elements have the largest variances. Before going further with analysis of variances, a refresher of basics is provided.

3.3.1 SCHEDULE VARIANCE (SV)

Schedule Variance (SV) is the difference between the dollars of budget earned {the budgeted cost of work performed (BCWP)} and the dollars planned to be earned to date {the budgeted cost of work scheduled (BCWS)}. BCWP and BCWS can be found on the CPR Format 1. Due to the various earned value techniques available for calculating the amount of budget earned (BCWP), the SV metric should not be confused with a behind schedule or ahead of schedule condition. It should be used as a general indicator of schedule performance, but must be used in conjunction with schedule analysis to determine the true schedule status of the project. The formula for calculating SV is as follows:

$$\text{Schedule Variance (SV)} = \text{Earned} - \text{Budgeted}$$

or

$$\text{SV} = \text{BCWP} - \text{BCWS}$$

A SV less than zero indicate a negative schedule variance and perhaps unfavorable performance. Conversely, SV values greater than zero indicate a positive schedule variance.

3.3.2 SCHEDULE VARIANCE PERCENTAGE (SV%)

The SV% metric quantifies the magnitude of the schedule variance (SV). The formula for calculating SV% is as follows:

$$SV\% = [SV / BCWS] \times 100$$

A high SV% indicates significant variance magnitude. Both positive and negative SV, and likewise SV%, are considered drivers.

3.3.3 COST VARIANCE (CV)

Cost Variance (CV) is the difference of the value of budget earned, or budgeted cost of work performed (BCWP), and the amount of costs incurred, or actual cost of work performed (ACWP). BCWP and ACWP can be found on the CPR Format 1. The formula for calculating CV is as follows:

$$\text{Cost Variance (CV)} = \text{Earned} - \text{Actual}$$

or

$$CV = BCWP - ACWP$$

A Cost Variance less than zero indicates a negative cost variance or more money has been spent to accomplish work to date than was originally planned and that the project may be currently over budget. A Cost Variance greater than zero indicates a positive cost variance.

3.3.4 COST VARIANCE PERCENTAGE (CV%)

The CV% metric quantifies the magnitude of the cost variance (CV) by dividing CV by BCWP and multiplying by 100. The formula for calculating CV% is as follows:

$$CV\% = \frac{CV}{BCWP} \times 100$$

A high CV% indicates significant variance magnitude. Both positive and negative CV and CV% metrics are considered drivers.

3.3.5 ANALYSIS OF VARIANCES

A good report to identify the project level schedule and cost variances is the EV Project Summary (6-Mo; PMB Level) Report. It displays key earned value data elements at the project level including standard EV calculations for the past 6 reporting periods. This is helpful to identify which projects have the more significant schedule and/or cost variances, and to see how performance has changed over the past six months.

It is important for the Project Analyst to recognize schedule and/or cost variances at the project level; however, it is just as important to monitor performance at lower levels. The reason is that sometimes poor performance on one WBS element may be offset by good performance on another when the WBS elements are rolled up to the project level. The Project Analyst should review two other PARS II reports to look for poor performing WBS elements that may grow into major schedule or cost concerns in the future. The first is the PARS II Performance Analysis (WBS Level) Report provides information for analysis of cost and schedule variances on the project and identifies WBS elements that contribute and/or offset overall project variances the most. It shows data and a graphical representation of contractor-reported Earned Value data and variances, identifies WBS elements that carry the most impact (positive and negative) on the overall cost and schedule variances, and is used by the Analyst to identify WBS elements that require the most management attention as largest contributors to overall variances. The report includes a CHART tab and a REPORT tab. Using the REPORT tab, a chart is generated when clicking on the blue text WBS description. Variances are shown in current period, cumulative, and variance at completion.

The second report is the PARS II Variance Analysis Cumulative (WBS Level) Report which provides variance analysis capabilities through comparison of cumulative and at complete variances between two periods. This allows identification of WBS elements that tripped variance thresholds and demonstrate if performance has gotten better or worse since prior period. The PARS II Variance Analysis Cumulative (WBS Level) Report consists of two tabs with the REPORT tab serving as a summary tab that contains information about variance change and performance against preset thresholds, while the DETAIL tab provides a more detailed view of the variance data and

numbers that support direction and color identifiers on the REPORT tab. The REPORT tab is primarily used to see how the cumulative SV or CV is trending since the past month and will be discussed more in the next step of the Analysis Plan.

The SV% and CV% fields are available on the DETAIL tab. In conducting analysis, sort the WBS elements by CV% from smallest to largest. If there are WBS elements with negative (unfavorable) CV% they will be displayed at the top of the list. If there are WBS elements with positive (favorable) CV% they will be displayed at the bottom of the list. Select the largest favorable and unfavorable cost drivers and investigate to determine if the contractor has taken steps to identify and correct the root cause behind the unfavorable cost drivers. Likewise, sort the list by SV% and select the largest favorable and unfavorable schedule drivers.

Once the top schedule drivers have been identified, identify any resulting impacts to the key milestones in the schedule. In order to do this, the WBS elements in PARS II must be correlated to activities in the schedule. Typically, contractors include a WBS reference column in the schedule for this purpose. Obtain a copy of the schedule for the same month as the data being analyzed. Filter for the WBS elements identified as top schedule drivers. A list of activities will be displayed with logic links. Follow the successors of these tasks until you find the first major milestone in the logic chain. This will be the key milestone impacted by the schedule variance.

