NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

JOINT APPLIED PROJECT REPORT

EFFECT OF THE EARNED VALUE MANAGEMENT SYSTEM (EVMS) COMPLIANCE REVIEW THRESHOLD INCREASE ON DATA INTEGRITY AND CONTRACTOR PERFORMANCE

September 2020

By: **Cindy Monohan**
Jeremy J. Loveday

Advisor: **Charles K. Pickar**
Co-Advisor: **Raymond D. Jones**

THIS PAGE INTENTIONALLY LEFT BLANK

REPORT DOCUMENTATION PAGE	*Form Approved OMB No. 0704-0188*

1. AGENCY USE ONLY *(Leave blank)*	**2. REPORT DATE** September 2020	**3. REPORT TYPE AND DATES COVERED** Joint Applied Project Report

4. TITLE AND SUBTITLE EFFECT OF THE EARNED VALUE MANAGEMENT SYSTEM (EVMS) COMPLIANCE REVIEW THRESHOLD INCREASE ON DATA INTEGRITY AND CONTRACTOR PERFORMANCE	**5. FUNDING NUMBERS**
6. AUTHOR(S) Cindy Monohan and Jeremy J. Loveday	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Postgraduate School Monterey, CA 93943-5000	**8. PERFORMING ORGANIZATION REPORT NUMBER**
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) N/A	**10. SPONSORING / MONITORING AGENCY REPORT NUMBER**

11. SUPPLEMENTARY NOTES The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government.

12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release. Distribution is unlimited.	**12b. DISTRIBUTION CODE** A

13. ABSTRACT (maximum 200 words)

This research investigates potential correlation between Defense Federal Acquisition Regulation Supplement (DFARS)-required Earned Value Management System (EVMS) compliance reviews and their effect on contractor Earned Value Management (EVM) performance and data integrity metrics. The primary objective is to determine if the 2015 DFARS deviation, which raised the dollar-value threshold for EVMS compliance reviews from $50M to $100M, and the resultant reduction in government oversight had any impact—positive or negative—on contractor performance. The authors examined EVM data for contracts requiring EVMS compliance reviews, data integrity metrics, and performance data on programs with varying dollar values for identifiable outcomes from the 2015 DFARS class deviation. The results of the study revealed that neither the 2015 DFARS class deviation nor the presence or absence of EVMS compliance reviews had a discernible impact on contractors' EV performance, EVM data integrity, or on their ability to perform on the contract.

14. SUBJECT TERMS Defense Federal Acquisition Regulation Supplement, DFARS, Earned Value Management System, EVMS, Earned Value Management, EVM, earned value, earned value data, earned value compliance review, earned value compliance threshold, earned value compliance threshold change, earned value compliance review threshold change, effect of earned value threshold change, effect of earned value compliance review threshold change, earned value data integrity	**15. NUMBER OF PAGES** 53
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT Unclassified	**18. SECURITY CLASSIFICATION OF THIS PAGE** Unclassified	**19. SECURITY CLASSIFICATION OF ABSTRACT** Unclassified	**20. LIMITATION OF ABSTRACT** UU

NSN 7540-01-280-5500 Standard Form 298 (Rev. 2-89) Prescribed by ANSI Std. 239-18

THIS PAGE INTENTIONALLY LEFT BLANK

Approved for public release. Distribution is unlimited.

EFFECT OF THE EARNED VALUE MANAGEMENT SYSTEM (EVMS) COMPLIANCE REVIEW THRESHOLD INCREASE ON DATA INTEGRITY AND CONTRACTOR PERFORMANCE

Cindy Monohan, Civilian, Office of the Secretary of Defense
Jeremy J. Loveday, Office of the Secretary of Defense

Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN PROGRAM MANAGEMENT

from the

NAVAL POSTGRADUATE SCHOOL
September 2020

Approved by: Charles K. Pickar
Advisor

Raymond D. Jones
Co-Advisor

Raymond D. Jones
Academic Associate, Graduate School of Defense Management

THIS PAGE INTENTIONALLY LEFT BLANK

EFFECT OF THE EARNED VALUE MANAGEMENT SYSTEM (EVMS) COMPLIANCE REVIEW THRESHOLD INCREASE ON DATA INTEGRITY AND CONTRACTOR PERFORMANCE

