A Program Manager's Guide to Reliable Subcontractor Reporting

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***Abstract*— Prime Government contractors execute work with significant subcontractor content. The use of discrete earned value performance measurement can be difficult and time consuming. In response, contractors may choose to utilize simpler earned value methods for subcontractor performance reporting such as Level of Effort or Percent of Estimate at Complete (EAC). However erroneous reporting of progress can result from using such methods. Shortcomings of LOE include no schedule status because the the true value of work accomplished is not reported. LOE data only reflects how much and how quickly money is being spent. Percent of Estimate at Complete provides schedule variances, but variances may not be a true reflection of schedule and cost status. The method is unreliable because it uses expenditures as a percentage of EAC as a means of measuring work accomplished such as budget cost of work performed. It only works if the subcontractor's EAC spent is equal to true percent complete. Using discrete earned value best practices provides Prime contractors and Government agencies realistic subcontractor performance that can provide objective forecast performance to identify emerging issues and develop corrective actions before significantly impacting the performance measurement baseline (PMB). This paper investigates how to implement low risk discrete earned value techniques to promote reliable and effective subcontractor reporting.**

TABLE OF CONTENTS

1. INTRODUCTION

Prime Government contractors execute work with significant subcontractor content. Figure 1 presents a context diagram showing the notional magnitude. Reporting objective performance measurement is sometimes difficult due to the lag in subcontractor reporting to the Prime, which must incorporate the data for reporting the Government. The result is "aged" subcontractor progress, which can mask potential issues and compromise forecasting accuracy. Erroneous progress can result from the method type such as *Level of Effort* (LOE) or percent spent of EAC. While an objective, discrete earning method provides more realistic reporting and forecasting results. Shortcomings of LOE include no schedule status or measurement of how much work is completed. The data only reflects how much and quickly budget is spent. *Percent of Estimate at Complete* (PEAC) is better than LOE because it provides schedule variances. However, the variances may not be a reliable indicator of actual schedule and cost status. PEAC is unreliable because

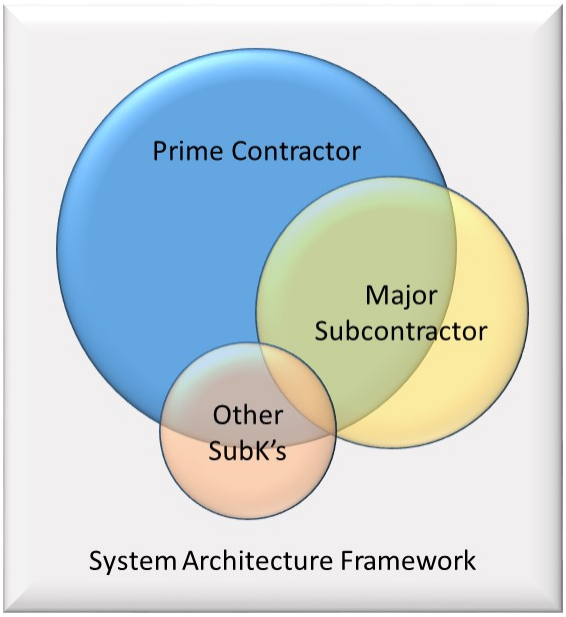


Figure 1- Major Subcontractors affect Prime contractor performance reporting based method.

it is based on the dubious premise that the budgeted cost of work performed (BCWP)[1] can be calculated based on the ratio of actual cost of work performed (ACWP) to EAC. Similar to the shortcomings of LOE, it may only reflect how quickly budget is spent, not what discrete work is completed. It is limited in that it only reflects true performance status if the subcontractor's PEAC spent is equal to true discrete percent complete. [1]

Table 1 – DoD 5000 MDAP and MAIS Thresholds

	Values (BY 2018)			
ACAT Level	**MDAP**	**Phase**	**MAIS**	**Phase**
ACAT I, ACAT 1A	$509M	RDT&E	$42M	All Increments
	$2.96B	Procurement	$175M	All Expenditures
			$551M	All Expenditures, Increments Life-cycle
ACAT II	$196M	RDT&E		
	$885M	Procurement		
ACAT III	N/A	Does not meet ACAT II or Above	N/A	AIS that is not MAIS

Using *Discrete* earned value best practices provides Prime contractors and Government agencies with a realistic means of evaluating subcontractor performance. It offers objective reporting of work scope completed which can help to identify emerging issues and develop corrective actions. This paper investigates how to implement low risk discrete earned value techniques to promote reliable and effective subcontractor reporting. We discuss three measurement methods and characteristics, then compare and contrast them. A process for repeatable results is provided. We show an example that can result in different conclusions or actions then summarize and discuss future work.

2. BACKGROUND

As programs are developed and executed they follow the DoD 5000 acquisition model for Major Defense Acquisition Programs (MDAPs) and Major Automated Information Systems (MAIS). [2] During program execution processes, tools and resources are applicable to all life-cycle phases. Recent DoD 5000 updates identify Acquisition Category (ACAT) I – III program metrics and Earned Value Management (EVM) threshold requirements for application during program execution. [3] Table 1 summarizes the threshold values for ACAT MDAPs and MAISs. Specific management guidance – "EVM is one of DoD's and industry's most powerful program planning and management tools. Its use is in conjunction with … discrete work scope. The purpose of EVM is to ensure sound planning and resourcing of all tasks required for contract performance including flow down to major Prime subcontractors." [4] Table 2 shows thresholds that require EVM use. Most MDAPs exceed the $100M threshold and require EVM. Some MAIS will required it. These thresholds also apply to subcontractors. As the table shows, EVM is optional for contracts valued at less than $20M, "but may be applied based on risk to the Government.

When EVM need is established, ANSI/EIA-748 "Earned Value Management Systems" requirements are mandated to track and execute programs. [5] Program management control and effectiveness is driven by the established Thirty-Two EVM guidelines. Additionally, the National Defense Industrial Association (NDIA) has published an intent guide to help managers understand how to implement and track program performance. [6] Utilizing EVM requires establishing and maintaining a PMB with appropriate Management Reserve (MR). The PMB is the total time-phased budget for the program. It is the plan for

Table 2 – DoD 5000 EVM Threshold Values

Contract Value	Applicability	Notes
< $20M	EVM not required; may be applied at PM discretion based on risk to the Government	Requires business case analysis and MDA approval
>= $20M to <$100M	EVM Required; contractor is required to have an EVM system (EVMS) that complies with the guidelines in EIA-748*	The Government reserves the right to review a contractor's EVMS when deemed necessary to verify compliance
>= $100M	EVM Required; contractor is required to have an EVMS that has been determined to be in compliance with the guidelines in EIA-748*	The Contractor will provide access to all pertinent records and data requested by the Contracting Officer or duly authorized representative as necessary to permit initial and ongoing Government compliance reviews to ensure that the EVMS complies, and continues to comply, with the guidelines in EIA-748*.