After the larger variances are identified, review the contractor's Variance Analysis Reports to determine if the root cause has been identified, if the issue is recurring or non-recurring (e.g. price of a one-time purchase), isolate the non-recurring data when performing trend analysis (next step of the Analysis Plan), and if the contractor's corrective action plan seems feasible to control the causes of the variances.

The "5 Whys" technique is an effective tool used in determining if the true root cause is fixed instead of the symptoms. "5 Whys" is a questions-asking method used to explore the cause/effect relationships underlying a particular problem, with the goal of determining a root cause of a defect or problem. Typically by the fifth question, the root cause is identified and can then be fixed rather than focusing efforts on the symptoms of the true root cause.

Using this thought process with variance analysis can guide us to the real root cause and then focus on a corrective action plan that will prevent this process failure from happening again. In serious issues, the process analysis may warrant a Six Sigma approach. Figure 2 below identifies some questions that may help initiate the “5 Whys” process.

	Schedule Variance	Cost Variance
Unfavorable	<ul style="list-style-type: none"> ■ Lack of resources due to... ■ Late vendor deliveries because... ■ Rework required due to... ■ Work more complex than expected because... ■ Unclear requirements in the areas of... 	<ul style="list-style-type: none"> ■ Work is more complex than anticipated because... ■ Extensive Design Review comments have resulted in... ■ Material price escalation due to... ■ The estimate was understated because...
Favorable	<ul style="list-style-type: none"> ■ Increased efficiency due to... ■ Work less complex than anticipated in the areas of... ■ Fewer revisions and rework because... ■ Subcontractor ahead of schedule because... 	<ul style="list-style-type: none"> ■ Efficiencies being realized because... ■ We used less expensive resources to accomplish the work and... ■ We negotiated a lower price with the supplier due to... ■ The new CAD system reduced the time required..

Figure 2. In Search of the Root Cause

3.4 ANALYSIS PLAN STEP 4: ANALYZE TRENDS

After analyzing major variances to ensure corrective actions have been identified to prevent reoccurrence, trend identification helps to see not only if corrective action has been effective (e.g. improvement trends), but also provides visibility into emerging problem areas where variances may not yet be significant.

The types of questions to consider once trends have been identified may include:

- What do the contractor's performance trends indicate over time?
- Is the current level of contractor performance projected to continue and why?
- What performance changes are expected and what are the drivers?
- Are MR and Contingency burn rates and use acceptable or are they used to mask/hide cost overruns?

The PARS II EV Project Summary (6-Mo; PMB Level) Report provides information at the project level for the past six months which can be used for trend analysis at the project level. The PARS II Variance Analysis Cumulative (WBS Level) Report, REPORT tab, serves as a summary tab that contains information about variance change and performance against preset thresholds by using directional arrow heads and color identifiers. These features prove helpful in identifying trends. The DETAIL tab provides the SV, CV, VAC, CV%, SV%, VAC%, CPI, and the SPI – all of which are explained in detail below.

3.4.1 SCHEDULE

The schedule performance metrics selected for performance indicators are the Schedule Variance (SV) Trend, Schedule Performance Index (SPI), SPI Trend, the Critical Path Length Index (CPLI), and the Baseline Execution Index (BEI).

3.4.1.1 SV TREND

The SV trend compares the metric for a specific reporting period (usually monthly) to the same metric in prior reporting periods. An SV trend is favorable if the SV improves in value over the

course of multiple reporting periods (i.e., three months). The SV may still be negative (unfavorable) but the trend is improving. Conversely, the SV trend is unfavorable when the SV worsens over time. Again, the SV could be positive (favorable) but the trend is degrading. The following tables provide examples of both trends at, say, a work package or control account level.

Table 1. Favorable SV **Trend**

Reporting	Schedule
January	-\$8K
February	-\$7K
March	-\$6K

Table 2. Unfavorable SV **Trend**

Reporting	Schedule
January	\$8K
February	\$7K
March	\$6K

3.4.1.2 SCHEDULE PERFORMANCE INDEX (SPI)

The Schedule Performance Index (SPI) is an efficiency factor representing the relationship between the performance achieved and the initial planned schedule. The SPI for projects without an Over Target Baseline (OTB) is calculated as follows:

$$SPI_{CUM} = \frac{BCWPCUM}{BCWSCUM}$$

An index of 1.00 or greater indicates that work is being accomplished at a rate on or ahead of what was planned. An index of less than 1.00 suggests work is being accomplished at a rate below the planned schedule. An index of less than 0.95 is used as an early warning indication of schedule slippage and should be investigated.

The adjusted SPI for projects with an OTB is calculated as:

$$SPI_{ADJ} = \frac{BCWP_{CUM} - BCWP_{CUM @ TIME OF OTB}}{BCWS_{CUM} - BCWS_{CUM @ TIME OF OTB}}$$

3.4.1.3 SCHEDULE PERFORMANCE INDEX (SPI) TREND

The SPI trend is a comparison of the metric for this reporting period (usually monthly) to the same metric in prior reporting periods. An SPI trend is favorable if the SPI increases in value over the course of multiple reporting periods. Conversely, the SPI trend is unfavorable if it decreases in value.

