Guide 1.9
Performance Measurement, Analysis, and Reporting

1.0 INTRODUCTION

This guidance is provided to assist the Project Teams in understanding performance measurement, analysis of Earned Value information, and reporting.

The performance measurement process uses an Earned Value (EV) approach to gather and provide information that measures the physical accomplishment of work against established baselines. The essence of earned value is that at some level of detail (appropriate to the degree of technical, cost, or schedule risk) a target planned value (i.e., budget/baseline) is established for each element of work. As these elements of work are completed, their target planned values are "earned". As such, work progress is quantified and the earned value becomes a metric against which to measure both what was spent to perform the work and what was scheduled to have been accomplished.

An earned value system will effectively integrate the work scope of a project with the cost elements and schedule for optimum planning and control. For the benefits of earned value to be fully realized, comprehensive planning at the outset, combined with the establishment and disciplined maintenance of a baseline for performance measurement are required. This combination of comprehensive planning, baseline maintenance, and earned value analysis yields earlier and better visibility into performance and enhances overall project management value through decisions based on the use of the earned value information. The point where most projects succeed or fail is right at the start: the planning stage. Good execution can not be expected to overcome a poor plan!

2.0 PURPOSE

The purpose of this guide is to provide a basic understanding of earned value management and provide a source of suggested techniques to aid in data analysis. Each analyst is encouraged to develop other techniques or do further research to find other techniques that may be better suited to their specific project.

3.0 RESPONSIBILITIES

The Project Manger (PM) and Control Account Manager(s) (CAM) are responsible for:

- Assuring EV status is occurring and the EV data is creditable
- Thoroughly understanding the Earned Value Management (EVM) metrics

- Utilizing the CPR for analysis and decision making
- Reviewing the Project Control Engineers analysis and performing their own analysis in preparation of writing the Variance Analysis Reports
- Preparing Variance Analysis Reports on any control accounts exceeding reporting thresholds
- Developing and ensuring implementation of corrective action plans

The Project Controls Engineer (PCE) is responsible for:

- Collecting, maintaining, organizing, and analyzing the Earned Value Management (EVM) metrics
- Preparing reports, graphs, and charts to assist in data analysis
- Identifying potential and existing problem areas
- Recommending corrective action and work-around plans
- Reporting to Senior Management, performance issues that jeopardize the project's chances for success by being masked or mismanaged

4.0 FUNDAMENTALS OF PERFORMANCE MEASUREMENT / EARNED VALUE MANAGEMENT

Earned Value Management (EVM) is a tool that provides a systematic approach to the integration and measurement of scope, cost, and schedule accomplishments on a project or task. Earned Value Management provides data from a management system that:

- Relates time-phased budgets to project tasks
- Integrates cost, schedule, and scope performance
- Indicates work progress objectively
- Is valid, timely and auditable
- Is at a practical level of summarization
- Is recognized by the Federal Government
- Is the corporate standard for project control

There are three key components to earned value:

- BCWS – (Budgeted Cost of Work Scheduled) the budget/planned value of the work scheduled or "what you plan to do"
- BCWP – (Budgeted Cost of Work Performed) the budget value of the physical work done to date or "what you physically accomplished"
- ACWP – (Actual Cost of Work Performed) the actual cost of the work done to date or "what you have spent"

The integration point for the BCWS, BCWP, and ACWP is the cost processor which is used to calculate the cost and schedule performance indices, cost and schedule variances, and variances at completion. The cost processor maintains the time-phased project dollar baseline at the task, Work Package, or Control Account level, summarizing to the various WBS levels and the total project. This BCWS becomes

the Performance Measurement Baseline (PMB). The PMB, which does not include contingencies, is the total time-phased budget plan against which project performance is measured.

4.1 Earned Value Methods and Techniques

All EV methods and techniques will include the following characteristics:

- **Stability –** One EV method will be chosen for each Work Package and it will not change after the Work Package is opened. The chosen method and techniques will be documented in the Control Account Plan.
- **Objectivity –** For discrete work, completion of an event will be based upon predetermined criteria or a tangible product.
- **Ability to audit –** The procedure and criteria for evaluating physical accomplishment will be auditable.

There are three basic Methods used for measuring performance. Application of these methods and their various techniques depends on the end product or service to be measured. Objective techniques are used where practicable. Each Work Package will utilize one of the following EV Methods to track work progress:

- **Discrete Effort –** Discrete tasks are those tasks which are quantifiable to individual work products or predetermined tangible measurement. Techniques utilized for Discrete efforts are:
    - **Fixed Formula –** 0/100, 50/50, 25/75 etc.
    - **Units Complete –** physical quantity count
    - **Milestone –** predetermined percent complete based on internal milestones within the work package
    - **Percent Complete –** predefined earning methodology based on detailed steps or hours necessary to complete the task.

- **Apportioned Effort –** This method involves the EV for a Work Package being based upon a defined relationship with a related discrete Work Package(s) from which progress is measured objectively. For example, Non-Manual Construction Support could be evaluated at 90% of the composite percent complete of all direct construction Work Packages. The final 10% would be earned when the paperwork closeout at the end of the project is complete (which is generally after the craft is gone).

- **Level of Effort –** This method effort of a general or supportive nature, which does not produce a definite end product. A LOE Work Package uses only one EV technique – the BCWP equals the BCWS in each reporting period. LOE tasks are measured through the passage of time rather than through application of a discrete EV technique. Project Management and Project Controls are examples of two Control Accounts

that could use the LOE method. LOE accounts are to be kept to a minimum.

Material and Subcontract items must utilize an effective performance measurement technique that allows for earned value to be claimed in the same accounting period as actual costs. The earned value techniques will be documented in the Control Account Plan, but in general they will be earned in the following manner:

- **Engineered Equipment –** Engineered materials are budgeted and costed for performance measurement reporting purposes when the material is received and accepted, or is based on a verifiable progress payment schedule.

- **Field or Bulk Materials –** Field materials are budgeted and costed for performance measurement reporting purposes when the material is withdrawn from stores or, in the case of project direct purchase orders, when the material is received and accepted.

- **Subcontracts –** The request for proposal shall include any subcontractor requirements for supporting the WSRC EVMS. The Project Manager balances this request by assessing the subcontract risk and management visibility requirements versus the subcontractor cost to generate the EVMS reporting.

4.2 Earned Value Tools

Various subsystems will be utilized by the Functional Departments to assess the physical percent complete of their assigned Control Accounts and Work Packages. Construction, for example, may utilize the Quantity Unit Rate Report (QURR) which tracks installed quantities and craft performance utilizing job hours.

The physical percent complete (through the current reporting period) is updated in the cost processor utilizing information from the EVMS process and subsystems for tracking physical progress. The cost processor calculates the BCWP (in dollars) which is the budgeted value of the physical work accomplished in terms of the dollar budget assigned to that work.

The cost processor is the WSRC tool which maintains the time-phased project dollar baseline at the task, work package, or control account level, summarizing to the various WBS/OBS levels and the total project. When actual costs are added to the cost processor, the three EVM key components (BCWS, BCWP, ACWP) becomes the source of information used for the reporting and analysis discussed in this guide.