[1] Budget Cost of Work Performed (BCWP) is also referred to Earned Value (EV) is a measure of work performed expressed in terms of the budget authorized for that work. It is the budget associated with the authorized work that has been completed. The EV being measured needs to be related to the PMB and cannot be greater than the authorized BCWS for a component.

expenditure of all organizational resources necessary to meet overall program scope and schedule objectives including Prime, subcontractors and suppliers. [7] Similarly, Management Reserve "is held for unexpected growth within the currently authorized work scope… risk handling and other program unknowns. Generally, reserve is held for current and future needs…" [8]

Following development of the Prime contractor PMB program execution begins collecting performance measurement data. Shortly thereafter, the team will conduct an integrated baseline review (IBR) to assess realism of the PMB based on initial artifacts. [9, 10] The purpose of the IBR evaluates four key elements of the PMB:

- That the PMB addresses the entire work scope
- The work is realistically and accurately scheduled
- Reducible and likely risks are addressed
- The proper amount and mix of resources are assigned

When assessing PMB realism, it has been observed, "A realistic PMB contributes directly to effective management of acquisition programs." [11] While not a "pass/fail" event an IBR provides common understanding of how work scope will be completed. This is also the time to select appropriate earned value techniques and set a proper ratio of level of effort versus discrete measurement.

Major subcontractors which trip the reporting thresholds shown in Table 2 will generally conduct a IBR that will flow up to one or more of the Prime's control accounts.

A dilemma related to major subcontractor work is whether to require discrete EVM. The perception may exist that it would be better to avoid the difficulty, complexity and additional effort by using simpler EVM methods such as level of effort or percentage of EAC Spent.

One example of difficulty with subcontractor EVM data is it may be one month behind the Prime contractor's report due to the lag in reporting. This is due to the subcontractor having its own internal reporting process that must be completed before the information can be reported to the Prime. The lag occurs because the subcontractor's data is not be delivered to the Prime in time for incorporation and reporting to the Government. This leads to earned value data "aging". The additional time and effort to measure and report discrete EVM may drive the one month delay compared to simpler methods. The result is that some data may reflect having made more or less progress than reported if the Prime incorporates the aged data it may not accurately represent current status reducing decision-making effectiveness. Alternatively, estimated actuals are sometimes used to normalize subcontractor progress and provide an estimate of ACWP, it is still not a true snapshot of progress due to the subjectiveness of the estimates.[2] [12] This difficulty due to the lag in reporting will be addressed with a recommended work-around solution later in this paper.

As mentioned, Prime contractors may opt to avoid imposing the discrete EVM requirement on subcontractors to avoid the additional work, complexity and difficulty. There could be perception that discrete EVM is not worth the effort and that subcontractor performance will not impact the prime's overall performance. Two potential simpler alternative performance measurement methods are LOE and PEAC. The next two sections compare and describe the characteristics of LOE, PEAC and discrete EVM methods showing the pros and cons of each to allow the program manager an opportunity to choose the best approach for their program.

3. COMMON PRACTICE

Apart from discrete EVM the two most common methods Prime contractors use to take earned value for a subcontractor are LOE and PEAC. The following subsections describe the characteristics of both.

Level of Effort:

The LOE method is for work having no measurable output or product that can be discretely planned at the work package level. [13] The reference states; "Level of effort must be limited to those activities that are unable to be measured discretely to avoid distorting project performance data." As mentioned in the prior section, subcontract cost is often reported as a material charge from the accounting system with no discrete performance metrics. In this case, LOE may be used for performance measurement. The reporting by the Prime of subcontractor performance as LOE may reflect the fact that the subcontractor is either not managing their work using an earned value management system or subcontractor EVM data is not being reported due to other factors (e.g. the reporting time lag issue already mentioned).

A key characteristic of LOE is that BCWP is always made equal to BCWS, eliminating a schedule variance. As time passes, performance is earned. The data will always indicate that the subcontractor is on schedule.

[2] From NDIA Intent Guide: Guideline 21 – Track and Report Material Costs and Quantities, Pg 33, "When necessary and significant, and when material actuals are not yet available, the use of estimated Actual Cost of Work Performed (ACWP) is required to ensure accurate performance measurement."

Actual cost incurred is either invoiced to date or estimated actuals. In the case of invoiced to date, with a lag of one reporting period, the sub-contractor performance will not accurately reflect true cost. A better approach in this case is to use invoices to date plus estimated actuals for the current month. This will more accurately reflect actual cost of work performed. Figure 2 illustrates subcontractor performance using LOE. This method shows the schedule performance is on track with a slight over budget position. Actual performance using the discrete method is much worse. Since BCWP is always equal to BCWS, it may not accurately reflect true progress.

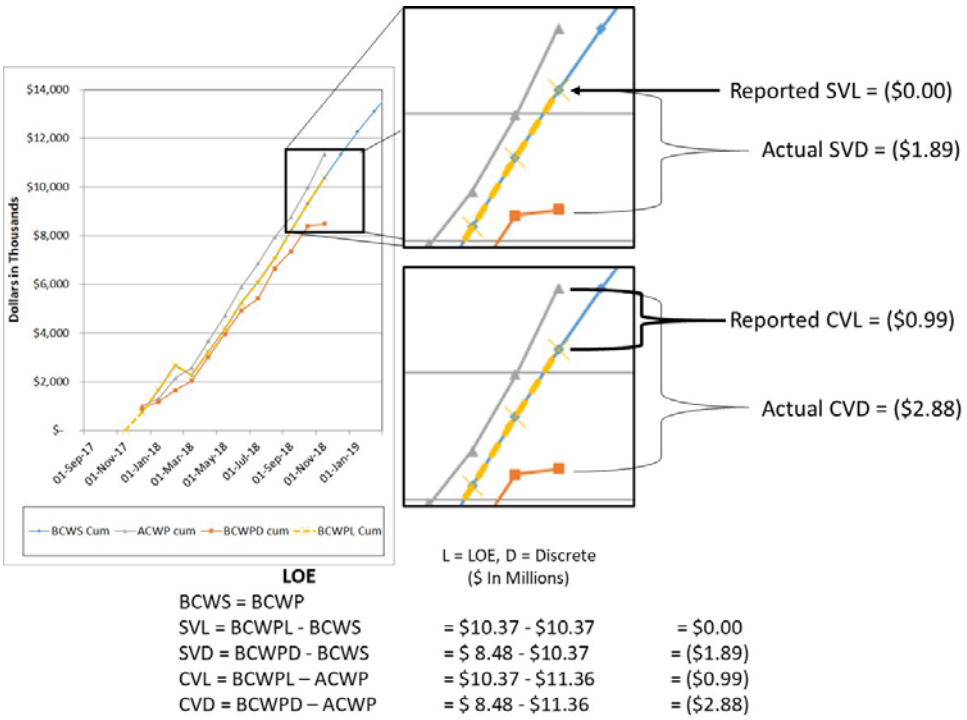


Figure 2 - LOE reporting inconsistency with discrete reporting

If the true actual BCWP is lower than what is reported using LOE, it may hide unfavorable schedule and cost performance.