ABSTRACT

This research investigates potential correlation between Defense Federal Acquisition Regulation Supplement (DFARS)-required Earned Value Management System (EVMS) compliance reviews and their effect on contractor Earned Value Management (EVM) performance and data integrity metrics. The primary objective is to determine if the 2015 DFARS deviation, which raised the dollar-value threshold for EVMS compliance reviews from $50M to $100M, and the resultant reduction in government oversight had any impact—positive or negative—on contractor performance. The authors examined EVM data for contracts requiring EVMS compliance reviews, data integrity metrics, and performance data on programs with varying dollar values for identifiable outcomes from the 2015 DFARS class deviation. The results of the study revealed that neither the 2015 DFARS class deviation nor the presence or absence of EVMS compliance reviews had a discernible impact on contractors' EV performance, EVM data integrity, or on their ability to perform on the contract.

THIS PAGE INTENTIONALLY LEFT BLANK

TABLE OF CONTENTS

THIS PAGE INTENTIONALLY LEFT BLANK

LIST OF FIGURES

THIS PAGE INTENTIONALLY LEFT BLANK

LIST OF TABLES

THIS PAGE INTENTIONALLY LEFT BLANK

LIST OF ACRONYMS AND ABBREVIATIONS

ACAT	Acquisition Category
ACWP	Actual Cost of Work Performed
$ACWP_{CUM}$	Actual Cost of Work Performed, cumulative
BAC	Budget at Completion
BCWP	Budgeted Cost for Work Performed
$BCWP_{CUM}$	Budgeted Cost for Work Performed, cumulative
BCWR	Budgeted Cost of Work Remaining
BCWS	Budgeted Cost for Work Scheduled
$BCWS_{CUM}$	BCWS, cumulative
$BCWS_{CUR}$	Budgeted Cost for Work Scheduled, current reporting period
BEI	Baseline Execution Index
CPI	Cost Performance Index
CPI_{CUM}	Cost Performance Index, cumulative
CPR	Contract Performance Report
CV	Cost Variance
DAES	Defense Acquisition Executive Summary
DCMA-INST	DCMA Instruction
EAC	Estimate at Completion
EAC_{DCMA}	DCMA's Estimate at Completion
EAC_{Ktr}	contractor's Estimate at Completion
ECD	Estimated Completion Date
ECD_{DCMA}	DCMA's Estimated Completion Date
EMD	Engineering & Manufacturing Development
ETC	Estimate to Complete
EVM	Earned Value Management
EVM-CR	EVM Central Repository
EVMS	Earned Value Management System
EVMSIG	Earned Value Management System Interpretation Guide

IMS	Integrated Master Schedule
IPMR	Integrated Program Management Report
IWMS	Integrated Workload Management System
LOE	Level of Effort
MAIS	Major Automated Information System
MDAP	Major Defense Acquisition Program
OSD	Office of the Secretary of Defense
OUSD (AT&L)	Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics
PM&BI	Portfolio Management & Business Integration Executive Directorate
PMB	Performance Measurement Baseline
SPIX	Schedule Performance Index
SOW	Statement of Work
SV	Schedule Variance
TAB	Total Allocated Budget
TCPI	To Complete Performance Index
VAC	Variance at Completion
VAC_{DCMA}	DCMA's Variance at Completion
WBS	Work Breakdown Structure

ACKNOWLEDGMENTS

The authors wish to thank their families for their encouragement during this pursuit of educational advancement. The authors also wish to show gratitude to their advisors, Dr. Charles Pickar and Dr. Raymond Jones, for their guidance in completing this Joint Applied Project. Lastly, The authors are indebted to the leadership at the Defense Contract Management Agency for providing this opportunity to develop themselves, improve the agency, and shape the future of acquisition within the Department of Defense.

THIS PAGE INTENTIONALLY LEFT BLANK

I. INTRODUCTION

Earned Value Management (EVM) is a well-established and widely accepted project management tool for integrating cost, schedule, and performance data to assess performance against established baselines for both government and private sector programs. EVM is designed to provide accurate and measurable data, and is used to perform predictive analysis of performance trends by program managers, contractors, and independent oversight agencies, such as Defense Contract Management Agency (DCMA). EVM was developed by the Department of Defense (DoD) in the 1960s, and is currently utilized on programs throughout the federal government (Dwivedi, 2009). The importance of integrating and applying EVM principles and practices for DoD acquisitions is emphasized in the *DoD Earned Value Management Implementation Guide (EVMIG)* (2019): "Insight into the contractor's performance (specifically program management and control) is a fundamental requirement for managing any major acquisition program" (*DoD Earned Value Management Implementation Guide* [EVMIG], 2019, p. 1).