5.0 REPORTING

Effective analysis of deviations from the plan for both schedule and cost provides management the ability to rapidly and effectively implement corrective actions. The Cost Performance Report (CPR) is an output of the cost processor which is one of the tools of the WSRC EVMS. The CPR provides the CAM(s) with the integrated cost and schedule data (expressed in dollars) for measuring the cost and schedule performance of their assigned Control Accounts. The CPR compares the BCWP with the BCWS and with the ACWP to provide schedule and cost variances. The CPR also compares the BAC (Budget At Completion) with the EAC (Estimate At Completion) to provide a Variance At Completion (VAC). The reports will be updated monthly, at a minimum, and will provide management the ability to:

- Measure actual progress, costs incurred, and their comparison to baseline plans
- Identify and analyze significant variances between planned and actual performance for initiation of corrective action
- Structure and summarize the status, progress, and analytical data to report to all levels of management
- Assemble and present the information in formal, contractually required reports for submittal to DOE

The CPR is not a real-time reporting system nor is it intended to provide the first indication of a problem. The CPR does provide the PM with the impact or quantification of problems in dollars. It can also be used to identify any statistical trends that may be developing, and to provide a basis for a detailed analysis of the financial health of the project. However, the WSRC Trend Program is closer to a real-time project analysis because it is designed to provide early warning for existing and potential problems. The WSRC Trend Program together with a critical path schedule analysis and risk assessment allows the project team to make assessments closer to a real-time project analysis.

The CPR has five required formats or report selections:

Format 1 - Work Breakdown Structure: Provides data to measure cost and schedule performance by summary level work breakdown structure elements.

Format 2 - Organizational Categories: Provides data to measure cost and schedule performance by organizational or functional cost categories

Format 3 - Baseline: Provides the budget baseline plan against which performance is measured

Format 4 - Staffing: Provides manpower loading forecasts for correlation with the budget plan and cost estimate predictions

Format 5 – Explanations and Problem Analyses: Provides a narrative report used to explain significant cost and schedule variances and other identified contract problems

6.0 CURRENT STATUS ASSESSMENT

In order for the PM/CAM to take corrective action early (and at the right points), they must know "Where are we? Where are the trouble spots? What's their magnitude and what are the implications?" For performance measurement purposes, the CPR will provide the information to analyze current and cumulative data to determine current status and to compute performance indices and percent variances for further analysis.

There are no established rules for (or specific kinds of) analysis of CPR data, and one analytical approach is not "better" or "worse" than another. However, the assumptions underlying each approach should be reviewed and thoroughly understood before relying on the results of any technique. While we will be discussing the comparisons of the EV information from the CPR, the analysis of this data must be done in conjunction with analysis of the Integrated Project Schedule and utilization of other project tools before finalizing any conclusions.

The metrics and indices that will be assessed are related to either cost or schedule.

Schedule Metrics begin with the comparison of the BCWS and BCWP. The BCWS is the time-phased approved baseline which resulted from the control account planning process. The BCWS exists for each work package within a control account and for every higher-level summary above the work package (i.e., control account, WBS element, OBS element, and total project).

Cost Metrics tend to be more meaningful than the Schedule Metrics and begin with the comparison of the ACWP and the BCWP. The ACWP exists for each work package within a control account and roll up to summarize data at a higher-level (i.e., control account, WBS element, OBS element, and total project). This comparison of BCWP with ACWP shows whether completed work has cost more or less than the value planned for that work.

6.1 Variance Calculations

The Project Execution Plan (PEP) or Team Execution Plan (TEP) will identify the Variance Thresholds which will trigger the completion of the CPR Format 5 (Explanations and Problem Analysis). The dollar variances discussed here are the Schedule Variance (SV) and Cost Variance (CV) and the Variance at Completion (VAC). The SV and CV can be either a current (monthly) period variance or a cumulative variance.

6.1.1 Schedule Variance

The SV is a simple subtraction to arrive at the absolute cost value of the schedule variance. A positive SV does not necessarily mean you are ahead of schedule, it means you are performing work earlier than planned. For example, a positive SV in a schedule area with a lot of float might offset a negative SV on the critical path. In such a case, there would be no SV even though the activities on the critical path may be so far behind schedule that they are unrecoverable.

- Schedule Variance (SV) = BCWP – BCWS

A negative dollar variance implies that of the work that had been scheduled to be accomplished (BCWS), an amount less than that had been accomplished (BCWP). This denotes an unfavorable, behind schedule condition.

Similarly, a positive dollar variance implies that of the work that had been scheduled to be accomplished (BCWS), an amount more than that had been accomplished (BCWP). This denotes a potentially favorable condition of performing work earlier than planned.

6.1.2 Cost Variance

This comparison of BCWP with ACWP shows whether completed work has cost more or less than the value planned for that work. The CV provides only the absolute cost variance between what was physically accomplished and what was actually spent.

- Cost Variance (CV) = BCWP – ACWP

A negative dollar variance implies that more was spent on the work accomplished than had been planned for that work. This denotes an unfavorable, overrun condition.

Similarly, a positive dollar variance implies that less was spent on the work accomplished than had been planned for that work. This denotes a favorable underrun condition.

6.1.3 Variance at Completion

The Variance at Completion (VAC) represents an estimate of potential cost overrun or underrun. The VAC is the difference between the BAC and the EAC. DOE Manual 413.3-1 defines BAC as not including Contractor Contingency and thus equal to the PMB. WSRC uses a different definition. For meaningful variances at completion, WSRC performs VAC analysis at both the PMB and TPC level. Because

analysis is performed at both the PMB level and the TPC level (which includes contingencies), it is important to identify the basis of any VAC calculation:

- $VAC_{(PMB)} = BAC_{(PMB)} - EAC_{(PMB)}$
- $VAC_{(TPC)} = BAC_{(TPC)} - EAC_{(TPC)}$

Note: The CPR uses the LRE (Latest Revise Estimate) in calculating the VAC. The LRE can be either the formal bottom-up EAC required by the contract every 6 months, or the less formal monthly FAC (Forecast at Completion) analysis. FAC or LRE can be substituted for EAC in any of the formulas using "EAC".

6.2 Percentage Relationships

The dollar variances discussed above do not always tell the complete story. The dollar variance is only significant relative to some base, thus variance thresholds on both dollars and on a percentage basis are generally preferred. Below are several percentage relationships:

6.2.1 Schedule Variance Percent (SV%)

A simple subtraction of BCWP – BCWS to arrive at the dollar Schedule Variance (SV) does not always tell the whole story without a relationship to some base. SV should be related to the amount of work planned to have been accomplished.

- SV % = (SV / BCWS) x 100

The SV% relates the absolute cost variance to a base, in this case the amount of work planned to be accomplished (BCWS). Schedule variances are less meaningful and can be misleading (optimistic) because they ignore the critical path.

At a particular point in time, a negative SV% means that the work is at least that percent behind schedule in terms of dollars which were to have been expended at that point in time.

In general, a positive percent means the work is at least that percent ahead of schedule in terms of dollars which were to have been expended at that point in time.

When reviewing all these metrics, variances may not indicate whether the scheduled milestones are being met, whether a completed activity is a critical event, or if delays in an activities' completion will affect the completion date of the project. Therefore, in addition to the above metrics, schedule analysis should include reviewing the critical path,

total float, as well as verifying there is not an excessive use of constraints, and that the resource availability plans are still valid.

6.2.2 Cost Variance Percent (CV%)

A simple subtraction of BCWP – ACWP to arrive at the dollar CV does not always tell the complete story. The CV should be related to the amount of work accomplished:

- CV % = (CV / BCWP) x 100

The CV% may be applied to the current or cumulative data, as well as to functional departments. This data can be plotted to assess statistical trends. However, the CV% does not distinguish between large and small efforts so the Project Controls Engineer must eyeball the relationship between the percent deviation and the absolute dollar amounts. This is why variance reporting thresholds are usually defined in terms of both percentages and absolute dollar values.

At a particular point in time, a negative percent means the project is experiencing a cost overrun of that percentage.

A positive percent means the project is experiencing a cost underrun of that percentage.