Percent of EAC:

The use of the PEAC method may also reflect the fact that the subcontractor is either not managing their work using an earned value management system or the subcontractor EVM data is not reported due to the time lags previously mentioned.

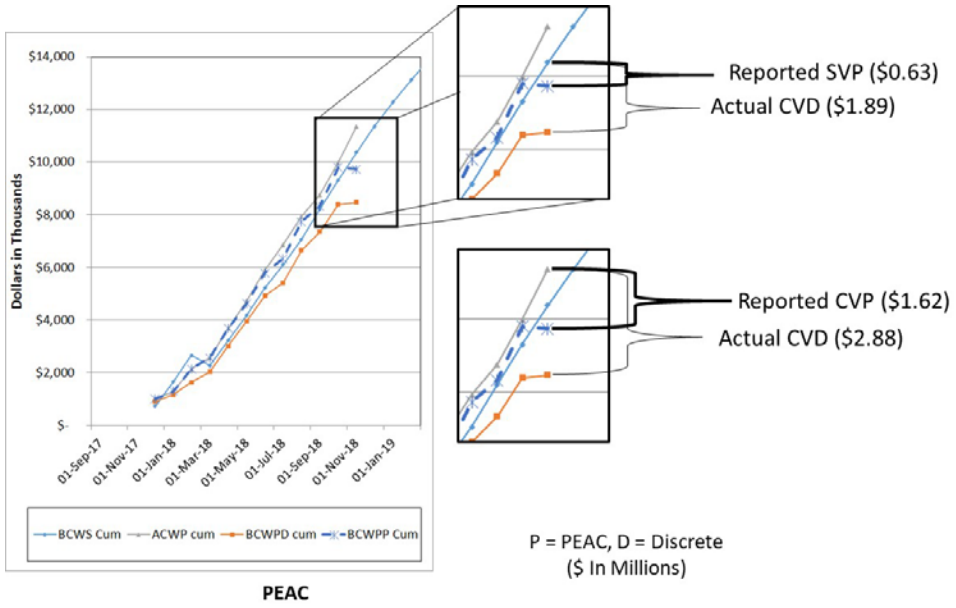
Equation 1 – Percent of EAC spent provides the following relationship.

$$\text{Cumulative BCWP} = \frac{\text{Cumulative ACWP}}{\text{Estimate at Complete}} \times \text{BAC}$$

The key to the PEAC method is how progress (BCWP) is determined. As actual cost (ACWP) is incurred, it is used as a proxy for performance (BCWP) whereby performance is determined on the basis of actual cost spent as a percentage of the estimate at completion (EAC). That percentage is applied to total budget BAC to generate cumulated BCWP. Monthly BCWP will then equal the difference between the cumulative BCWP for the current month and the cumulative BCWP for the prior month. ACWP may be based on cost recorded in the Prime's accounting system (payments made to the subcontractor) or based on estimated actuals. Equation 1 illustrates how cumulative BCWP is calculated using the PEAC method. PEAC assumes progress is made in lock step as resources are applied and cost is incurred, relative to the EAC. The dynamics of this method dictate that as expenditures (ACWP) accelerate or "run hot", and EAC remains constant or declines, more credit for progress (BCWP) is taken. Conversely, as expenditures (ACWP) decrease, and EAC remains constant or increases, less credit for progress (BCWP) is taken. In either case it may not accurately represent true progress. Figure 3 illustrates a situation where costs are "running hot" and performance is taken based on the expenditures while actual performance is significantly less.

4. Discrete Practice

Using a well-structured, objective and discrete earned value methodology has proven to provide Prime contractors and Government agencies with high quality forecasting information during program execution of subcontractor data. NDIA EVM application guide states "EVM is an effective integrator of the work scope, schedule, resources, and risk that should be applied consistent with the program type, complexity, and size."



PEAC

BCWS = BCWP		
SVP = BCWPP - BCWS	= $9.74 - $10.37	= ($0.63)
SVD = BCWPD - BCWS	= $ 8.48 - $10.37	= ($1.89)
CVP = BCWPP – ACWP	= $9.74 - $11.36	= ($1.62)
CVD = BCWPD – ACWP	= $ 8.48 - $11.36	= ($2.88)

Figure 3 - PEAC reporting inconsistency with discrete methods

[14] Discrete earned value applied to subcontracts supports overall program control at the Prime level.

Discrete Earned Value

Discrete effort applies directly to specific work efforts that trace to and identify with the ultimate completion of the project-related work products within the work breakdown structure components as well as specific deliverables. [15] To accomplish this, establishing well planned baseline budget plans BCWS with objective progress metrics is required. Prime contractors receive this budget data from the subcontractor based on their expectation of cost incurred over time. For example, completion of the sub-system requirements specification or integrated test plan, each with a discrete "value" (in hours or dollars). This practice would indicate the subcontractor is managing their work using an objective earned value management system.

Subcontractors are required to use an earned value management system if their contract value is greater than $20M (FAR Subpart 234.2). See Table 2 for a description of the requirement to use an Earned Value Management System based on the FAR. Once the requirement to use an earned value management system is established, it will likely be levied on a subcontractor by the Prime based on contract flow down clauses. For work valued at less than $20M or if the work is thought to be high risk or critical to the success of the contract, then EVM may still be required for the subcontractor.

When implementing EVM, data reported to the Prime contractor by the subcontractor in their integrated program management report (IPMR) can provide accurate metrics. That data in turn is rolled up into the Prime contractor's IPMR to provide visibility into the subcontractor's performance and as a part of comprehensive Prime metrics. In some cases, as mentioned previously, EVM data from the subcontractor is not received in time for incorporation into Prime contractor's reporting to the government. This may drive the Prime contractor to believe they must rely on the LOE or PEAC methods as a surrogate. To avoid reverting to these suboptimal methods the process below can be used to estimate actual performance and be used as a "work around" when late reporting from the subcontractor is a reality:

First, assess the critical data missing from the monthly BCWP and ACWP and other available data. Second, generate estimates for these items. They can be developed and used on an interim basis until real BCWP and ACWP for the subcontractor is provided.