3.4.1.4 CRITICAL PATH LENGTH INDEX (CPLI)

The Critical Path Length Index (CPLI) is a measure of the efficiency required to complete a milestone on time. It measures critical path “realism” relative to the baselined finish date, when constrained. A CPLI of 1.00 means that the project must accomplish one day’s worth of work for every day that passes. A CPLI less than 1.00 means that the project schedule is inefficient with regard to meeting the baseline date of the milestone (i.e. going to finish late). A CPLI greater than 1.00 means the project is running efficiently with regard to meeting the baseline date of the milestone (i.e. going to finish early). The CPLI is an indicator of efficiency relating to tasks on a milestone’s critical path (not to other tasks within the schedule). The CPLI is a measure of the relative achievability of the critical path. A CPLI less than 0.95 should be considered a flag and requires further investigation.

The CPLI requires determining the project schedule’s Critical Path Length (CPL) and the Total Float (TF). The CPL is the length in work days from time now until the next project milestone that is being measured. TF is the amount of days a project can be delayed before delaying the project completion date. TF can be negative, which reflects that the project is behind schedule. The analyst should coordinate with the Federal Project Director (FPD) to ensure the contractor performs the calculation and provides the results to the analyst until a PARS II report is created to provide this information.

The mathematical calculation of total float is generally accepted to be the difference between the “late finish” date and the “early finish” date (late finish minus early finish equals total float). The formula for CPLI is as follows:

$$\text{Critical Path Length Index (CPLI)} = \frac{\text{CPL} + \text{TF}}{\text{CPL}}$$

The critical path is identified in the scheduling tool. The CPL is calculated by inserting a new task into the schedule, with an actual start date of the schedule status date. The CPL is determined by inserting a number value in the duration of this new task until the finish date equals the finish date of the completion milestone identified by the critical path analysis. This is a trial and error process to get the correct duration for the CPL. Total Float for the completion milestone is recorded for conducting the CPLI calculation.

In addition to recording the CPLI results, it is important to document any rationale for the completion milestone chosen and the analysis method used to calculate the critical path. It is also important to note if the final milestone or task in the schedule has a baseline finish date beyond the project period of performance.

3.4.1.5 BASELINE EXECUTION INDEX (BEI)

The Baseline Execution Index (BEI) metric is a schedule-based metric that calculates the efficiency of tasks accomplished when measured against the baseline tasks. In other words, it is a measure of task throughput. The BEI provides insight into the realism of project cost, resource, and schedule estimates. It compares the cumulative number of tasks completed to the cumulative number of tasks with a baseline finish date on or before the current reporting period. BEI calculations can be obtained from the PARSII Reports, Schedule tab, Schedule Baseline Execution Index.

BEI does not provide insight into tasks completed early or late (before or after the baseline finish date), as long as the task was completed prior to time now. See the Hit Task Percentage metric in the PARSII Schedule Hit or Miss Report for further insight into on-time performance.

If the contractor completes more tasks than planned, then the BEI will be higher than 1.00 reflecting a higher task throughput than planned. Tasks missing baseline finish dates are included in the denominator. A BEI less than 0.95 should be considered a flag and requires additional investigation. The BEI is calculated as follows:

$$BEI_{CUM} = \frac{\text{Total \# of Tasks Complete}}{\text{Total \# of Tasks Completed Before Now} + \text{Total \# of Tasks Missing Baseline Finish Date}}$$

The BEI is always compared against the Hit Task Percentage. The Hit Task Percentage is a metric that measures the number of tasks completed early or on time to the number of tasks with a baseline finish date within a given fiscal month. This metric can never exceed a value of 1 since the metric assesses the status of tasks with a base finish date within a single fiscal month.

3.4.2 COST

The cost performance metrics selected for performance indicators are CV Trend, Cost Performance Index (CPI), CPI Trend, and the ratio “% complete” to “% spent.”

3.4.2.1 CV TREND

Similar to the SV Trend, the CV Trend is a comparison of the metric for a specific reporting period (usually monthly) to the same metric in prior reporting periods. A CV trend is favorable if a positive CV increases (or negative CV decreases) in value over the course of multiple reporting periods. Conversely, the CV trend is unfavorable if a positive CV decreases (or negative CV increases) in value. Examples are similar to those provided in the SV Trend tables shown previously.

3.4.2.2 COST PERFORMANCE INDEX (CPI)

The Cost Performance Index (CPI) is an efficiency factor representing the relationship between the performance accomplished (BCWP) and the actual cost expended (ACWP). The CPI for projects without an OTB is calculated as follows:

$$CPI_{CUM} = \frac{BCWP_{CUM}}{ACWP_{CUM}}$$

An index of 1.00 or greater indicates that work is being accomplished at a cost equal to or below what was planned. An index of less than 1.00 suggests work is accomplished at a cost greater than planned. A cumulative index of less than 0.95 is used as an early warning indicator of cost increase and should be investigated.