6.2.3 Percent Complete

This is the relationship of the dollar value of budgeted work accomplished to date (BCWP) to the dollar value of the budgeted work for the total project or control account. The base for determining percent complete is the Budget at Completion (BAC_{PMB}). The calculation for percent complete is as follows:

- Percent Complete = ($BCWP_{(cum)}$ / $BAC_{(PMB)}$) x 100

Percent Complete is useful as a quick gauge of where a project is in relationship to other indices such as CPI, percent scheduled, and percent spent. For example, if we are 35% complete and the cumulative cost performance index (CPI) is .92 we have an idea of how much time and effort remain for overcoming problems, and improving the efficiency of the effort to date.

(There are times when the PCE may wish to see how the project is tracking against a work execution strategy and EAC that is considerably different from the BAC plan. In these cases, the Percent Complete can be calculated using the EAC plan. This analysis can provide statistical information to evaluate the health of the EAC when

compared to EAC percent scheduled and EAC percent Spent. The formula is the same as above except EAC is substituted for BAC.)

6.2.4 Percent Scheduled

The Percent Scheduled is the relationship of the dollar value of work schedule to date (BCWS) to the dollar value of the budgeted work for the total contract, or BAC.

- Percent Scheduled = ($BCWS_{(cum)}$ / $BAC_{(PMB)}$) x 100

The Percent Scheduled provides another data point when compared to the percent complete and percent spent.

If the current working schedule is considerably different than the baseline schedule, this technique can be utilized to compare the current schedule to the EAC. The current schedule will often reflect work-a-rounds or schedule accelerations, and may reflect the latest EAC value. In such a case, the BCWS for the current schedule can be compared to the EAC utilizing the same formula as above. It can then be utilized in comparisons to EAC percent complete and EAC percent spent to evaluate the status of achieving the current work plan.

6.2.5 Percent Spent

This is the relationship of the dollar value spent to date (ACWP) to the dollar value of the budgeted work for the total project or control account. The base for determining percent spent is the Budget at Completion (BAC).

- Percent $Spent_{(BAC)}$ = ($ACWP_{(cum)}$ / $BAC_{(PMB)}$) x 100

When you compare the percent spent to the percent complete (or accomplished) a question may be raised regarding the adequacy of the budget established for this scope of work.

Percent Spent may also be used to access the health of the latest EAC by substituting EAC for BAC in the formula.

- Percent $Spent_{(EAC)}$ = ($ACWP_{(cum)}$ / $EAC_{(PMB)}$) x 100

6.3 Performance Indices and Factors

A variety of performance indices and factors are used to quantify performance. The more common ones will be discussed in this section.

6.3.1 Schedule Performance Index (SPI)

The SPI is an indication of the schedule efficiency with which work has been accomplished.

- SPI = BCWP / BCWS

A SPI can be calculated for both monthly and cum-to-date. SPIs can be plotted on a statistical performance trend graph for further analysis.

A word of caution: Out of sequence progress (BCWP) can give a false indicator of schedule health. A positive SV or a SPI greater than 1.00 does not necessarily mean you are ahead of schedule, it means you are performing work earlier than planned. The SPI ignores whether items may be on the critical path, because the SPI reflects an average of the WBS items' schedule status. As a result, the SPI isn't nearly as reliable or as valuable an indicator as the CPI.

A SPI less than 1.0 represents a behind schedule condition.

When reviewing all these metrics, variances may not indicate whether the scheduled milestones are being met, whether a completed activity is a critical event, or if delays in an activities' completion will affect the completion date of the project. Therefore, in addition to the above metrics, schedule analysis should include reviewing the critical path, total float, as well as verifying there is not an excessive use of constraints, and that the resource availability plans are still valid.

6.3.2 Cost Performance Index (CPI)

The CPI is an indication of the cost efficiency with which work has been accomplished.

- CPI = BCWP / ACWP

A CPI can be calculated for both monthly and cum-to-date. CPIs can be plotted on a statistical performance trend graph for further analysis. While the CPI is generally applied to the WBS or total project levels, it can also be applied to the functional departments utilizing the Format 2 CPR.

The CPI is an efficiency ratio, "output" (in terms of earned value) divided by "input" (in terms of actual cost). When a CPI of 1.0 is "par", anything below 1.0 indicates less progress for the money than expected. Conversely, if the index is greater than 1.0 than the value received is greater than the amount budgeted (an underrun condition).

The cumulative CPI is an important indicator of health, however, once a project has progressed beyond its “mid-point” the cumulative CPI becomes less sensitive to recent problems. Therefore, the current CPI tends to grow in significance as the project approaches the completion date.

6.3.3 "To Complete" Performance Index (TCPI)

Another way to look at performance is from an end-of-contract viewpoint where the relationship between the work remaining and the money required to accomplish the work remaining is examined. The TCPI addresses the question, "At what efficiency will the project have to perform on the remaining work in order to meet the BAC or EAC?" The basic formula for the TCPI, based on the expectation of completing the work within the BAC is:

- $TCPI = (BAC_{(PMB)} - BCWP_{(cum)}) \ / \ (BAC - ACWP_{(cum)})$

The alternative formula to analyze the EAC would substitute the EAC in place of the BAC in the denominator.

- $TCPI = (BAC_{(PMB)} - BCWP_{(cum)}) \ / \ (EAC - ACWP_{(cum)})$

The TCPI provides a basis for evaluating the realism of achieving either the BAC or EAC as the final cost of the project. If the project or control account has been experiencing a CPI of .88 how are you going to perform at greater than this historical rate to finish at 1.0 (par)? Analyzing the scope of the remaining work and its relative complexity to the historical CPI will help validate your analysis.

6.4 Narrative Problem Analysis

This is the project's statement of problem areas and corrective actions taken, and is captured on CPR Format 5 or another Variance Analysis format. This document is the number one most used and most useful tool available as it provides status information on a silver platter.

There in lies the pros and cons. It is immediately available without number crunching and the reviewer can tend to jump immediately to this format thus accepting the writers conclusions without first developing their own assessment. The completed Format 5 (Explanation and Problem Analysis) report, needs to clearly and concisely identify the specific causes for a significant variance, the action being taken to correct the problem, and the period of time necessary to correct them.

The narrative analysis should include, although not limited to:

- Identification and characterization of the problem (i.e.: labor variance, material variance, design problem, and test failure)
- Impact of problem on cost, schedule, and related project performance
- Corrective action to be taken, including the estimated "get-well" date
- Identification of the actual variance and percent deviation from plan
- Traceability of all Contractor Contingency activity
- Identification of all baseline changes (including changes in scope) either as a result of internal replanning or customer direction

When setting the variance reporting thresholds in the PEP or TEP, the optimum thresholds are at a level where not too much is reported, but where the PM is aware of significant problem areas. Too many reported areas present a problem in analysis, as well as adding to the cost of data. However, too few create the opportunity for surprises. Generally the variance reporting will be at the Control Account (CA) level.

6.5 The Eyeball Method

For lack of a better term, eyeballing is visual scanning of the CPR to discover things we might not otherwise catch. For example, elements in a BCWP column (current or cumulative) may be identical to the BCWS or ACWP for the same item, meaning a "zero variance". (We're speaking here of other than LOE tasks.) While a zero variance could occur, it is highly unlikely and could more likely mean the figures have been pulled out of thin air, in order to produce a zero variance.

Another item that can be picked up by eyeballing is the situation where a task or CA VAC is identical to the cumulative cost variance and the item is not complete. This literally says "We've already encountered all the unexpected problems"!

There are many more items that your experience and knowledge will pick up that "look" strange or even wrong when eyeballing the reports.