To generate the estimate of BCWP, an estimate of SPI can be used. To do so, choose the SPI metric perceived to be the most accurate predictor of schedule performance efficiency for the month. Here are some options:

- 3 month moving average SPI (recent performance)
- 6 month moving average SPI (longer term recent performance)
- Cumulative SPI (inception to date performance)
- SPI not based on historical performance, but on judgement and understanding of expected schedule performance or efficiency for the month.

The estimated SPI is then applied as a factor to the current month BCWS yielding an estimate of current month BCWP. BCWP estimation formula as presented in Equation 2:

Equation 2 – BCWP based on SPI and Plan

Current month BCWP estimate =
Forecast SPI X Current month BCWS

For ACWP, an estimate is made of the monthly CPI to do so, choose the CPI metric perceived to be the most accurate predictor of cost performance efficiency for the month. Options may include:

- 3 month average CPI
- 6 month average CPI
- Cumulative CPI
- CPI not based on historical performance, but on judgement and understanding of expected cost performance or efficiency.

The estimated CPI can then be applied as a factor to the BCWP estimated above to provide an estimate of ACWP. The formula for calculation is shown in Equation 3 below:

Equation 3 – ACWP based on CPI and Historical Performance

Current month ACWP estimate =
Forecast CPI X Current month BCWP estimate

Another option for estimating ACWP is to base it on invoices received from the subcontractor during the month. In the ideal case, invoices received would cover the time through the earned value reporting period. A potential ACWP variance can occur from subcontractor earned value reporting based on estimated actuals for material, whereas actual invoicing would reflect value of the subcontractor's payments to their suppliers. Another reason for a variance, albeit small, could be the difference between subcontractor's booking and billing burden rates.

In the following month, when the real subcontractor BCWP and ACWP data is reported, it is compared to the Prime's estimate. If there are differences, corrections to the estimates are needed. The corrections should be made as adjustments in the subsequent month. The advantage of making adjustments in the subsequent month is that it avoids making changes to earned value history.

A benefit from using the discrete method is it helps a program manager limit the LOE at program phases and

Table 3 – Maximum Percent LOE Targets in Detail Planned PMB to support objective project progress

Pre-PDR	PRE-CDR	Post-CDR
30%	20%	15%

maximize objective progress measurement. Table 3 shows targets for LOE for three typical program phases. [16]

Though estimated current month EV data may not be 100% accurate, the earned value data for cumulative performance will, over time improve in accuracy and reliability because as time elapses, the value of the estimated current month data as a percentage of the cumulative data will decrease.

There is another option for working around the problem of late reporting from a subcontractor. This option is not recommended. The process would be to report last month's performance by the subcontractor in the prime's current month. To do this, the baseline for the subcontractor has to be shifted one month forward in the prime's baseline. For example, in order for January subcontractor

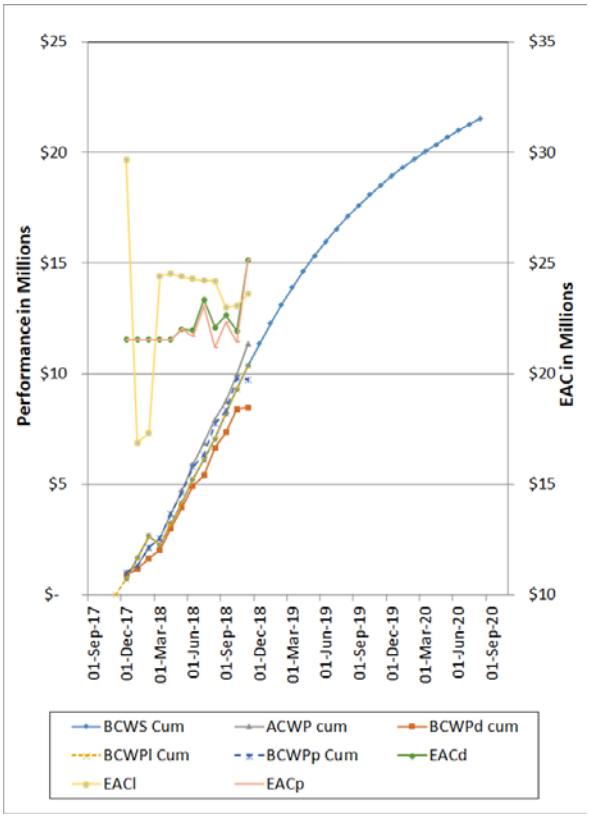


Figure 4 – Comparison of performance techniques and estimate at completion for the subcontract produces conflicting results

performance to be reported by the prime in February, the subcontractor's budget (BCWS) for January must be in the Prime's budget (BCWS) for February. The problem with this practice is it misrepresents of the underlying schedule for the budget baseline. That is, in the prime's reporting, subcontractor work scheduled for completion in January is represented as a requirement for completion in February.

5. COMPARE AND CONTRAST

Thus far, we have discussed three methods a Prime contractor may use to measure progress of a major subcontractor. This section combines them emphasizing the impact of each. Figure 4 is a plot of the subcontractor performance over time showing the traditional performance of BCWS, ACWP, and BCWP for the three methods of LOE, PEAC and discrete. In addition, the forecast EAC using metrics developed for each method is shown. When integrating the three methods into one chart, it is clear that each has advantages and shortcomings when forecasting performance.

LOE disadvantages:

LOE is appropriate when work content is not measurable, however, when LOE is used for the sake of ease and convenience, performance measurement can be inadequate. If the contractor is actually performing discrete work, the BCWP reported using LOE may not reflect true progress because the LOE method sets BCWP equal to BCWS. This can result in the masking of unfavorable schedule and cost performance. The value of performance data will be limited, as it will only reflect whether actual expenditures are over or under the baseline plan (BCWS). There is no visibility into what work scope has been accomplished.

LOE advantages:

LOE is the simplest and easiest to implement and manage. When actuals are received, a review of the data will show any cost variances. This is perhaps permissible for use on small value subcontracts that are not program critical, but is not recommended for key subcontractors or critical, high-risk purchases.

Percent Spent of EAC disadvantages:

For the PEAC method, BCWP is determined as the product of applying the percentage of EAC spent to the BAC (Budget at Complete). However, this may not be an accurate representation of true progress. These inaccuracies can stem from BCWP that is simply calculated as a percentage of EAC spent. It assumes progress should be taken as cost is incurred, as a percentage of the EAC.

Percentage spent of EAC only reports you how quickly money is being spent. It does not report how much work scope is truly being completed. This method is based on the potentially fallacious assumption that work is accomplished as cost is incurred relative to, or as a percentage of EAC. This method can produce erroneous data when cost is incurred, but progress is delayed due to factors such as inefficiency, rework and re-design. If this occurs without a commensurate increase in EAC, it can lead to misleading reporting. In order for the PEAC method to forecast accurate BCWP, the percent spent of EAC must equal true percent complete.