Earned Value Management measures a contractor's performance of actual work completed as compared to scheduled activities and the planned budget. Using three primary metrics, Budgeted Cost of Work Performed, Budgeted Cost of Work Scheduled, and Actual Cost of Work Performed, measured along the Program Management Baseline, or budget, government personnel can gain insight into a program's health. Contractors employ Earned Value Management on Cost-Plus and Fixed-Fee-Plus-Incentive type contracts longer than 18-months in duration with discrete tasks (Defense Acquisition University, n.d.). The Earned Value Management System tracks the number of tasks completed on time, called the Baseline Execution Index (BEI), as an indicator of continuous performance over time. Other indicators measure how well a contractor performs to schedule (SPI), how well they perform to budget (CPI), and how well they will have to perform for the remainder of the contract to complete both on-time and on-budget (TCPI). By using current-period or cumulative data along with various factors, the Estimate At Complete (EAC) results vary with best-case, worst-case, and most-likely estimates.

Defense Federal Acquisition Regulation Supplement (DFARS) Subpart 234.2 "Earned Value Management System" stipulates that contractors must have an American National Standards Institute/Electronic Industries Alliance Standard (ANSI) 748-compliant Earned Value Management System (EVMS) for all cost-type prime and sub-contracts valued over $20 million. Contracts valued over $100 million must have their EVMS validated by the "cognizant federal agency," which per DFAR 234.201(3) is DCMA. The previous dollar threshold for EVMS compliance reviews was $50 million as recently as 2015, until a DFARS Subpart 234.2 class deviation increased it to $100 million (Grady, 2015). A class deviation is a change to the prescribed FAR or DFARs provisions or procedures affecting multiple contracts. This class deviation reduced DCMA's EVMS compliance review activities, intended to ensure contractor's proper implementation and compliance to the ANSI 748 guidelines.

This research examines the impacts of increasing the EVMS compliance review threshold by analyzing current contract performance and data integrity metrics for a Defense Acquisition program directly affected by this change. The contract value for this program is between $40 million and $75 million. Additionally, the authors analyzed Defense Acquisition programs that fell below the previous threshold (>$50 million), or above the current threshold (>$100 million). These additional programs serve as both research controls and as well as analysis for EVM performance on a radar program that never required DCMA reviews, and those requiring continuous DCMA surveillance since contract inception.

Current literature and studies of EVM generally fall into two categories: examinations of the "value" of EVM to contractors and program managers compared to the costs of implementation (Members et al., 2017), or proposed methodologies and metrics to improve EVM performance measurement (Bruchey, 2012). Despite available literature on the cost of EVMS compliance reviews, there is a paucity of information and study regarding the effects of DCMA's compliance reviews on EVM performance metrics, or the validity of EVM data. This study compliments and expands existing research on the impacts of EVMS compliance by evaluating program performance and data integrity trends.

A. RESEARCH SCOPE

This study examined whether the 2015 DFARS class deviation affected EV performance and data integrity for contracts under the $100 million threshold both before and after the class deviation. For the control and comparative analysis, the authors also examined contracts unaffected by the deviation. Data collection included earned value performance and data integrity on four DoD weapons system programs. The authors selected programs based on dollar amount, contract type, acquisition phase, period of performance, and availability of EV data. Because of EVM requirements for cost-type contracts exceeding $20 million, and not for fixed-price efforts, the authors excluded programs with fixed-priced contracts and work (i.e., sustainment or full-rate production). Similarities in acquisition phase and contract type facilitate analysis and correlation of data.

The authors analyzed four programs for relationships between Cost Performance Index (CPI) and Schedule Performance Index (SPI), Cost Variance Percentage (CV%) Schedule Variance Percentage (SV%), Variance-at-Completion Percentage (VAC%), and the percentage of WBS elements with EV data integrity anomalies (tripwires). The class deviation removed compliance reviews on one of the four programs analyzed. One other program, valued under $50M, was exempt from EVM system surveillance both prior to and following the class deviation. This exempt program serves to compare EV performance between programs with and without EVM system surveillance. Surveillance remained constant on two MDAP programs, both valued at over $100 million; therefore, they will serve as control samples. Each index or metric established trends across a six-year period spanning the date of the class deviation reducing systems compliance reviews. The focus intended to identify outliers in performance and variance post-oversight reduction. This analysis should identify any pejoration or improvement in contractor performance to contractual goals.