6.6 Labor or Material Costing Rate Analysis

Various Labor or Material Costing Rates were utilized in the preparation of the baseline estimate along with assumptions for price increases or escalation. An occasional review of the actual rates versus the budget and to-go rates will often highlight potential or existing problems.

For example, steel prices have recently soared due to increased building in China. The economic reality of supply and demand has driven steel costs considerably higher which could adversely impact the project costs. These types of analyses are generally performed during the development of the Estimate at Completion (EAC). However, a sudden increase or decrease in costing rates between EACs may help explain current variances on the project.

6.7 Contingency Analysis

Contingency is included in the baseline estimate to cover costs, based on past experience, which are known to regularly occur but are difficult or impossible to identify. As such they are part of the original intended scope of work. The adequacy of the Contingency (C) and its use have a direct bearing on cost performance assessment. For example, cost performance in the early stage of a project may appear adequate. However, if the contingency budget has been depleted early in the project because of work omitted in the original planning, then a serious forthcoming cost problem is indicated. The E11 Procedure has a guidance document on Contingency Utilization, for additional information. There are, however, some percentage relationships that can be analyzed to assist in determining the health of the project contingency:

- % C Remaining = (C $ Remaining / Original Baseline C $) x 100

The % C Remaining can be compared to the remaining percent to complete the project (100% - % Complete = % to Complete). For example, if there is 62% of the contingency remaining but 75% of the project scope to complete there may be an indication the contingency is being utilized to quickly. Obviously all these comparisons need to take into consideration the remaining risks associated with the remaining scope of work.

- % C To $Go_{(BAC\ or\ EAC)}$ = (C $ Remaining / $PMB_{(BAC\ or\ EAC)}$ $ To Go) x 100

The % C To Go of the PMB provides another indicator relative to the original contingency percentage of the PMB prior to the start of work. For example, if the original contingency percent was 15% of the PMB and it is currently 35% of the PMB to go with most of the major risks behind the project, the remaining contingency may be very healthy. For a more thorough analysis, comparing the % C To Go to both the $BAC_{(PMB)}$ and the $EAC_{(PMB)}$ may be desirable.

7.0 TREND ANALYSIS TECHNIQUES

(Note: Do not confuse the mentioning of "trends" in this section with the formal WSRC Trend Program which is an early warning program and is discussed in other procedures and guides. This section will discuss utilizing historical statistical information to recognize performance trends.)

Past and current data may be used to assess current trends in performance. There is particular value in being able to detect trends, since they give you an idea of how things will be in the future, and once detected, they are generally expected to continue except for outside or unusual influences. These influences may take the

form of failures or breakthroughs, corrective action, or technical performance parameter changes. Often trends are more meaningful than current information alone because they allow you to see what's going to happen.

Individual items of CPR data by themselves do not generally provide a basis for decision making. After establishing CPR data credibility, and assessing the current status, it is necessary that the time phased data analysis occur. Data analysis can utilize two main formats; tabular and/or graphic.

Tabular Formats are often difficult to read, analyze, interpret, compare, or draw conclusions from. This is especially true when the relationships are complex, there are multiple time periods and formats become "busy". Although tabulation is an improvement over the basic CPR reports, it still presents a problem of "seeing" the trend in the numbers.

Graphic portrayal of basic data overcomes this problem. When presented in graphic form, relationships between data elements are easier to see and understand.

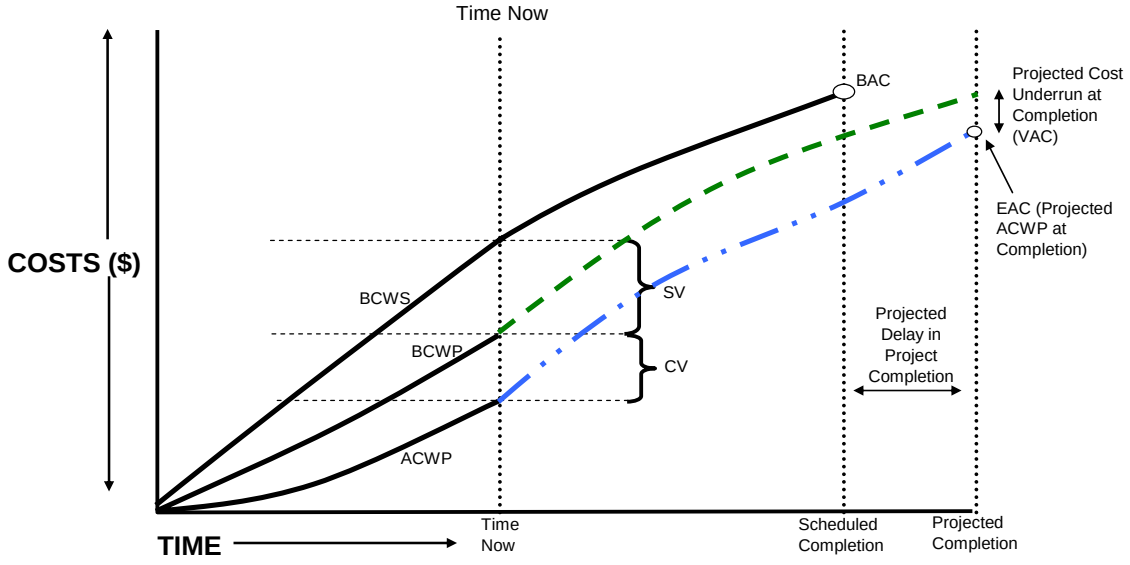
While there are many techniques that can be used to analyze trends, the more common ones are discussed in this section. The objective of using any of the trend analysis techniques discussed below is to communicate project status quickly and meaningfully.

7.1 Cumulative Project Performance Status

Graphical displays of the CPR cost and schedule data can assist in the understanding and aid in the analysis of the data. This chart plots the time-phased BCWS, BCWP and ACWP on a cumulative basis from the beginning of the project. It provides the overall status of the project, WBS, Control Account, or functional department. This chart reflects changes to budgets, schedules, and EAC as they have occurred since the beginning of the effort. Major cost and schedule baseline changes are easy to identify and, by showing the entire time span of the project, current status is put in proper perspective. Because this chart depicts cumulative to date history and status, it does not highlight recent performance. When the projected EAC and projected schedule completion is included the graph clearly depicts projected cost underruns or overruns as well as projected schedule improvements or delays.

The graph below shows the cumulative project performance status for a project that is underruning the BAC but projecting a schedule delay.

Cumulative Project Performance Status

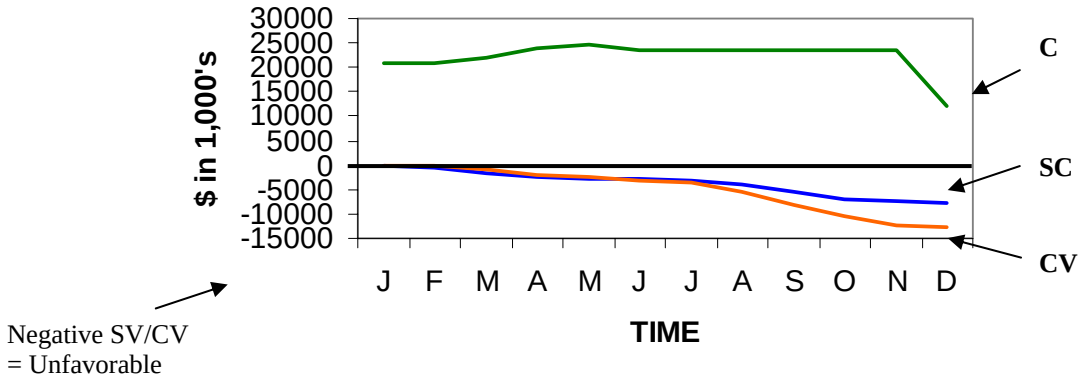


A disadvantage associated with this chart is that it does not emphasize trends toward or away from planned performance. Another limitation is that problems will not be readily perceivable from the graphed data until late in the life of the project. Further, rebaselining the project will break the shape of the baseline. Early extremes are to be expected since the base from which the data is obtained is very small. Since BCWP represents the work actually accomplished, all comparisons for both schedule and cost are made against the BCWP line.