Percent Spent of EAC advantages:

Out of three methods, this one ranks second in terms of ease to implement and manage. This method makes an attempt to report objective progress (BCWP) so it can provide an assessment of performance that is better than the LOE method. Perhaps permissible for use for small value subcontracts that are not critical to program

Discrete Earned Value disadvantages

When compared to LOE and Percent Spent of EAC methods, the Discrete earned value method requires more work, judgement and thought because the requirement to develop and spread work scope and define discrete progress methods are more in-depth and structured. If an execution plan is not developed with consistency between with the Prime contractor and subcontractor, erroneous variances occur. Estimates of current month BCWP and ACWP will not be consistent in progress reporting leading to the Prime making adjustments or manual entries to cost management software tools (e.g. MPM or COBRA) that attempt to provide more realistic subcontractor performance in an attempt to correct the mismatch problem.

The additional time effort required to report using discrete EVM can drive a one month delay in reporting to the prime. This can offset overall Prime performance and can be a critical factor on cost reimbursable (CPFF, CPIF, etc.) contracts. The reporting delay may drive the requirement for the development of time consuming work arounds. These work arounds may produce inaccurate estimates of performance.

Discrete Earned Value advantages:

When a well thought out discrete subcontract PMB is developed, an accurate assessment of cost and schedule status can be realized when compared to status provided by LOE and PEAC methods. The importance of having accurate assessment of subcontractor true cost and schedule status should not be overlooked because when

subcontractor content is significant, it can skew total Prime performance.

Moreover, using discrete methods that follow ANSI/EIA-748-B, page 3, section 2.2e, guidance which states, "To the extent it is practicable to identify the authorized work in discrete work packages, establish budgets for this work in terms of dollars, hours, or the measurable units." [17] This supports the Prime contractor's objective and realistic reporting when flowed up from the subcontractor.

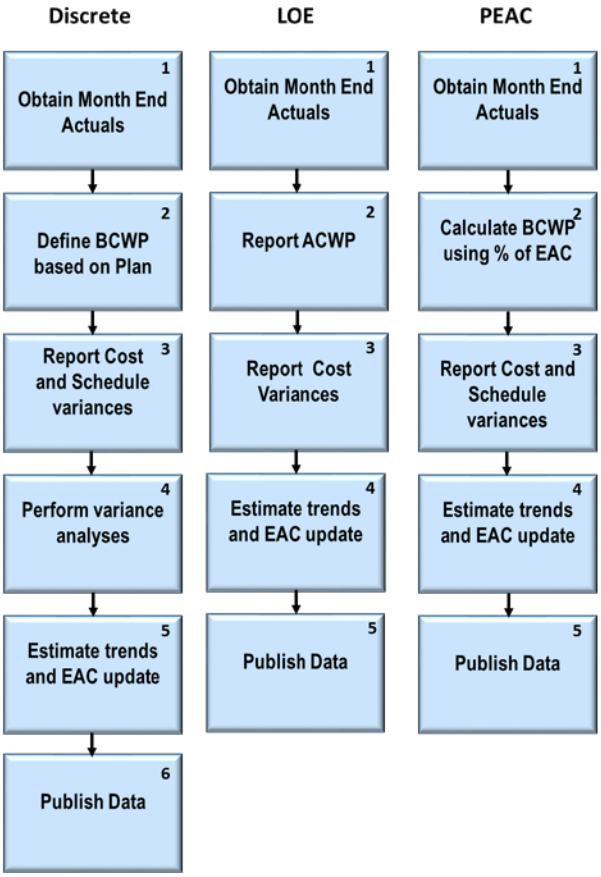


Figure 5 – Comparison of the three methods processes.

6. PROCESS

The processes for each method are shown in Figure 6. Taking key subcontractor performance measurements independent of earnings method contain a minimum of four basic steps. Common are A) obtaining month end actuals, B) taking performance, C) reporting variances and D) publishing findings. The results are integrated into the Prime reports. The following subsections describe differences of each reporting method within each process.

Discrete

Following validation of month end actuals, taking discrete performance to a prescribed plan is done. These are objective progress measurements that are tied to completion of specific work scope. Next performing an assessment of control account variances is completed. If thresholds are "tripped" and explanation is required to identify the problem, assess the impact and discuss corrective actions. The result is a complete record of performance deviations.

LOE

LOE is the simplest approach to performance measurement with the least fidelity. Month end actuals are validated and compared to the budget. The control account is under, over or on budgeted cost. There is no schedule variance.

PEAC

PEAC provides some performance data. Using the newly reported ACWP, the percentage spent of EAC is determined. This percentage is applied to the Budget at Complete (BAC) to generate the update of BCWP. In addition, a Schedule and cost variances are produced. Trends are monitored for assessing corrective action when variance reporting thresholds are "tripped".

Table 4 – Performance Method Comparisons showing reporting metrics of each.

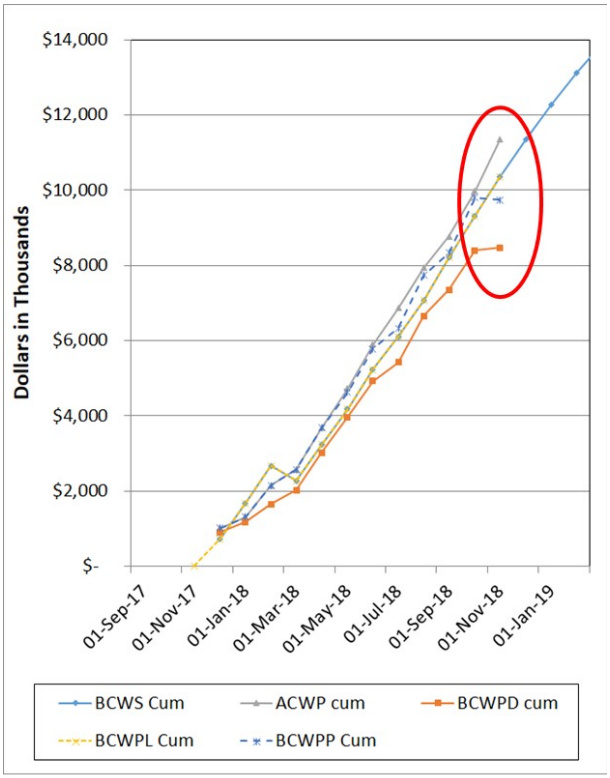
	Performance Measurement Methods $(000)		
	Discrete	Level of Effort	Percent of EAC
BCWS	$ 10,370	$ 10,370	$ 10,370
BCWP	$ 8,477	$ 10,370	$ 9,737
ACWP	$ 11,360	$ 11,360	$ 11,360
SV	$ (1,892)	$ -	$ (633)
CV	$ (2,882)	$ (990)	$ (1,623)
SV%	-22%	0%	-6%
CV%	-28%	-10%	-16%
BAC	$ 21,540	$ 21,540	$ 21,540
SubK EAC	$ 25,130	$ 25,130	$ 25,130
VAC	$ (3,590)	$ (3,590)	$ (3,590)
% of EAC Spent	45%	45%	45%
% Complete	39%	48%	45%
CUM SPI	0.82	1.00	0.94
CUM CPI	0.75	0.91	0.86
TCPI	0.95	0.91	0.86
IEAC	$ 28,863	$ 23,596	$ 25,130
IEAC VAC	$ (7,323)	$ (2,057)	$ (3,590)

All three methods require reporting metrics and publishing a report that is flowed up to the Prime contractor for integration into their report.