The adjusted CPI for projects with an OTB is calculated as follows:

$$CPI_{ADJ} = \frac{BCWP_{CUM} - BCWP_{CUM @ TIME OF OTB}}{ACWP_{CUM} - ACWP_{CUM @ TIME OF OTB}}$$

3.4.2.3 COST PERFORMANCE INDEX TREND

The CPI Trend is a comparison of the metric for a specific reporting period (usually monthly) to the same metric in prior reporting periods. A CPI trend is favorable if the CPI increases in value over the course of multiple reporting periods. Conversely, the CPI trend is unfavorable if it decreases.

3.4.2.4 THE RATIO: “PERCENT COMPLETE” TO “PERCENT SPENT”

The Percent Complete and Percent Spent metrics each provide valuable information, but as a ratio they gauge the amount of budget spent in relation to the amount of work completed. These calculations are shown in the PARS II MR Balance v. CV, VAC, & EAC Trends Report, REPORT tab. The first part of this metric, the numerator, is Percent Complete (%comp). The formula to calculate %comp is as follows:

$$\text{Percent Complete (\%)} = \%comp = \frac{BCWP_{CUM}}{BAC} \times 100$$

The value range of %comp is from 0% to 100%. It provides a measure of how far along the project is toward project completion. The second part of the metric, the denominator, is Percent Spent (%spent). The formula to calculate % spent is as follows:

$$\text{Percent Spent (\%)} = \%spent = \frac{ACWP_{CUM}}{BAC} \times 100$$

The value range of %spent starts at 0% and since it tracks actual cost, theoretically has no limit. It provides a measure of how far along the project is toward completion. If %spent is over 100%, it indicates a cost over-run condition has been realized. The combination of these two metrics results in the following formula:

$$\frac{\%comp}{\%spent} = \frac{BCWP_{CUM}/BAC}{ACWP_{CUM}/BAC} = \frac{BCWP_{CUM}}{ACWP_{CUM}} = \text{Cost Performance Index (CPI)}$$

When measured independently, %comp and %spent provide additional insight into project performance. As shown above, the ratio of these two metrics results in the CPI.

3.4.3 USING SPI AND CPI TRENDS

Another way to track trends on a WBS level is by viewing graphs in the PARS II Performance Index Trends (WBS Level) Report. Click on the graph you want on the REPORT tab, and the selected graph will appear on the CHART Tab. When you see trends of SPI or CPI dropping over time, it indicates a negative trend that needs investigating. Remember that all PARS II reports that have “WBS Level” in the name can provide information at the lowest level of WBS being reported into the system. The Analyst can determine the WBS element causing the negative trend.

3.4.4 VAC TRENDS

The Variance at Completion (VAC) is calculated by subtracting the contractor’s EAC from the Budget at Completion (BAC) of the project. This calculation over the past 12 months may be found on the PARS II MR Balance v. CV, VAC, & EAC Trends Report, REPORT tab. The graph is show on the MR vs. CV & VAC tab. VAC in general is calculated with the following formula:

$$\text{Variance at Completion (VAC)} = \text{Budgeted} - \text{Estimated}$$

Or

$$\text{VAC} = \text{BAC} - \text{EAC}$$

The Variance at Completion identifies either a projected over-run (negative VAC) or an under-run (positive VAC). If a project is projected to overrun, it means the total cost at completion will be greater than the budget.

3.4.5 MANAGEMENT RESERVE (MR) TRENDS

MR trends are identified on the PARS II MR Balance v. CV, VAC, & EAC Trends Report. The purpose of this report is to provide the Analyst with a range of tools to complete the analysis of the Management Reserve account. While the REPORT tab shows the entire set of data required for analysis, the individual charts provide graphical representation of individual areas of analysis.

Report is intended to only suggest that best practices for Management Reserve use are being followed and sufficient Management Reserve balance is available to the project. In the event report data suggests that there are problems with usage or availability of MR, further analysis of the data and a conversation with the performing contractor should be initiated in order to understand the issues presented by the data. *Concerns in this area not only apply to Project performance but also to systemic concerns with the contractor's EVMS.*

3.4.6 THE RATIO: “% COMPLETE” TO “% MANAGEMENT RESERVE USED”

This metric divides the project percent complete (%comp) by the percentage of management reserve (%MR) used to date. It provides insight into how quickly the MR is being depleted. If the rate of MR usage is high, it may indicate the original performance measurement baseline did not contain the necessary budget for accomplishing the project statement of work or it could indicate improper use of MR. *Concerns in this area not only apply to Project performance but also to systemic concerns with the contractor's EVMS.* Since this metric is a ratio of two different metrics, those components must be calculated first.

To calculate %comp use the following formula:

$$\text{Percent Complete} = \% \text{comp} = \frac{\text{BCWP}_{\text{Cum}}}{\text{BAC}} \times 100$$

To calculate %MR, use the following formula:

$$\text{Percent Management Reserve} = \% \text{MR} = \frac{\text{Total amount of MR used}}{\text{Total amount of MR on the project}}$$

Keep in mind that MR may be added or removed based on contractual actions. So it is important to account for all the MR debits and credits when calculating this metric. It is not simply the current value of MR divided by the original value of MR. In fact, if significant credits have been made to MR since project inception, the current MR value might actually be greater than the original value, even if some MR was debited.