7.2 Dollar Variance Trends

The dollar variances plotted in the graph below are the differences between BCWP and BCWS, giving SV; and BCWP and ACWP, giving CV. Again, such variances can be addressed at the total project level or any level to which management attention is desired. The chart also provides visibility of the use of the contingency budget which is not available on the previous chart. Visibility of the contingency budget usage is a valuable indicator of problems and should be considered together with the cost variance trend line in assessing performance.

Cum-To-Date Variance Trend in Dollars

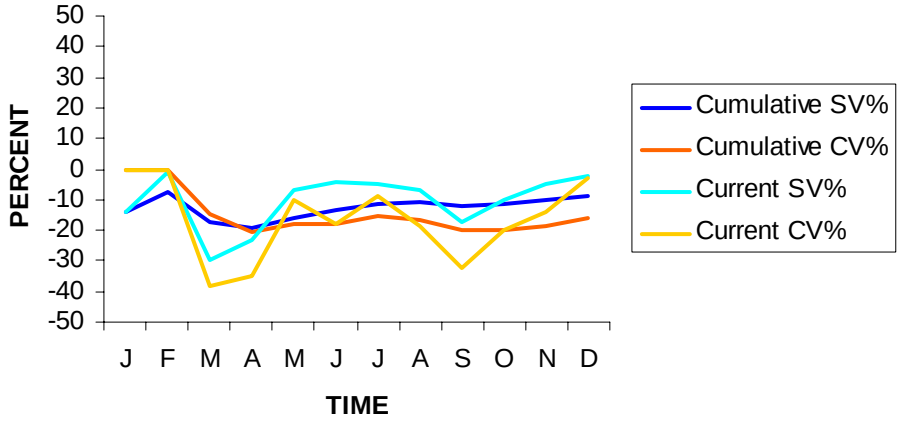


Schedule and cost status are often presented on the same graphic. Schedule status often reflects changes a month or two before they show up in cost status.

7.3 <u>Percentage Variance Trends</u>

Dollar Variance Trends can sometimes require a dollar scale that does not readily depict small changes and trends. Therefore, plotting the SV% and CV% can sometimes provide more visibility of trends. Plotting both the current period and the cum-to-date numbers can assist with the analysis.

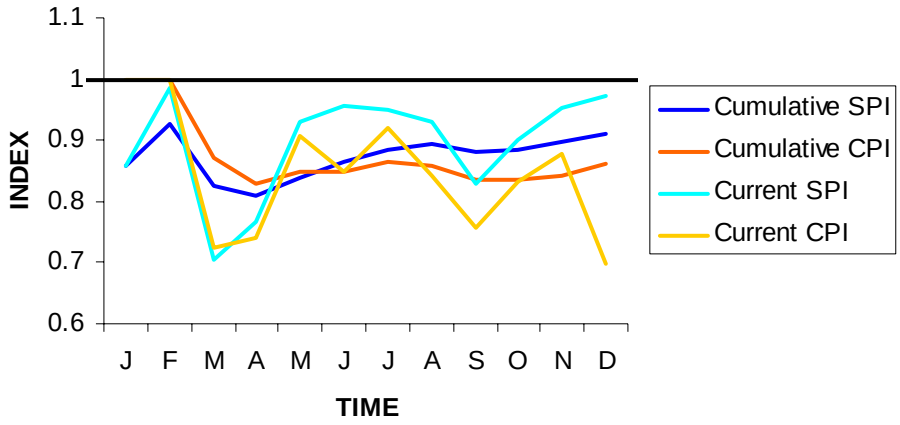
Variance Trend in Percent



7.4 Plotting CPI and SPI

The performance trend charts utilizing CPI and SPI can be plotted both on a cum-to-date and a current month basis. Two such graphs should be developed for each WBS element which has been identified as a problem for management's attention. The monthly chart should never be analyzed separately from the cumulative chart. Its only purpose is to give an early warning of possible trends. It does not provide an actual indication of the present situation. The number of current variables is so great that it would be erroneous to state that the project situation is anything other than that shown on the cumulative chart. However, remember that while the cumulative CPI is an important indicator of health, once a project has progressed beyond its "mid-point" the cumulative CPI becomes less sensitive to recent problems. Therefore, the current CPI tends to grow in significance as the project approaches the completion date. Placing both charts on one page, with the cum-to-date first or both sets of lines on one chart will insure the monthly chart can never be seen without the cumulative chart.

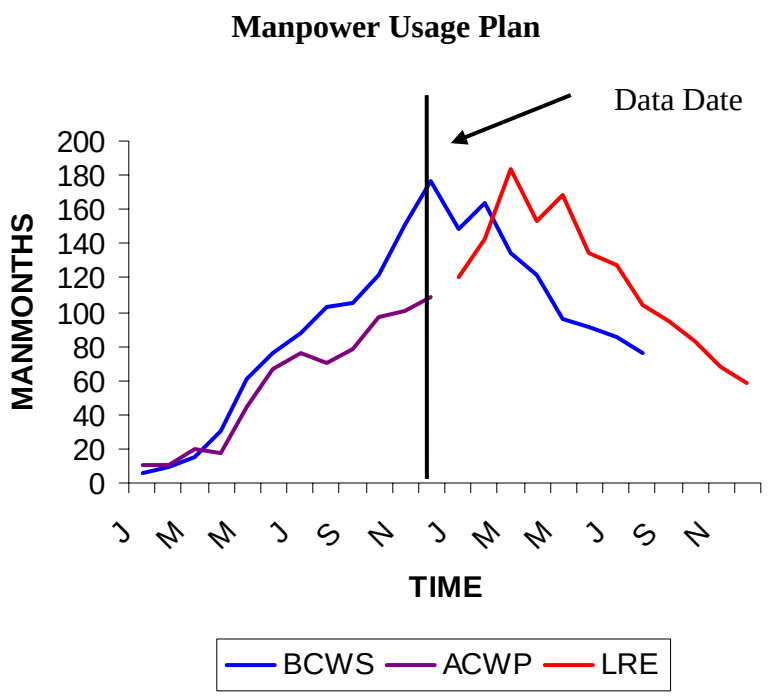
SPI and CPI Indices



Problem areas pointed out by the WBS element graphs may be further narrowed through the use of organizational/function department graphs.

7.5 Manpower Loading (CPR only)

Manpower usage charts are for monitoring the usage of the labor resource to provide an indication of the problems. The source of the data is the original manpower loading plan taken from the first CPR for the BCWS and the ACWP comes from succeeding CPRs. Plotting the current forecast along with the actual manpower usage provides additional information for analysis.



The original curve can be compared with actual performance and current forecasts to determine if the curve changes dramatically. This comparison must take into consideration all scope changes. Moving labor from later periods of the contract to the current or near future periods indicates poor planning and the possibility of a cost overrun.

Increases in total manpower loading should be accompanied by an increase in the estimated cost at completion column within the CPR.

Another aspect of manpower analysis is relating direct manpower to specific project milestones. This is a useful tool for monitoring the application of direct manpower in achieving project milestones within budgeted cost. The milestones can be overlaid on the above chart.