7. Example and Analysis

Overview

The following example provides performance of a major subcontractor within the framework of the Prime contractor. In this case, the Prime contract has a Budget at completion of $100M. The Major subcontractor BAC is a major portion the total at $21.5M or 22%. As we walk through the example and show the differences in earnings methods, we summarize the impact it can have on the Prime contractor reporting to the Government.



L = LOE, P = PEAC, D = Discrete

Figure 6 –Earning techniques differences provide confusing conclusions

Reporting Impact

The data in Table 4 is based on subcontractor EVM data for a realistic program. It is graphically illustrated in Figure 5. The discrete method shows the true performance by the subcontractor. The subcontractor was experiencing technical challenges, which drove down its efficiency producing cumulative behind schedule and cost over-run positions. The real status is reflected in the Discrete Performance Measurement Method which shows the subcontractor is behind schedule (negative schedule variance of -$1,892K) and is over-run on cost to date (negative cost variance of -$2,882K). The table also shows performance measurements using the using Level of Effort and Percent of EAC as well. Performance based on each method have provided different results which will be described below.

The *LOE* method, of course, shows no schedule variance. The cost variance is only -$990K which is significantly less than true cost variance of -$2,882K produced by the discrete method. LOE overstates work completed (BCWP) by the subcontractor due to the fact it assumes what has been planned has also been completed (i.e. BCWP = BCWS). This highlights the fact that for this subcontractor, LOE is an inappropriate method because the nature of the work is discrete, measurable and a significant portion of the Prime effort.

The PEAC method incorrectly yields a relatively minor negative schedule variance of -$633K compared to the true schedule variance of -$1,892K. This is because the PEAC method overstates work being completed (BCWP) based on the assumption that work is accomplished commensurate with actual expenditures as a percentage of the EAC. This overstatement of BCWP also produces a cost variance of -$1,623K, which is 40% lower than the true cost variance of -$2,882K.

In order for the PEAC method to properly reflect performance, the EAC must be increased by $3,733K to make it equal to the IEAC of $28,863K (IEAC = BAC/Cum CPI). The increase in the EAC drives the cumulative BCWP down to make it equal to true BCWP reflected in the discrete method. At this point, Percent Spent is equal to true Percent Complete. Equation 4 shows the calculation of cumulative BCWP with the adjustment required to EAC that brings in the Percent of EAC in line with true performance.

Equation 4 – Required adjustment of EAC to align with true discrete BCWP

$$\$8{,}477 \text{ (BCWP Cum)} = \frac{\$11{,}360 \text{ (ACWP)}}{\$21{,}540 + \$3{,}733 \text{ (SubK EAC w/Update)}} \times \$21{,}540 \text{ (BAC)}$$

It is noteworthy that in this example, for the PEAC to be accurate, the EAC may have to be adjusted in a way that may overstate the EAC in the order to produce correct schedule and cost variances.

The *Discrete* method produces a true picture of performance. For this example, the subcontractor's performance shows behind schedule and over cost

positions that were either not evident or were understated using the LOE and PEAC methods.

Equation 5 – PEAC BCWP method

$$BCWP = \frac{ACWP}{EAC} \text{ X } BAC$$

Impact to Variance reporting:

It is notable that if the cumulative variance reporting thresholds for the program are 10% or greater, none of the cumulative schedule and cost variances for the LOE and PEAC methods would be reported. This means that although the Discrete method shows the true schedule and cost variances to be unfavorable at -22% and -28% respectively, the LOE and Percent Spent of EAC methods would require no variance explanations for LOE and only a cost variance for PEAC.

Impact to estimate at complete analysis:

Impacts to Estimates at Complete are realized by misrepresentations of performance generated by the LOE and PEAC methods. This is reflected in the TCPIs for the three methods. The TCPI for LOE and PEAC methods are lower than for discrete. LOE and PEAC are 0.04 and 0.09 points respectively lower than the discrete TCPI which should generate some concern. The TCPI for the PEAC is equal to the cumulative CPI, setting off no alarm. The two are naturally equal because the BCWP is calculated based on the ratio of actuals spent to EAC. This is reflected in Equation 5. To reinforce this concept, Equation 6 provides the proof showing the basic CPI calculation, then substituting the PEAC BCWP with its fundamental inputs and reducing term, the result is the ratio of BAC to EACP. The true performance represented in the discrete method has a TCPI at 0.95 based on the EAC reported by the subcontractor. This is likely unachievable based on the true cumulative CPI of 0.75.

Equation 6 – CPI calculation with BCWP for PEAC substituted showing TCPI relationship

$$CPI = \frac{BCWP}{ACWP} = \frac{\frac{\cancel{ACWP}}{EAC} \text{X } BAC}{\cancel{ACWP}} = \frac{BAC}{EAC}$$

Distortion of the CPI and the TCPI is significant and is manifested and quantified in the Indicated Estimates at Complete (IEACs) as shown in Table 4. Based on performance to date indicated in the discrete method, the IEAC should be $28,863K. This is $5,266K (61%) higher than the LOE method and $3,733K (51%) higher than the PEAC method.

Integrated Solution Context

Thus far, our discussion has addressed how three key earned value methods of a major subcontractor performance can provide different actions depending on the method used. Here we compare and show the impact of the Prime EVM performance when the subcontractor data is integrated. Returning back to the Prime contractor and content of the major sub contractor; data presented in Table 5 provides a summary of the impact of each subcontractor method to the Prime performance reporting.