Now take the ratio of %comp and %MR:

$$\text{Ratio} = \frac{\text{Percent Complete}}{\text{Percent Management Reserve}} = \frac{\% \text{comp}}{\% \text{MR}}$$

The information required for this metric requires access to the MR Logs which may not be contained in PARS II. Run PARS II Management Reserve Log to see if the report data exists as not all projects load this information. If not, this calculation may be limited to a Stage 2 Surveillance after the Documentation Request.

3.4.7 BASELINE VOLATILITY TRENDS

Baseline Volatility is an early warning indication that the project's time-phasing and control of budget is volatile and that a significant departure from the original plan has occurred.

- Substantial changes to the baseline time phasing indicate the contractor has inadequate plans in place and the performance metrics may be unreliable.
- Change is inevitable but the near term plan should be firm.

Rolling wave planning is when the BCWS is only detail planned for the near term (say the next six months) as opposed to detail planning the entire project. Since EV best practices encourage rolling wave planning in six month increments, one would expect to see little flux in the near term except for unpredictable government-caused events or real-time realized risks. *Concerns in this area not only apply to Project performance but also to systemic concerns with the contractor's EVMS.*

The PARS II Baseline Volatility – Past and Near-Term (PMB Level) report is split into two sections - past 6 months and near-term 6 months with a visible divider between the two that indicates Current Performance Period. The significance of this report is that it highlights if the near term baseline is constantly churning in the near term or being pushed to future periods in order to achieve seemingly favorable current period metrics. This practice can cause misleading results and potentially mask future schedule issues.

There are three calculations on this report. The two Baseline % Change metrics highlight changes made to the time-phased Performance Measurement Baseline (or BCWS) over the past 6 periods.

A change of five or more percent is used as an early warning indicator that the project's time-phasing and control of budget is volatile in the near term and that a significant departure from the original plan has occurred. The first compares the Minimum and Maximum BCWS values for the report period within the past six months. The second compares the First (earliest) and Last (most recent) BCWS values for the report period within the past six months. If the First/Last value is negative, then BCWS is moved forward (later in the project). If BCWS is positive, then work is being moved sooner, to be done earlier than planned.

$$\text{Baseline \% Change 1} = \frac{\text{Maximum} - \text{Minimum}}{\text{Minimum}} \times 100$$

$$\text{Baseline \% Change 2} = \frac{\text{First} - \text{Last}}{\text{First}} \times 100$$

The individual calculations for the past six months are added to determine the Ave % Change for Min/Max and the Ave % Change for First/Last. If either of the absolute values for the six month averages exceeds 5% there is high volatility in the near term plan. If the re-plan is not government-directed, it should be investigated and potentially documented in the monthly assessment as an indicator of baseline churn.

The third calculation identifies changes made during the current reporting period. Changes made to the BCWS during the current period are considered retroactive changes once the period begins and should not happen. The current period should be a freeze period for baseline changes and changes within a current period can be an indicator of problems with the cycle time of the contractor's revisions processes or baseline discipline issues. This report is designed not to display zero (0) values in the % Change cells. Therefore, blank cells indicate a true zero (0) percent (no change in values), while 0% indicates there is insignificant difference (< 0.5%) between compared values. Anything greater than 0% is of concern for the current period changes calculation.

In summary, substantial changes to the baseline time phasing may indicate the contractor has inadequate plans in place and the performance metrics may be unreliable. Change is inevitable, but the near term plan should be firm and change control should be exercised.

3.5 ANALYSIS PLAN STEP 5: ASSESS REALISM OF CONTRACTOR'S EAC

The contractor is required to provide an Estimate At Completion (EAC). The formula is based on actual cost of work performed to date plus the estimate of the costs to complete. An accurate EAC is vital to DOE as it provides a dynamic estimate of the projected funding required to cover the contractor's costs to perform the work in the PMB. *Concerns in this area not only apply to Project performance but also to systemic concerns with the contractor's EVMS.*

The PARS II reports are available for assessing EAC reasonableness and will be explained in more detail below. These include:

- EV Data Validity (WBS Level) Report
 - CV_{CUM} more negative than VAC
 - $TCPI_{EAC}$ and CPI differ by more than 5%.
- Performance Index Trends (WBS Level)
- CPI v. TCPI (PMB Level) for project level views

3.5.1 “COST PERFORMANCE INDEX” – “TO COMPLETE PERFORMANCE INDEX”

This metric compares the Cost Performance Index (CPI_{CUM}) to the To Complete Performance Index ($TCPI_{EAC}$). The CPI_{CUM} and the $TCPI_{EAC}$ are compared to evaluate the realism of the contractor's EAC and to evaluate the reasonableness of using past efficiencies to predict future efficiencies. *Concerns in this area not only apply to Project performance but also to systemic concerns with the contractor's EVMS.*

A mathematical difference of 0.05 or greater is used as an early warning indication that the contractor's forecasted completion cost could possibly be unrealistic, stale, or not updated recently. If the 0.05 threshold has been breached, the PARS II EV Data Validity (WBS Level) Report will indicate this under the $CPI < > TCPI \pm 0.05$ column. It is merely a metric to flag concerns but it is not considered an error because it is possible that the nature of the work has changed, thus making predictions of the future based on past performance unjustified. When the TCPI is greater than the CPI by more than 5%, it may indicate an overly optimistic EAC. In other words, the ETC is based on an increase in cost efficiency by more than 5% for the remainder of the project. A TCPI less than

the CPI by 5% or more may indicate an overly pessimistic EAC. In this case, the ETC is based on an expected drop in cost performance by 5% or more for the remainder of the project. This metric is available at the control account to identify individual drivers (PARS II Performance Index Trends (WBS Level Report)) or total project level (PARS II CPI v. TCPI (PMB Level) Report).