8.0 ESTIMATE AT COMPLETION (EAC) ASSESSMENT

WSRC employs several techniques to develop project cost projections. The EAC is the most disciplined tool used to evaluate the approved execution plan. The site contract and the PEP define the frequency for preparing a comprehensive EAC, and it is generally every six to twelve months. An EAC is prepared to accurately reassess the total cost, schedule, and risk of the project.

A detailed estimate, schedule reassessment, risk analysis, and associated Contingencies are prepared for the remainder of work to go on the project. This

establishes the ETC (estimate to complete) value and, when combined with actual cost to date on the project, determines the EAC.

The formal EAC is reviewed with WSRC Senior Management and the customer for input and approval. After the approvals, the EAC is summarized and incorporated in the monthly customer and WSRC management reports. A formal EAC becomes the latest Trend Forecast in the WSRC Trend Program.

Procedure E11 along with guidance documents provide details on preparing an EAC. The EAC is a bottom-up review of the project and is never calculated or extrapolated from statistical information. These statistical methods may be utilized to perform a sanity check against the validity of the EAC if significant changes in performance or other issues may have occurred and the next official EAC is not scheduled for several months.

9.0 FORECAST AT COMPLETION (FAC) ASSESSMENT

The Forecast at Completion (FAC) is a less rigid high spot evaluation of final project costs performed on a routine basis. The FAC is prepared periodically to capture performance issues, trends, and resource requirements identified since the last formal EAC. The FAC process is detailed in E11, and is generally done monthly.

The FAC is intended to be an evaluation, less rigid, then the EAC, but it too is not intended to be a statistically calculated number. However, these statistical methods can become a sanity check against FAC's presented by the CAMs. For example, if a CAM provides an FAC holding the BAC and the account has experienced significant performance problems, what plausible execution strategy is going to be employed that will allow the account to recover? Simple mathematical checks discussed below may identify unrealistic FAC information.

9.1 Cross-checking the FAC using Statistical Methods

The methods to be discussed in this section are strictly statistical approaches based on data from the same project. They are critically dependent on the similarity and validity of the previous data. These techniques use mathematics but the math is secondary. The major influencing factor is objective managerial judgement using all available sources of information. Since the data used in these techniques comes from the project, estimates are critically dependent upon both the validity and amount of data, plus the quality of the managerial judgement.

While current status determinations and trend analyses assist in validating reported FACs and variances at completion, they do not substitute for a basic knowledge of current and expected problems or breakthroughs. Even though performance indices are useful for estimating future conditions, it should be

remembered that they are valid only to the degree that the future resembles the past. For example, if a work package for installing conduit is currently 60% complete and performance is at 1.12, an understanding of the remaining work is necessary to validate projecting the 1.12 performance on the to-go scope. Typically, the long easy runs are installed first. In this case, large quantities can be installed very efficiently. The remaining quantities may be in all the tight fitting areas requiring bending and alignment not seen in the large bulk runs. If the to-go work is not estimated at a less efficient performance factor an unrealistic FAC will be prepared.

9.2 Analysis Techniques utilizing the Cost Performance Index (CPI)

The techniques discussed below can be applied at the total PMP level or at individual Control Account (WBS levels). It is possible to utilize these techniques at a lower level and summarize the information up to the total project level. This will provide a more accurate analysis but greatly increases the calculations to be performed and the amount of information to support these calculations. A cost/benefit decision should be made with the project team to determine the level or accounts to track.

9.2.1 BAC and CPI

Dividing the $BAC_{(PMB)}$ by the $CPI_{(cum)}$ assumes that the efficiency with which the work will be done will continue at the current performance.

- Calculated FAC $= BAC_{(PMB)} / CPI_{(cum)}$

Basing a calculated FAC on the cumulative CPI experienced since project start might not be the best approach. In a stable environment it may be reasonable, however, in the dynamic environment of some projects the use of this approach should be carefully considered.

9.2.2 Planned Work Remaining and CPI

An indicator which usually leads the above formula by 2 to 6 months is calculating the FAC using the current period CPI. However, there is a great deal of fluctuation in incremental data. Thus, using the current period CPI to calculate a FAC needs to be balanced by looking at the above cumulative CPI calculation.

- Calculated FAC $= ACWP + (BAC_{(PMB)} - BCWP / CPI_{(cur)})$

9.2.3 6-Month CPI Moving Average

It may be more realistic to modify the CPI using management judgement. Consideration should be given to using a 3 or 6 month moving average of the cumulative to date CPI.

- Calculated FAC $= ACWP + (BAC_{(PMB)} - BCWP / CPI_{(aver)})$

(The average CPI is calculated by adding the 6 month period of cumulative CPI numbers and dividing by 6.)

9.2.4 Weighted 6-Month CPI Moving Average

Because of the need to emphasize more recent data, it is possible to calculate a weighted average in which the most recent data receives the greatest weight. (See Attachment II for a demonstration of this weighting of the 6 months cumulative CPI).

- Calculated FAC = ACWP + ($BAC_{(PMB)}$ - BCWP / $CPI_{(weighted\ aver)}$)

Be careful not to calculate a CPI by weighting periods of low technical risk heavily when planned efforts involve high technical risk.

9.3 Analysis Techniques utilizing the To Complete Performance Index (TCPI)

If the Calculated FAC is based on the CPI, then for work remaining a deliberate effort should be made to adjust the CPI and, thus, create a TCPI (to complete performance index).

The TCPI is the cost efficiency level at which work must be accomplished in order to attain the desired final cost, while the CPI is the cost efficiency level at which work has been or is currently being performed. The difference between the two provides an indicator of whether the expected final cost can be met. As the CPI decreases and the TCPI increases, it becomes more likely that the expected final cost will be exceeded. For example, if the $TPCI_{(BAC)}$ has been calculated as 1.07 and the $CPI_{(cum)}$ is only .862, the probability of meeting the BAC is slim unless there is a dramatic increase in efficiency. Even comparing the current month CPI may show meeting the BAC is still not achievable.

10.0 CONCLUSION

There are many techniques that can be utilized in analyzing the CPR data and a few of the more common ones have been discussed here. It is not intended that all these techniques be used on a regular basis, but analysis by both the CAM, and the Project Controls Engineer is necessary to help prevent unwanted surprises. For a quick reference document, Attachment I is a listing of the main terms and formulas discussed in this guide. Attachment II includes mathematical examples and analysis of an example project utilizing the techniques being described in this document.

The importance of reviewing and using the performance data cannot be overemphasized. The basic data (BCWS, BCWP and ACWP) convey a great deal of information; however, the use of analytical techniques can supplement the data reported and establish a better basis for appropriate decision making. The

analytical techniques described in this guide are not all inclusive. The Project Controls Engineer should review the data reported and apply pertinent analysis techniques emphasizing the information which appears most important in depicting performance. The resulting analysis should be made in a way which will fully and fairly inform management. Any analysis techniques which may distort or mislead the meaning of the data should be avoided. These techniques include, but are not limited to:

- Collapsing vertical scales to level out or obscure variances
- Enlarging either axis to explode the data and exaggerate the differences between lines
- Slanting performance by emphasizing either current or cumulative data to present the desired assessment.