B. RESEARCH OBJECTIVE

The objective of this research is to examine and evaluate the effects of the EV class deviation on program EV performance and data integrity metrics. This research will

determine if DCMA EVMS compliance reviews, or lack thereof, influence EVMS data validity, and if there is correlation between EV data integrity and performance metrics.

1. Primary Research Question

Did the DFARS 234.2 class deviation that raised the dollar threshold from $50M to $100M for Earned Value (EV) compliance reviews affect contractors' EV performance and data integrity metrics?

2. Secondary Research Question

Is there a correlation between the incidence of EV data integrity "tripwire" metrics and program performance metrics? If so, what are the implications for any correlation?

C. METHODOLOGY

The researchers developed project methodology to show a comparison between the number and frequency of EV data integrity "tripwire" metrics to EV performance metrics for programs directly affected by increasing the EVMS compliance review threshold, and those not impacted by the change. It collected EVM performance data and EVM data integrity metric data on four DoD programs with the same acquisition phase, and contract type, and considered those whose period of performance intersected the 2015 EVMS compliance review threshold change. The EV data used in this analysis was already in the proper, authorized possession of the authors pursuant to their official duties, readily and properly accessible via the Earned Value Management Central Repository (EVM-CR), or voluntarily provided to the JAP team by DCMA peers performing EV analysis.

The primary analysis tool is the DCMA Cost Analysis Workbook (CAW), an internal agency EV program analysis tool. The CAW is an Excel spreadsheet with cost and schedule data imported and analyzed by DCMA specialists. The CAW also performs data integrity analysis of Work Breakdown Structure (WBS) elements and produces a count of WBS elements that trigger data integrity "tripwires." EV data tripwire metrics measure instances of anomalous EV data conditions such as Actual Cost of Work Performed (ACWP) exceeding Estimate at Completion (EAC), negative Budgeted Cost of Work Performed (BCWP), negative EAC, Budgeted Cost of Work Scheduled (BCWS) exceeding

Budget at Completion (BAC), etc. The researchers then developed a separate spreadsheet to perform comparative analysis of standard EV performance metrics, aggregate the raw number of EV tripwire occurrences, and measure correlation between the performance and tripwire metrics.

The analysis of metrics and indices intend to show correlation between contractor performance and the reduction of oversight on programs valued under $100 million. By identifying trends before and after the class deviation occurred, the authors will be able to identify contractors' ability to self-monitor and maintain performance levels conducive to the standards previously established with government oversight. The data may also reveal cost savings by reducing the impact of government compliance reviews on the programs analyzed, thereby serving as a model for further reduction of cost across Major Defense Acquisition Programs (MDAPs).

D. ORGANIZATION

This research team documented and organized the project as a logical flow from the research objective, data analysis, and conclusion, to answer the primary research question: Did the class deviation for Earned Value (EV) compliance reviews affect contractors' EV performance and data integrity metrics?

The INTRODUCTION chapter provides a broadened narrative of the proposal, establishing the scope, objective, and methodology used to examine the research questions.

The BACKGROUND chapter introduces the DFARS class deviation, explains concepts of EVM, and defines and relates EV data integrity metric evaluation to the research. It identifies key EVM performance and EV data integrity metrics and describes their value and application to program performance measurement.

The CASE STUDY AND ANALYSIS chapter examines four MDAP programs by analyzing their key EVM performance metrics and EV data integrity metrics over a duration spanning the 2015 DFARS class deviation. A comparison between the data elements addresses and answers the research questions.

The SUMMARY AND RECOMMENDATIONS chapter provides answers to the research questions, and provides suggestions for follow-on studies of the relationship between the DFARS class deviation and EVM performance and EV data integrity.