A $CPI_{CUM} - TCPI_{EAC}$ difference greater than or equal to 0.05 (using the absolute value of the difference) should be considered a flag. $TCPI_{EAC}$ reflects the work remaining divided by the cost remaining as follows:

$$\text{To Complete Performance Index (TCPI}_{EAC}) = \frac{BAC - BCWP_{CUM}}{EAC - ACWP_{CUM}}$$

While the report flags information +/- .05; it also provides the total calculated answers. A larger difference of greater than or equal to +/- .1, i.e. 10%, indicates the EAC is not achievable based on current performance. Studies of major acquisition programs at DOD validated that 10% was the reasonable threshold at which the EAC should be updated.

3.5.2 CV_{CUM} MORE NEGATIVE THAN VAC

When the Cost Variance (CV) to date is more negative than the Variance at Completion (VAC), it may indicate that the EAC has not been updated to reflect the overrun. Refer to the $CV < VAC$ column of the EV Data Validity (WBS Level) Report. This condition is not considered an error, but a significant discrepancy between two variances may be an indicator that the contractor's EAC was not properly updated to reflect performance. An example would be where the CV to date is -\$280,000; however, the VAC is -\$30,000. It would generally be quite difficult to recover an overrun to that extent.

3.6 ANALYSIS PLAN STEP 6: PREDICT FUTURE PERFORMANCE AND AN IEAC

The last step in the Analysis Plan is to provide the insights gained by the analysis in the form of an Independent Estimate at Completion (IEAC) and a narrative assessment.

3.6.1 INDEPENDENT ESTIMATE AT COMPLETION (IEAC)

An IEAC is the Government's forecast of the final total cost of the project. The PARS II IEAC Analysis (WBS Level) Report provides information for analysis and comparison of contractor EAC to three industry standard calculations of cost estimate based on contractor-reported data and variety of performance factors to establish reasonableness range for at-complete cost of the project. These three IEACs formulas are:

- $EAC_{CPI} = BAC / CPI_{cum} = ACWP_{cum} + BCWR / CPI_{cum} = \text{Estimate at Completion (CPI)}$
- $EAC_{COMPOSITE} = ACWP_{cum} + BCWR / (CPI_{cum} * SPI_{cum}) = \text{Estimate at Completion (composite)}$
- $EAC_{CPI3} = ACWP + (BCWR/CPI_3) = ACWP + [(BAC - BCWP_{cum}) / [(BCWP_4 - BCWP_1) / (ACWP_4 - ACWP_1)]] = \text{Estimate at Completion (CPI 3 Period Cum)} = ACWP - = \text{Estimate at Completion (CPI 3 Period Cum)}$

Typically the EAC_{CPI} formula provides the most optimistic result, the $EAC_{COMPOSITE}$ provides the most pessimistic, and the EAC_{CPI3} provides the most likely based on studies of hundreds of completed projects. This assumption is based on CPI_{CUM} and SPI_{CUM} being less than 1. If both of these metrics are greater than 1 then the reverse will be true; meaning EAC_{CPI} will become the most pessimistic IEAC. These formulas are most accurate when the project is between 15% complete and 95% complete. Outside of these ranges the formulas may not provide accurate bounds.

The next step performs a detailed analysis of the contractor's EAC by Work Breakdown Structure (WBS) element at the lowest level available. This analysis is very important in two situations:

- Verification of the reasonableness of the Comprehensive EAC
- Adjustments to the IEAC based on known issues with one or more WBS elements

It involves determining the reasonableness of the WBS level estimates with information gained from project surveillance, reviews, and/or site-level input. This is the perfect place to make adjustments if the contractor's value does not appear reasonable. Using the PARS II IEAC Analysis (WBS Level) Report, an analysis graph for the lowest WBS level can be created by clicking the WBS Description link on the REPORT tab. The analysis should include comparison of contractor-reported EAC to independent EAC calculated based on of the high risk WBS elements to determine if contractor-reported EAC is valid, reasonable, and current.

Roll up any adjustments made to individual WBS element EACs and any changes made to risks to determine the value of the OAPM IEAC. Check the rolled-up value against the two formula values that are most pessimistic and most optimistic. The rolled-up value may fall outside of the statistical formula bounds, but this should be considered a flag. If this occurs, double check your adjustments and ensure they are properly documented.

3.6.2 FUNDING STATUS

The EAC is an important number used by project stakeholders. A project office relies on the EAC for securing sufficient funding for the project. The OAPM IEAC is an independent second opinion of the final costs of the project. This provides the project office with important information to aid in funding decisions. This leads to the next element of the predictive analysis section.