11.0 REFERENCES

- WSRC EVMS System Description (Rev. A issued November 19, 2004)
- U.S. Department of Energy Cost and Schedule Control Systems Criteria – Data Analysis Guide (published March 1986)
- Contractor Performance Measurement Data Analysis Techniques by The Defense Systems Management College, Fort Belvoir, Virginia (published January 1983)
- U.S. Air Force Systems Command Guide to Analysis of Contractor Cost Data (published August 1979)

12.0 ATTACHMENTS

Attachment I – EVM Definitions and Formulas
Attachment II – Example Project with Analysis

ATTACHMENT I – EVM Definitions and Formulas

DEFINITIONS

ACWP	Actual Cost of Work Performed
BCWP	Budgeted Cost of Work Performed
BCWS	Budgeted Cost of Work Scheduled
BAC	Budget-At-Completion
CPI	Cost Performance Index
CV	Cost Variance
EAC	Estimate-At-Completion
ETC	Estimate-To-Complete
FAC	Forecast –At-Completion
LRE	Latest Revised Estimate (can be EAC or FAC)
SPI	Schedule Performance Index
SV	Schedule Variance
TCPI	To Complete Performance Index
VAC	Variance At Completion

PERFORMANCE FORMULAS

Variance Calculations:

SV =	BCWP - BCWS
CV =	BCWP – ACWP
VAC =	BAC - EAC

Percentage Calculations:

SV % =	(SV / BCWS) x 100
CV % =	(CV / BCWP) x 100
% Complete =	($BCWP_{(cum)}$ / $BAC_{(PMB)}$) x 100
% Scheduled =	($BCWS_{(cum)}$ / $BAC_{(PMB)}$) x 100
% BAC Spent =	($ACWP_{(cum)}$ / $BAC_{(PMB)}$) x 100
% EAC Spent =	($ACWP_{(cum)}$ / $EAC_{(PMB)}$) x 100

Performance Indices Calculations:

SPI =	BCWP / BCWS
CPI =	BCWP / ACWP
TCPI =	($BAC_{(PMB)}$ - $BCWP_{(cum)}$) / (BAC – $ACWP_{(cum)}$)

ATTACHMENT II Example Project with Analysis

The example project we will use in this analysis is the design, construction, and testing of a small Glovebox . Figure 1 provides an example of the most current month's Cost Performance Report (CPR) by WBS. This report is for December. You will notice that the Project is broken into 6 Control Accounts (CA):

1.1.1 Design Engineering
1.1.2 Major Equipment Purchases
1.1.3 Bulk Material Purchases
1.1.4 Construction
1.1.5 System Testing
1.1.6 Project Support

These CA's will have additional tasks or Work Packages to further define the scope and to track performance measurement.

For these analysis examples we will be looking at the total project, not specific CA's unless variance's require us to drill deeper into the details to analyze any existing or potential problems.

The analysis discussions will follow the same outline as the guide to cover the formulas and techniques discussed.

GLOVEBOX PROJECT - December CPR - Format 1 by WBS

WBS Summary	Current Period					Cumulative To Date Through Current Period					At Completion			
	Budgeted Cost		Actual Cost	Variance		Budgeted Cost		Actual Cost	Variance			Latest	Variance	
	Work Scheduled	Work Performed	of Work Performed	Schedule	Cost	Work Scheduled	Work Performed	of Work Performed	Schedule	Cost	Budgeted	Revised Estimate	Cost	Pct
1.1 Glovebox														
1.1.1 Design Engineering	1,080	1,055	1,055	(25)	0	19,095	18,881	19,192	(214)	(311)	23,026	23,239	(213)	-0.9%
1.1.2 Major Equipment	4,140	3,901	4,134	(239)	(233)	25,091	20,664	27,551	(4,427)	(6,887)	76,534	76,584	(50)	-0.1%
1.1.3 Bulk Materials	232	278	243	46	35	5,016	4,844	4,847	(172)	(3)	19,377	19,077	300	1.5%
1.1.4 Installation	5,076	5,064	5,147	(12)	(83)	18,796	17,530	20,032	(1,266)	(2,502)	82,194	83,255	(1,061)	-1.3%
1.1.5 System Testing	760	685	788	(75)	(103)	2,633	1,801	3,121	(832)	(1,320)	26,681	26,995	(314)	-1.2%
1.1.6 Project Support	630	630	624	0	6	5,651	5,651	5,751	(0)	(100)	18,836	18,836	0	0.0%
Total Costs - Bare	**$ 11,918**	**$ 11,613**	**$ 11,991**	**$ (305)**	**$ (378)**	**$ 76,282**	**$ 69,371**	**$ 80,494**	**$ (6,911)**	**$ (11,123)**	**$ 246,648**	**$ 247,986**	**$ (1,338)**	**-0.5%**
Total Burdens/Fee	1,632	1,591	1,643	(41)	(52)	10,451	9,504	11,028	(947)	(1,524)	33,790	33,974	(184)	-0.5%
Total Costs - Burdened	**$ 13,550**	**$ 13,204**	**$ 13,634**	**$ (346)**	**$ (430)**	**$ 86,733**	**$ 78,875**	**$ 91,522**	**$ (7,858)**	**$ (12,647)**	**$ 280,438**	**$ 281,960**	**$ (1,522)**	**-0.5%**
Undistributed Budget													0	0.0%
TOTAL at Completion	**$ 13,550**	**$ 13,204**	**$ 13,634**	**$ (346)**	**$ (430)**	**$ 86,733**	**$ 78,875**	**$ 91,522**	**$ (7,858)**	**$ (12,647)**	**$ 280,438**	**$ 281,960**	**$ (1,522)**	**-0.5%**

Figure 1: CPR by WBS for Current Month

The first step is to perform a "current status assessment" by reviewing or calculating the metrics and analysis formulas discussed in Section 6 of the guide. While the PCE and CAM will be looking at both the Current Period and Cumulative To-Date Period, we will review the Cum To-Date in these calculations.

Variance Calculations and Percentage Relationships

The CPR Format 1 report performs the SV, CV, and VAC calculations for us, so let's review what we see:

- Cumulative Period SV is $(7,858) {$78,875 - $86,733}
- Cumulative Period CV is $(12,647) {$78,875 - $91,522}
- Cumulative Period BCWS is $86,733
- Cumulative Period BCWP is $78,875
- Cumulative Period ACWP is $91,522
- $BAC_{(PMB)}$ is $280,438
- $LRE_{(PMB)}$ is $281,960
- VAC is $(1,522) {$280,438 - $281,960}

The negative SV shows we achieved less than was scheduled, and the negative CV shows it cost us more to do it! Looking at the details we see that the Major Equipment, Installation, and System Testing CA's contributed the most to these variances. However, the VAC indicates we will recover most of these cumulative variances by the end of the project. (We will test the LRE and that assumption later)

Now let's check the SV% and CV% to see if we have exceeded our reporting thresholds.

- SV% = (SV / BCWS) x 100 = (7,858) / 86,733 x 100 = (9%)

This means the project is 9% behind schedule, and a schedule analysis of the critical path needs to occur to verify how far behind the critical path may be. (Remember, working non critical work out of sequence can skew schedule indicators in an EVMS).

- CV% = (CV / BCWP) x 100 = (12,647) / 78,875 x 100 = (16%)

This means that the project is 16% over cost.

Our variance reporting threshold in the Project Execution Plan (PEP) was established at 15% (positive or negative) for reporting to the client. Therefore, the PM will need to write a narrative variance report or CPR Format 5 for the cost variance. For internal control, the Team Execution Plan (TEP) requires the CAM's to report a 10% variance if 10% is greater than $1,000. A quick review of the report shows the following WBS CA's will require internal variance reports:

Major Equipment	(18%) SV and (33%) CV
Installation	(14%) CV (the SV% is less than 10%)
System Testing	(32%) SV and (73%) CV

(You will also note the "Total Burdens/Fee " CV% is (16%), the same as the "Total Costs – Bare" and the total CV% above. This is because Indirects are being earned apportioned to the direct bare costs.)