II. BACKGROUND

A. EARNED VALUE MANAGEMENT DATA INTEGRITY CONCEPTS

The *DoD EVMIG* (2019) highlights the importance of EVM data validity. It states: "an EVMS compliant with the Guidelines and properly used helps to ensure that valid cost, schedule, and technical performance information are generated, providing the PM with an effective decision-making tool" (p. 4). The Government Accounting Office's *Cost Estimating and Assessment Guide* further emphasizes the importance of data validity to EVM data analysis. Step 1 of the data analysis process is to "check data to see if they are valid" (*United States Government Accountability Office* [GAO] 2009, p. 256). The *Guide* further explains that, "if the CPR data contain anomalies, the performance measurement data will be distorted….and performance measurement data will not reflect true status" (p. 257). Emphasis placed on specific CPR data validity checks on EVM data includes:

- Negative values for ACWP, BAC, BCWP, BCWS, or EAC;
- BCWP and BCWS data with no corresponding ACWP;
- BCWP with no BCWS;
- BCWP with no ACWP;
- ACWP with no BCWP;
- ACWP that is way above or below the planned value;
- ACWP exceeds EAC; and other metrics. (GAO 2009, p. 257)

DCMA's Program Support Analysis and Reporting Manual (DCMA MAN-3101-02) includes discussion of data integrity and directs the EVM analyst to report WBS elements with the similar conditions as those in the GAO's *Guide* (Defense Contract Management Agency, 2017). The CAW contains a worksheet dedicated to analyzing WBS elements for these specific anomalies:

- $BCWS_{CUM} > BAC$
- $BCWP_{CUM} > BAC$

- ACWP with No BAC
- Negative BAC or EAC
- Negative $BCWS_{CUM}$ or Negative $BCWS_{CUR}$
- Negative $BCWP_{CUM}$ or Negative $BCWP_{CUR}$
- BCWP with No ACWP
- Completed Work with Estimate To Complete (ETC).
- Incomplete Work without ETC
- ACWP on Completed Work
- BCWP with No BCWS
- $ACWP_{CUM}$ > EAC

These tripwire metrics identify anomalous EVM data and prompt the DCMA EV analyst to investigate those WBS elements. Appendix A contains full definitions of all EV metrics. Appendix B details the tripwire metrics for cost and schedule integrity. Defense Contract Management Agency (DCMA) developed all definitions and acronyms listed in the appendices.

B. EARNED VALUE MANAGEMENT PERFORMANCE METRICS CONCEPTS

The below performance indices and metrics are standard to all programs covered under Earned Value Management requirements. As such, they will serve as a common assessment tool to identify contractor performance for the entire six-year period measured before and after conducting the previously required systems-level compliance reviews.

- Cost Performance Index (CPI = BCWP/ACWP)
- Schedule Performance Index (SPI = BCWP/BCWS)
- Variance at Completion Percentage (VAC% = (BAC – Most Likely EAC) * 100)
- Cost Variance Percentage (CV% = CV/BCWP * 100)
- Schedule Variance Percentage (SV% = SV / BCWS * 100)

III. CASE STUDY AND ANALYSIS

A. INTRODUCTION

The four DoD programs selected for this research are cost-type contracts exceeding $20 million and follow the DFARS Subpart 234.2 EVM requirement for an ANSI 748-compliant EVMS. All four programs consistently provide EVM cost and schedule performance data to the program manager and DCMA. The researchers chose these four programs based on their common acquisition phase (Engineering and Manufacturing Development [EMD]), contract type (cost-plus), contract value (exceeding $20M requiring EVM reporting), and period-of-performance (POP) spanning the 2015 EVMS compliance review threshold change.

Due to the proprietary and sensitive nature of the data, the authors cannot disclose actual program or contractor names in this research. The remainder of this work below refers to the four programs as "Program A," "Program B," "Program C," and "Program D." Additionally, the authors omitted actual cost figures from this analysis to protect against unintentional release of program or contractor data. Indices and percentages express EV program performance analyses results to safeguard against disclosure of actual program or contractor identity.

Obtaining EVM data for programs directly affected by the EVM class deviation was a challenge for the research team. Many of the affected programs, with cost-type contract values between $20M–$100M, and periods-of-performance spanning the 2015 deviation, are non-MDAP efforts with unreported EV data via the EMV-CR. Consequently, the researchers depended on information available via internal DCMA automated tools. Only two affected programs identified via this method with cost-type contracts, and periods-of-performance spanning the 2015 class deviation, were in the same acquisition phase. The researchers found that only one of these two programs had EV data reported with continuity and readily available; therefore, the authors included it in this study.

The researchers analyzed a second program exempt from EVM system surveillance due its contract value (>$50M), as a means of comparing EV performance between programs with, and without, EVM system surveillance. The research team selected this program due to availability of EV data and its period-of-performance spanning the 2015 class deviation. The authors selected two MDAP programs as controls with contract values over $100M based on their period-of-performance, continuity of EV data reporting, availability of EV performance data to the researchers via the EVM-CR.