The purpose of PARS II Funding Status (Monthly at Project Level) Report is to show if sufficient funding is available to complete the project. In addition, the report can be used to validate accuracy of data reporting at the project level and note any significant fluctuations in project cost components to identify anomalies. Major components of Total Project Cost (TPC) are plotted in a stack column on the SUMMARY tab. This allows the Analyst to identify current balances of each major TPC component - mainly DOE Contingency and Contract Budget Base (CBB). Further analysis should look at how the contractor-reported forecast, i.e. the EAC, is plotted against TPC and if additional funding may be required to complete the project.

In addition, the Analyst can verify that all components of TPC are being accurately reported and the height of each column for each period is the same or very close. Fluctuations in the CBB line

without corresponding reverse changes in DOE Contingency, a significant change in Contingency balance that is not reflected in CBB line, a decrease in without corresponding reverse changes in DOE Contingency, a significant change in Contingency balance that is not reflected in CBB line, a decrease in Contingency and an associated increase in MR without any change to BAC, etc. - all are indicators that the risk reserves and contractor baseline have not been reported accurately or are being used improperly.

Some projects may have a Contract Funds Status Report (CFSR) requirement. CFSRs are typically submitted to the project office on a quarterly basis. The CFSR provides a forecast of the total project price at completion, to include any applicable fee. The contractor's most likely EAC reported on the monthly Contract Performance Report (CPR) should reconcile with the forecast in the CFSR after taking into account the timing differences of the reports.

3.6.3 NARRATIVE ASSESSMENTS

The narrative assessment is where the Analyst provides a concise, well-written summary of the analysis. Avoid providing too many details; instead focus on broad trends or major issues that require attention related to cost, schedule, or Estimated at Completion (EAC) growth. For example, an Over Target Baseline (OTB) would be a significant issue to be addressed. Do not repeat metrics that are easily visible on the Monthly Report; rather, provide insight behind the metrics such as the top cost and schedule drivers driving the CPI or SPI. Make predictions based on the analysis such as IEAC and any funding concerns. Lastly, provide the latest EVM System Status as this indicates the higher reliability of contractor reports generated by their EVMS.

Typical format should follow:

- Problem(s)
- Cause(s)
- Impact to overall project
- Effectiveness of corrective actions taken and corrective actions needed
- Predictions based on special knowledge gained through analysis and project oversight
- EVMS System Status

4.0 PARSII ANALYSIS REPORTS CROSSWALK TO SOP TABLE

All of the reports below are found in PARS II, Reports, Analysis Folder – Project Analysis SOP unless otherwise indicated.

PARSII REPORT	PURPOSE	ANALYSIS PLAN	REF
Baseline Volatility – Past and Near-Term (PMB Level)	Identifies changes made to the time-phased performance measurement (or budget) baseline over a most recent 6 month period as well as near-term 6 month period using contractor time-phased BCWS.	Step 4: Trend Analysis	EPASOP 3.4.7; ESSOP Risk Matrix Template
CPI v. TCIP (PMB Level)	Compares current period and cumulative cost performance efficiencies against performance efficiencies needed to complete project on budgeted or at estimated cost.	Step 5: EAC Reasonableness	EPASOP 3.5.1
EV Data Validity (WBS Level)	Detects contractor data accuracy, validity, and reasonableness concerns in numerous areas	Step 1: Data Validity Check; Step 5: EAC Reasonableness	EPASOP 3.1.1 – 3.1.10; 3.5.1 – 3.5.2; ESSOP Risk Matrix Template
EV Project Summary (6-Mo; PMB Level)	Provides key Earned Value data elements and project performance metrics over the last 6 performance periods at the PMB level.	Step 3: Variance Analysis; Step 4: Trend Analysis	ESSOP Risk Matrix Template
Funding Status (Monthly at Project Level)	Provides visibility of current levels of CBB, DOE Contingency, and TPC to identify current or potential funding concerns.	Step 6: Predictive Analysis	EPASOP 3.6.2
IEAC Analysis (WBS Level)	Establishes a range to assess reasonableness of contractor’s EAC	Step 6: Predictive Analysis	EPASOP 3.6.1
Invalid Forecast and Actual Dates (Activity Level)	Detects errors on incomplete tasks where forecast start and finish dates are in the past and actual start and finish dates are not in the future	Step 2: Schedule Health Assessment	EPASOP 3.2.8
MR Balance v. CV, VAC, & EAC Trends	Provides a range of tools to identify possible problems with usage or availability of MR that would warrant further analysis and discussions.	Step 4: Trend Analysis	EPASOP 3.4.2.4; 3.4.4; 3.4.5; ESSOP Risk Matrix Template
Management Reserve Log	Provides detailed transaction log consisting of all transactions that involved budget transfer to and from Management Reserve account established for the project.	Step 4: Trend Analysis	EPASOP 3.4.6
Performance Analysis (WBS Level)	Provides information for analysis of cost and schedule variances on the project and identify WBS elements that contribute and/or offset overall project variances the most.	Step 3: Variance Analysis	EPASOP 3.3
Performance Index Trends (WBS Level)	Provides 3 months of SPI, CPI, TCPI to BAC, and TCPI to EAC to aid in identifying key contributors of recent poor performance at the WBS level. Also identifies EAC reasonableness concerns for each WBS element.	Step 4: Trend Analysis; Step 5: EAC Reasonableness	EPASOP 3.4.3; 3.5.1