Another way to look at these variances to the Baseline is to review % Complete, % Scheduled, and % Spent of the BAC.

% Complete = BCWP / BAC = 78,875 / 280,438 = 28%
% Scheduled = BCWS / BAC = 86,733 / 280,438 = 31%
% Spent = ACWP / BAC = 91,522 / 280,438 = 33%

This confirms the previous analysis, the project is behind schedule and over budget.

<u>Performance Indices and Factors</u>
Now we will look at the Performance Indices and Factors discussed in Section 6.3.

- SPI = BCWP / BCWS = 78,875 / 86,733 = .909

The SPI is an indicator of schedule efficiency, and a .909 index means that work has been accomplished at a rate of 91% of the plan. (Remember that 1.0 is "par").

- CPI = BCWP / ACWP = 78,875 / 91,522 = .861

The CPI is an indicator of cost efficiency, and a .861 index means that for each budget dollar spent, 86 cents in value was received. This indicates poor efficiency or a cost overrun. If the index had been greater than 1.0 is would indicate a cost underrun or higher efficiency.

Next we will look at the TCPI which estimates the chance the actuals for the contract will exceed the BAC. This is done by calculating the CPI that must be achieved to bring the actuals in on budget - or the To-go Cost Performance Index (TCPI).

- TCPI = (BAC – BCWP) / (BAC – ACWP) or
  = (280,438 – 78,875) / (280,438 – 91,522) = 201,563 / 188,916 = 1.07

Since the cumulative CPI through December is .861, the project team must drastically improve cost performance to finish on budget. If the CPI and the TCPI do not start to approach each other as the months progress, the chance increases that there will be an overrun at completion.

Remember when we noticed the LRE and VAC was indicating a remarkable recovery from December's variances by project completion? Let's review the chances of this occurring (statistically) by looking at what the TCPI would need to be to meet the LRE value.

- TCPI = (BAC – BCWP) / (EAC – ACWP) or
  = (280,438 – 78,875) / (281,960 – 91,522) = 201,563 / 190,438 = 1.06

This TCPI does not even assure us we will complete the project within the LRE! Obviously we need to evaluate the remaining work scope versus the completed work, but remember, when you are building a Glovebox, there is a lot of equipment, conduit, tubing, etc. being installed in a small space. The more you install, the more congested it becomes, and the more time (less efficiency) it will take to complete the work.

Contingency Analysis

By now we have confirmed that we are currently behind schedule and over budget. We have also begun to question whether our "LRE" is a valid assessment. However, our analysis has all been at the Performance Measurement Baseline. It is now time to look at the Total Project Cost level and access how healthy our Contingency is and whether it is sufficient to cover our problems. Therefore, our next analysis will be to look at the contingency we have on the project (Section 6.7).

Our Format 1 report example does not show the Contingency information, however, it will be available on the standard CPR Format 1 reports. We will be examining two numbers:

- The Original Baseline Contingency which is $20,829
- The BAC Remaining Contingency as of December which is $11,982

The first review will be to determine the percent of BAC Contingency remaining:

- %C Remain. = (C $ Remaining / Original Baseline C $) x 100
  = (11,982 / 20,829) x 100 = 58%

You will recall the project is 28% complete and we have used 42% (100% - 58%) of our Contingency. Another way to look at it is we have 72% of the work scope to complete with only 58% of the Contingency. Obviously both of these comparisons are cause for concern, but a review of the remaining risks will add intelligence to these statistical comparisons.

The next analysis will look at what percent the contingency is of the to-go BAC PMB.

- %C To-Go$_{(BAC)}$ = (C $ Remaining / PMB$_{(BAC)}$ $ To-Go) x 100
  = (11,982 / 188,916) x 100 = 6%

  When the original estimate was established, the $20,829 contingency was equal to 10% of the PMB versus a current 6%. However, keep in mind the BAC contingency number may be higher than what is actually available because performance issues can not be change controlled into the PMB but must be covered in "funding" space. Therefore, reviewing the LRE contingency is necessary. The LRE remaining contingency dollars as of December is $10,460.

- %C To-Go$_{(LRE)}$ = ($ Remaining / PMB$_{(LRE)}$ $ To-Go) x 100
  = (10,460 / 190,438) x 100 = 5%

Again we see a to go contingency percentage considerably low for 72% of the work scope remaining.

<u>Assessing the EAC, FAC (or LRE):</u>
So far in our analysis we have seen reason to question the validity of the LRE. In Section 9 we discussed ways to prepare a statistically calculated FAC as a sanity check against the formal FAC. Let us now look at these calculations in comparison to the FAC/LRE in the CPR Format 1 Report. You will recall the LRE$_{(PMB)}$ in the most current report (December) is $281,960.

The first formula assumes that the efficiency with which the work will be done will continue at the cumulative to-date performance. The second formula utilizes the current period performance. It is important to balance your analysis by looking at both techniques.

- Calculated FAC = BAC$_{(PMB)}$ / CPI$_{(cum)}$ = 280,438 / 0.862 = 325,334
- Calculated FAC = ACWP + (BAC$_{(PMB)}$ - BCWP / CPI$_{(cur)}$) =
  91,522 + (280,438 – 78,875 / .968) = 299,748

It may be more realistic to modify the CPI by using a 6 month moving average of the cumulative to-date CPI. This can be approached as a 6-Month CPI Moving average or a Weighted 6-Month CPI Moving average. The two methods of calculating these "average" CPI's is demonstrated in the charts below:

6 – Month CPI Moving Average			
Mo.	Cum CPI	Weight	Average
J	.866	1	
A	.859	1	
S	.835	1	
O	.835	1	
N	.843	1	
D	.862	1	
Total	5.10	6	5.10 / 6 = .850

Weighted 6- Month CPI Moving Average			
Mo.	Cum CPI	Weight	Weighted Average
J	.866	1	.866
A	.859	2	1.718
S	.835	3	2.505
O	.835	4	3.340
N	.843	5	4.215
D	.862	6	5.172
Total		21	17.816 / 21 = .848

Using the above CPI numbers we will now calculate the FAC:

- Calculated FAC = ACWP + (BAC$_{(PMB)}$ - BCWP / CPI$_{(aver)}$) =
  91,522 + ((280,438 – 78,875) / .850) = 328,655

- Calculated FAC = ACWP + (BAC$_{(PMB)}$ - BCWP / CPI$_{(weighted\ aver)}$)
  91,522 + ((280,438 – 78,875) / .848) = 329,214

We used four different methods of utilizing historical information to calculate the FAC, all of which have indicated the FAC should be higher than the current LRE. The comparisons are as follows (all are at the PMB level):

Current LRE:	$281,960
Calculated FAC Method 1:	$325,334
Calculated FAC Method 2:	$299,748
Calculated FAC Method 3:	$328,655
Calculated FAC Method 4:	$329,214

Comparing the "worst case", Method 4 to the BAC ($280,438) we see we would need an additional $48,776 (329,214 – 280,438). This additional $49,000 (rounded) is greater than the available BAC contingency of $11,982, indicating a review of the entire project utilizing a more structured bottom-up EAC approach may be necessary.

Conclusion:
The calculations we have demonstrated at the project level can also be used against the control accounts to determine which control account LREs are suspect. You will recall earlier in the analysis we identified three CA that have exceeded the variance reporting requirements:

Major Equipment
Installation
System Testing

The PCE should review the CPR Format 5 – Explanations and Problem Analyses Report prepared by the CAM to see if their explanations of the problems support a recovery strategy that helps to validate their current LRE. If the conclusion is no, then the CAM needs to work with the PCE to re-evaluate the LRE so the Project Manager can have better information on which to base any decisions or corrective action plans.