Table 5 – Compare and contrast Prime and Subcontractor performance outcomes

Prime Contract Impact of Subcontractor Earned Value Methods				
(Thousands)	Prime/Sub Content	Sub-Contractor	Sub Percent of Total	Prime Content Only
	A	B	C	D
BAC	$ 100,000	$ 21,540	21.5%	$ 78,460
BCWS	$ 59,800	$ 10,370	17.3%	$ 49,430
ACWP	$ 55,800	$ 11,360	20.4%	$ 44,440
BCWP Discrete (d)	$ 44,600	$ 8,477	19.0%	$ 36,123
BCWP LOE (l)	$ 59,800	$ 10,370	17.3%	$ 49,430
BCWP PEAC (p)	$ 55,800	$ 9,737	17.4%	$ 46,063
SVd	$ (15,200)	$ (1,892)	12.4%	$ (13,308)
SVl	$ -	$ -	N/A	$ -
SVp	$ (4,000)	$ (633)	15.8%	$ (3,367)
CVd	$ (11,200)	$ (2,882)	25.7%	$ (8,318)
CVl	$ 4,000	$ (990)	-24.8%	$ 4,990
CVp	$ -	$ (1,623)	N/A	$ 1,623
CUM SPId	0.75	0.82		0.73
CUM SPIl	1.00	1.00		1.00
CUM SPIp	0.93	0.94		0.93
CUM CPId	0.80	0.75		0.81
CUM CPIl	1.07	0.91		1.11
CUM CPIp	1.00	0.86		1.04
IEACd	$ 125,112	$ 28,863		$ 96,527
IEACl	$ 93,311	$ 23,596		$ 70,539
IEACp	$ 100,000	$ 25,130		$ 75,696
TCPId	0.80	0.75		0.81
TCPIl	1.07	0.91		1.11
TCPIp	1.00	0.86		1.04

The data in column “A” presents a solution that integrates the major subcontractor data. The IEAC calculation uses the aggregate performance metrics that “wash out” the individual element performance. When the Prime and subcontractor data are broken out separately, then combined in a discrete fashion, as shown in columns “B” and “D” the IEAC based on earning method provides significantly different outcomes. Table 6 illustrates the

range of outcomes the Prime may report is based on subcontractor performance methods. The column shows the Prime metrics using discrete earned value to the other methods. It has a range of $5.3 M. This can be significant when looking at Government appropriations, award fee calculations and other metric.

8. SUMMARY

Table 6 – Comparison of IEAC at the Prime level based on earned Value methods with supporting statistics

	Prime Discrete
Sub Discrete	$ 125,390
Sub LOE	$ 120,124
Sub PEAC	$ 121,657

It's up to every program manager to decide how to set up earned value methods for major subcontractor reporting. The effort required to develop discrete earned value reporting for subcontractors may be worth the additional effort required. We have shown, depending on the EV method, that actual subcontractor performance can provide misleading information that impacts the program manager's ability to make appropriate programmatic decisions. Additionally, Prime contract performance can be impacted in a significant way.

Therefore, there are good reasons to adopt the use of the discrete best practices and tracking of earned value performance for major subcontractors. Other methods of tracking or managing cost and schedule performance have significant potential liabilities in that they can unintentionally distort true performance. Those methods may compromise the "early warning system" provided by discrete earned value measurement processes and lead to the failure to identify potential serious damage to a program caused by the degradation in schedule or cost performance.

APPENDICES

A. EVM METHOD COMPARISONS

	Methods	Implementation Rank	Data Quality	Pros	Cons
1	LOE	Low	Low	• Simplest and easiest to implement and manage • Actuals quickly show cost variances • Common applications on small value subcontracts that are not program critical	• No status provided on how much work is accomplished • BCWP equal to BCWS, no schedule variance • May not accurately reflect status • Value of performance data limited. Only reflects that actual expenditures are over or under the baseline plan (BCWS) There is no visibility into what work scope has been accomplished • Not recommended for key subcontractors or critical, high-risk purchases.
2	PEAC	Med	Med	• Provides a schedule variance, • Accuracy may be questionable • Use for small value subcontracts that are not critical to program	• Estimate of BCWP based on actual or estimated actuals (ACWP) • May not represent true progress Inaccurate BCWP calculated as a percentage of EAC • Assumes progress taken as cost incurred • Only reports how quickly money is being spent • No insight as to how much work scope is completed • Progress may mislead as EAC changes
3	Discrete	High	High	• Discrete provides a fully resourced and scheduled plan • Provides objective performance measurements for completed work • Shows cost and schedule variances • More in-depth and structured reporting is possible • Can be easily integrated into Prime's EVM	• Is more time consuming and requires more thought than LOE or PEAC • Can contain "aged" reporting (one month or more) when reported by the Prime. • If aged data, Prime may estimate BCWP and ACWP • If an execution plan is not developed with consistency between with Prime reporting errors result

B. MCR's Triple Gold Card Excerpts

MCR's "TRIPLE" GOLD CARD©
MCR, LLC
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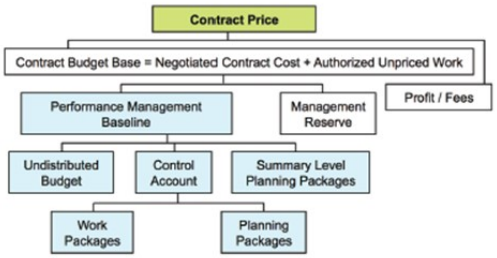
Establish the Performance Measurement Baseline

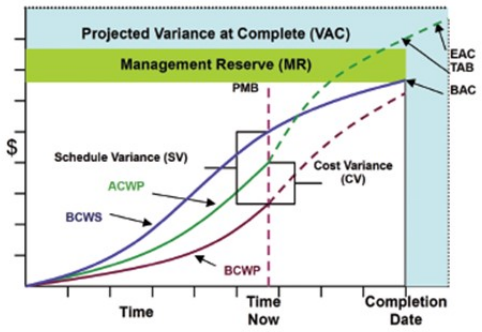


Accounting Considerations

- Record / reconcile costs with accounting system at the control account or lower
- Record and allocate indirect costs in accordance with established procedures
- Record costs for work performed in same period that earned value is measured

Analysis and Management Reports

Measure and Report Performance Monthly



Report the Data and Analyze the Variances

Variances – Favorable is Positive, Unfavorable is Negative

Cost Variance	CV = BCWP – ACWP	CV% = (CV / BCWP) * 100
Schedule Variance	SV = BCWP – BCWS	SV% = (SV / BCWS) * 100
Variance at Completion	VAC = BAC – EAC	

Performance Indices – Favorable is >1, Unfavorable is <1

Cost Efficiency	CPI = BCWP / ACWP
Schedule Efficiency	SPI = BCWP / BCWS

Overall Status

%Schedule	= (BCWS$_{CUM}$ / BAC) * 100
% Complete	= (BCWP$_{CUM}$ / BAC) * 100
% Spent	= (ACWP$_{CUM}$ / BAC) * 100

Estimate At Completion

EAC (LRE) = Actuals to Date + [(Remaining Work) / (Efficiency Factor)]