Relationship Leads and Lags	Provides contractor reported schedule activities with lead and lag logic relationships for use in assessing schedule health.	Step 2: Assess Schedule Health	EPASOP 3.2.2 and 3.2.3
Retroactive Change Indicator (6-Mo; PMB Level)	Identifies when contractor has changed historical reporting which is non-compliant with GL 30	Step 1: Data Validity Check	EPASOP 3.1.1; 3.1.11
Schedule Baseline Execution Index (Schedule tab)	Calculates efficiency of task completion against the baseline tasks to provide insight into realism of project cost, resource, and schedule estimates.	Step 4: Trend Analysis	EPASOP 3.4.1.5
Schedule Duration Analysis	Identifies activities with long durations that may benefit from being broken down into discrete tasks	Step 2: Schedule Health Assessment	EPASOP 3.2.7
Schedule Hard Constraints	Indicates if the contractor schedule is over constrained, preventing the schedule from being logic driven	Step 2: Schedule Health Assessment	EPASOP 3.2.5
Schedule Hit or Miss	Identifies how well or poorly the schedule is meeting the baseline plan	Step 2: Schedule Health Assessment	EPASOP 3.2.10; 3.4.1.5
Schedule Missing Logic (Activity Level)	Counts incomplete tasks with missing logic links to ensure all discrete tasks have both a predecessor and a successor task..	Step 2: Schedule Health Assessment	EPASOP 3.2.1
Schedule Relationship Types (Activity Level)	Counts incomplete tasks by type of logic link. At least 90% per project should be Start-to-Finish (SF). Significant fluctuations in relationship types may be an indicator of an unstable baseline and work reshuffling.	Step 2: Schedule Health Assessment	EPASOP 3.2.4
Schedule Total Float Analysis (Activity Level)	Calculates percentage of total float and negative float.	Step 2: Schedule Health Assessment	EPASOP 3.2.6
Variance Analysis Cum (WBS Level)	Provides comparison of cumulative and at complete variances between two periods at WBS level to identify elements that tripped variance thresholds and indicate if performance has improved or declined since prior period.	Step 3: Variance Analysis and Step 4: Trend Analysis	EPASOP 3.3.5; 3.4

5.0 ADDITIONAL RESOURCES

DCMA (Defense Contract Management Agency), *EVMS Program Analysis Pamphlet*, DCMA-EA PAM 200.1. Ft. Lee, VA: July 2012

DOE OAPM MA-63, *Earned Value Management System Surveillance Standard Operating Instruction (ESSOP)*. Washington, DC: September 26, 2011

DOE Office of Management, Project Management, Earned Value Management website.
<http://energy.gov/management/office-management/operational-management/project-management/earned-value-management>

DOE, *Program and Project Management for the Acquisition of Capital Assets*, DOE O 413.3B, Washington, DC: 11-29-2010.

GAO. *GAO Cost Estimating and Assessment Guide*, GAO-09-3SP. Washington, DC: March 2009

GAO. *GAO Schedule Assessment Guide*, GAO-12-120G. Washington, DC: May 2012
<http://www.gao.gov/products/GAO-12-120G> – currently a draft. Until the GAO Schedule Assessment Guide is issued final following resolution of public comments, it is not recommended as a primary reference.

Humphreys, Gary C. *Project Management Using Earned Value*. Orange, CA: Humphreys & Associates, Inc., 2nd Ed. 2011

NDIA PMSC, *Planning and Scheduling Excellence Guide (PASEG)*, June 2012,
<http://www.ndia.org/Divisions/Divisions/Procurement/PMSC/Pages/PMSCCommitteeDocuments.aspx>

6.0 ACRONYM GLOSSARY

ACWP	Actual cost of work performed
ASAP	As-Soon-As-Possible
BAC	Budget at Completion
BCWP	Budgeted Cost of Work Performed
BCWS	Budgeted cost of Work Scheduled
BEI	Baseline Execution Index
CA	Control Accounts
CAM	Control Account Manager
CBB	Contract Budget Base
CFSR	Contract Funds Status Report
CPI	Cost Performance Index
CPL	Critical Path Length
CPLI	Critical Path Length Index
CPR	Contract Performance Report
CV	Cost Variance
EAC	Estimate at Completion
EV	Earned Value
EVMS	Earned Value Management System
EPASOP	EVMS Project Analysis SOP
FF	Finish-to-Finish
FNET	Finish-No-Earlier-Than
FNLT	Finish-No-Later-Than
FPD	Federal Project Director
FS	Finish-to-Start
IEAC	Independent Estimate at Completion
LOE	Level of Effort
MFO	Must-Finish-On
MSO	Must-Start-On
OAPM	Office of Acquisition and Project Management
OTB	Over Target Baseline

PAR	Project Assessment Report
%comp	Percent Complete
MR	Management Reserve
PMB	Performance Measurement Baseline
SF	Start-to-Finish
SNET	Start-No-Earlier-Than
SNLT	Start-No-Later-Than
SPI	Schedule Performance Index
SS	Start-to-Start
SV	Schedule Variance
TAB	Total Allocated Budget
TCPI	To Complete Performance Index
TF	Total Float
TPC	Total Project Cost
VAC	Variance at Completion
WBS	Work Breakdown Structure
WP	Work Package