Each program has a single prime contractor that manages the overarching EVM system and provides EV performance data. Although two of the programs have multiple sub-contractors, the prime contractor reports the EV performance data. Table 1 depicts the overall characteristics of the four programs selected for this research.

Table 1. Characteristics of Programs Selected for Earned Value Performance Comparison

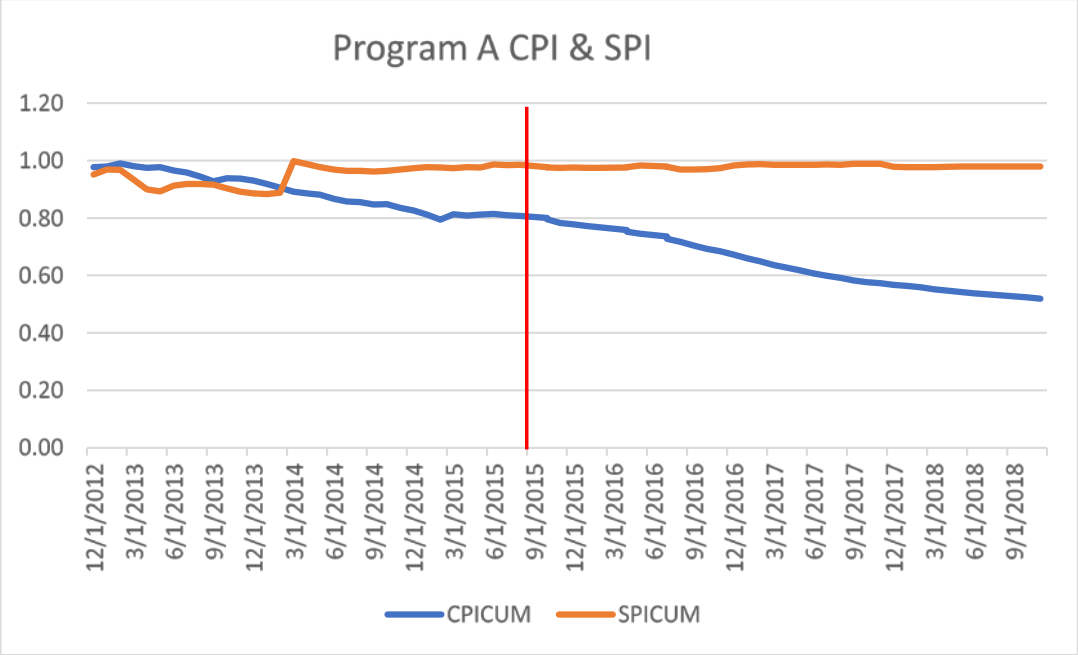
Program	Dollar Value	MDAP	Data Spans 2015 Class Deviation?	Affected by Class Deviation?
Program A	>$50M <$100M	N	Y	Y
Program B	<$50M	N	Y	N
Program C	>$100M	Y	Y	N
Program D	>$100M	Y	N	N

The programs' incidence of EV data integrity tripwire metrics reflects a percentage of WBS elements with one or more tripwires. Since one WBS element may have up to fourteen tripwires, the authors carefully developed and calculated this metric, named "percentage of WBS with any tripwire," and expressed as % WBS elements with tripwires = number of WBS elements with tripwires / total number of WBS elements), to avoid skewing and artificially inflating the measured incidence of EV data integrity tripwires.

B. PROGRAM A

The 2015 EVMS class deviation directly affected Program A, as its Total Allocated Budget (TAB) rests between $50 million and $100 million. Prior to the class deviation, DCMA routinely performed and documented EVM System compliance reviews. The class deviation/threshold change immediately obviated the requirement for continued DCMA surveillance and validation of their EVMS.

Figure 1 shows Program A's CPI and SPI over a six-year period spanning the 2015 class deviation.