EAC$_{CPI}$ = ACWP$_{CUM}$ + [(BAC – BCWP$_{CUM}$) / CPI$_{CUM}$] = BAC / CPI

EAC$_{COMPOSITE}$ = ACWP$_{CUM}$ + [(BAC – BCWP$_{CUM}$) / (CPI$_{CUM}$ * SPI$_{CUM}$)]

To Complete Performance Index (TCPI)

TCPI = Work Remaining / Cost Remaining = BAC – BCWP$_{CUM}$) / (EAC – ACWP$_{CUM}$)

Variance Analysis

Variances that exceed thresholds must be analyzed and explanations provided: Problem, Root Cause, Impact, Corrective Action, and Get Well Date

Address: Poor Planning, Rate Variances, Technical Problems, Risks, Effect on Control Account, and Effect on Contract

Revisions and Data Maintenance

- Incorporate changes in a timely manner, prior or with start of effort
- Control retroactive changes and control revisions to the baseline

Glossary

ACWP - Actual Cost for Work Performed; Cost of work accomplished = ACTUAL COST (AC)
BCWP - Budgeted Cost of Work Performed; Value of work accomplished = EARNED VALUE (EV)
BCWS - Budgeted Cost of Work Scheduled; Value of work planned to accomplish = PLANNED VALUE (PV)
BAC - Budget at Completion; Total budget for total contract through any given level
CA - Control Account; Lowest CWBS element assigned to a single focal point to plan and control technical / cost / risk / schedule
CBB - Contract Budget Base; Sum of all work scope assigned to a designated contract
EAC - Estimate at Complete; The best estimate of the total cost at the completion of the program
LRE - Latest Revised Estimate; Contractor's EAC or EAC
MR - Management Reserve; Budget withheld by Ktr PM for unknowns / risk management
PMB - Performance Measurement Baseline; Program time-phased budget plan
PP - Planning Package; Far-term CA activities not yet defined into WPs
SLPP - Summary Level Planning Package; Far-term activities not yet defined into CAs
TAB - Total Allocated Budget; Sum of all budgets for work on contract = NCC, CBB, or OTB
TCPI - To Complete Performance Index; Efficiency needed from time now to achieve an EAC
UB - Undistributed Budget; Broadly defined activities not yet distributed to CAs
WP - Work Package; Near-term, detail-planned activities within a CA

References

Office of Management and Budget www.omb.gov
Circular A-11, Supplement to Part 7 – Capital Programming Guide

Federal Acquisition Regulations www.acquisition.gov/far/
52.234-2 Notice of EVM System - Pre-Award IBR.
52.234-3 Notice of EVM System - Post Award IBR
52.234-4 Earned Value Management System

Data Item Descriptions (DIDs) https://assist.dla.mil/

CWBS	DI-MGMT-81334
CPR	DI-MGMT-81466
IMS	DI-MGMT-81650
IPMR	DI-MGMT-81861

Guidance www.ansi.org www.gao.gov www.ndia.org/ipmd
ANSI/EIA-748 Earned Value Management Systems
GAO-09-3SP GAO Cost Estimating and Assessment Guide
Earned Value Management Systems Intent Guide
Earned Value Management Systems Application Guide

Planning, Scheduling and Budgeting

Planning, Scheduling and Budgeting

Plan the work by breaking the control accounts into work packages which can be "easily" executed.
Schedule the work using a Critical Path Methodology schedule.
Budget the work by assigning resources to the schedule elements.

Earned Value Techniques (suggested implementations)

- **A - Level of Effort** (Work that is impossible or impractical to measure)
- **B - Weighted Milestones** (At least one milestone per month)
- **C - Percent Complete** (Subjective estimate of performance; 3 – 6 months)
- **D - Units Complete** (Production lots; each item is assigned an equivalent cost)
- **E - 50/50** (Fixed formula 50% to start, 50% to finish; not more than 2 months)
- **F - 0/100** (Fixed formula 0% to start, 100% to finish; not more than 1 month)
- **G - 100/0** (Fixed formula 100% to start, 0% to finish; not more than 1 month)
- **H - User Defined** (User defined fixed formula; not more than 2 months)
- **I - Apportioned Effort** (Performance is based upon another control account)
- **J - Planning Package** (Future work that is planned at a high level)
- **K - BE% Complete** (Budget element percent complete; subjective estimate)
- **L - Calculated Apportioned** (Performance based on percentage of other CA)

Earned Value techniques should reflect the control account technical performance measures and risk profile

Source: MCR's Triple Gold Card Version 5.0

C. Acronyms

ACAT	Acquisition Category
ACWP	Actual Cost of Work Performed
ANSI	American National Standards Institute
BAC	Budget at Completion
BCWP	Budget Cost of Work Performed
BCWS	Budget Cost of Work Scheduled
CPI	Cost Performance Index
d	Discrete
DoD	Department of Defense
EAC	Estimate at Completion
EIA	Electronic Industrial Association
EV	Earned Value
EVM	Earned Value Management
FAR	Federal Acquisition Regulations
IBR	Integrated Baseline Review
IEAC	Independent Estimate at Completion
l	Level of Effort
LOE	Level of Effort
MAIS	Major Automated Information System
MDAP	Major Defense Acquisition Program
MR	Management Reserve
NDIA	National Defense Industrial Association
p	Percent of EAC
PEAC	Percent of Estimate at Completion
PM	Program Manager
PMB	Performance Measurement Baseline
SMC	Space and Missile Systems Center
SPI	Schedule Performance Index
SubK	Subcontractor
TCPI	To Complete Performance

References

[1] Program Management Institute Book of Knowledge, Sixth Ed. 2017, Pg 261.
[2] DoD 5000.2R, "Operation of the Defense Acquisition System", Enclosure 1, 2017
[3] Ibid, DoD 5000.2R Enclosure 1.
[4] Ibid, DoD 5000.2R Enclosure 1.
[5] ANSI/EIA-748-C, "Earned Value Management Systems", 2013.
[6] National Defense Industrial Association (NDIA), "EIA-748 Intent Guide, April 29, 2014
[7] Ibid, EIA-748, EVMS, Pg 16.
[8] Ibid, EIA-748, EVMS, Pg 13.
[9] "Guide to the Integrated Baseline Review", NDIA, 2015.
[10] DoD/ATL, Memo "Program Managers Guide to the Integrated Baseline Review Processes", 2003.
[11] Ibid, NDIA Guide to IBR, Pg 2.
[12] Ibid. NDIA Intent Guide, 2014, Pg 33.
[13] Ibid. NDIA Intent Guide, 2014, Pg 21
[14] NDIA EVM Application Guide, 2018, Pg. 1.
[15] https://project-management-knowledge.com /definitions/d/discrete-effort/
[16] SMCI63-107, section 1.3.2, Pg 5.
[17] Ibid, EIA-748, EVMS, Pg 3.