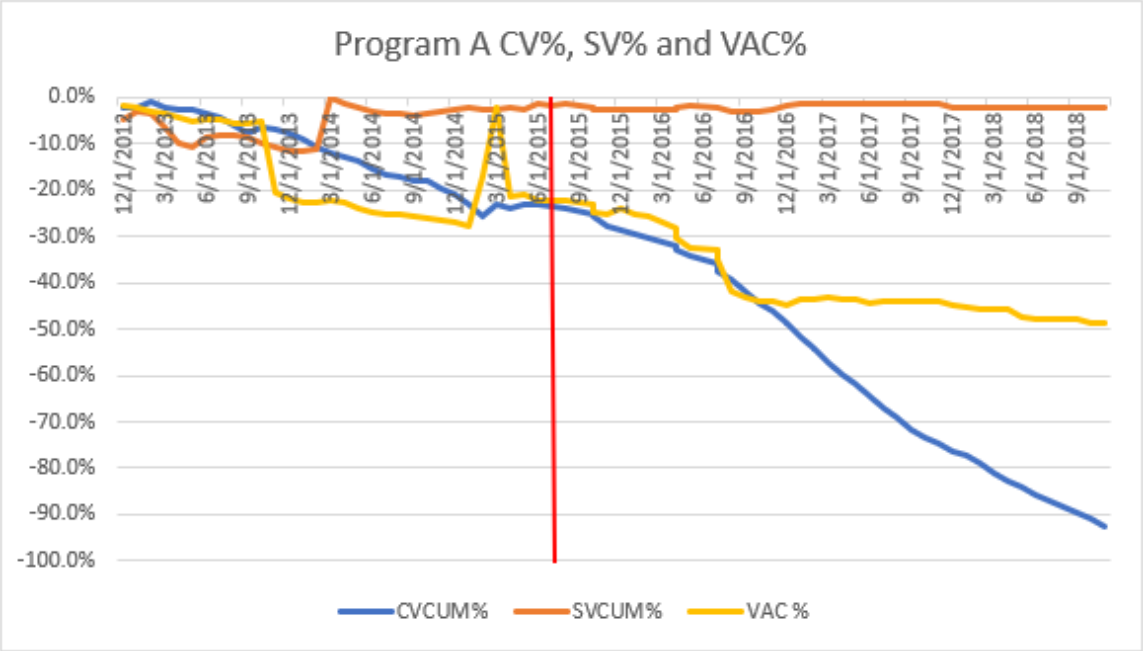


The red vertical line indicates the effective date of the class deviation.

Figure 1. Program A's CPI and SPI Over a 6-Year Period Spanning the 2015 Class Deviation

Program A's CPI and SPI declines until March 2014. After this point, SPI stabilizes near 1.0, while CPI continues a steady and consistent decline through Sept 2018. While CPI appears to stabilize between March 2015 and September 2015, and declines again after the class deviation, the authors are unable to discern whether the degradation in CPI relates to the class deviation, or is simply a continuation of negative cost performance trends since

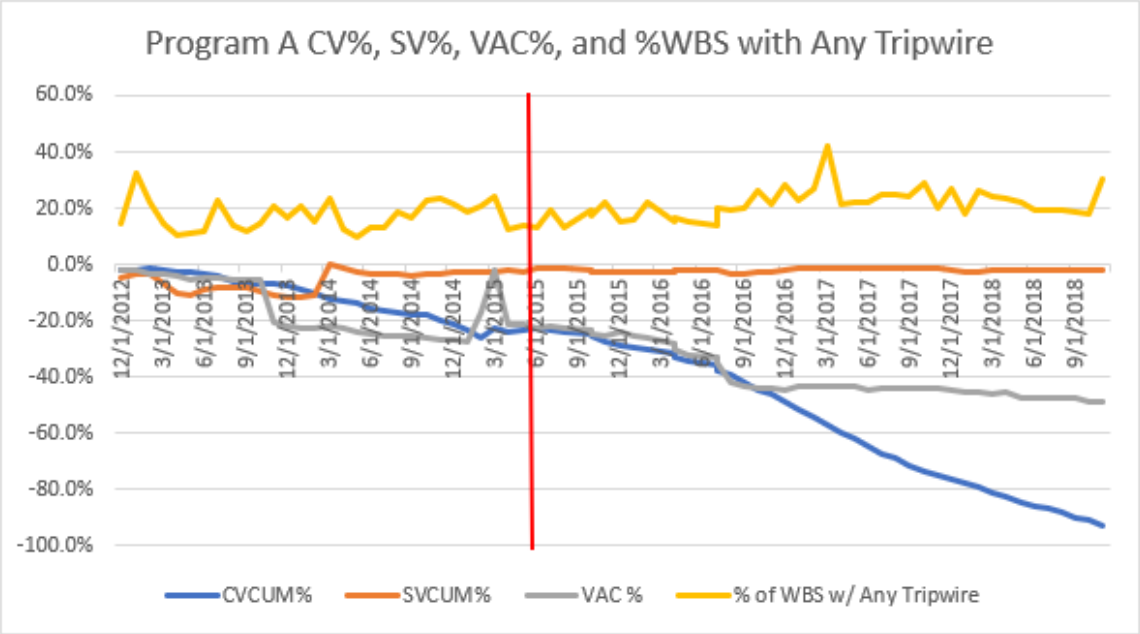
program inception. Figure 2 shows Program A's CV%, SV% and VAC% over the same six-year period. The vertical line indicates the effective date of the class deviation.



The red vertical line indicates the effective date of the class deviation.

Figure 2. Program A's CV%, SV% and VAC% Over 6-Year Period Spanning the 2015 Class Deviation.

Program A's CV% and SV% performance closely resemble CPI and SPI, respectively. VAC% fluctuates throughout the timespan, but shows consistently declining performance. The authors speculate that intermittent, parallel improvement in all EVM performance metrics may correspond to program re-baseline efforts; however, there is insufficient program insight to confirm this theory. As with the CPI trends in Figure 1, the authors are unable to discern whether the VAC% and CV% performance degradation is related to the 2015 class deviation, or represents continued negative program performance trends. Figure 3 on the following page shows Program A's CV%, SV%, VAC% and %WBS with Any Tripwire. The vertical line indicates the effective date of the class deviation.



The red vertical line indicates the effective date of the class deviation.

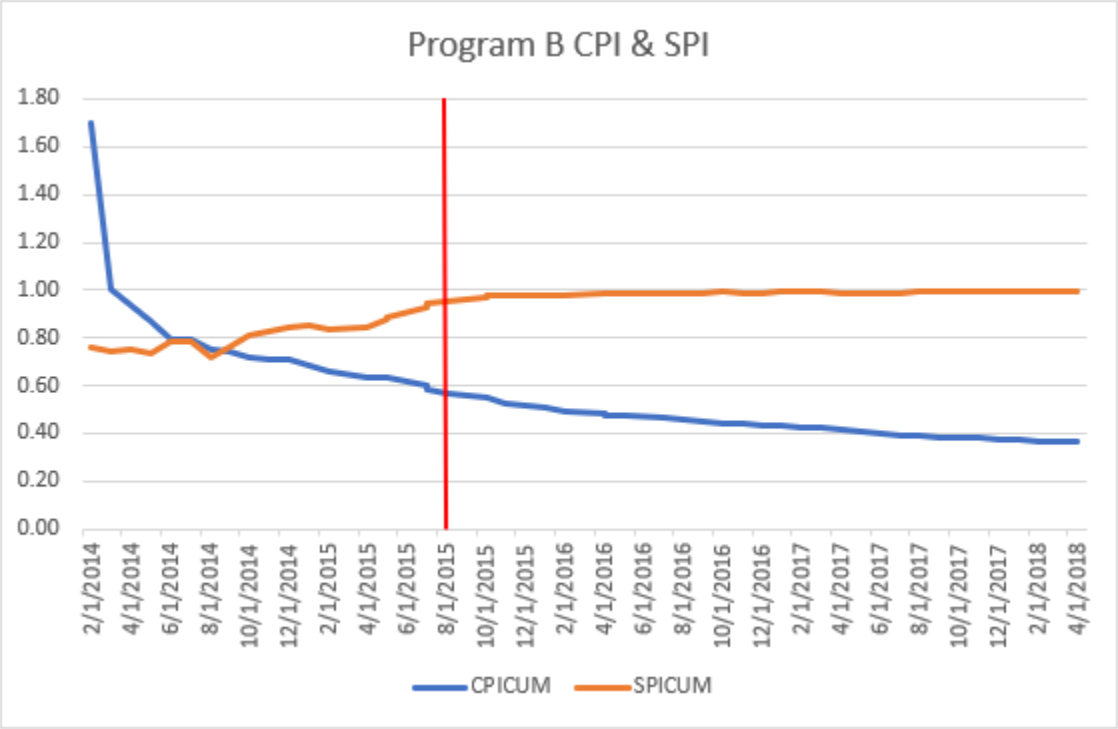
Figure 3. Program A's CV%, SV%, VAC% and %WBS with Any Tripwire Over 6-Year Period Spanning the 2015 Class Deviation

Comparing Program A's CV%, SV%, VAC% and the percent of WBS elements with any tripwires reveals that the incidence of EV data integrity anomalies remained steady throughout the program and do not appear to influence program performance. Additionally, the absence of DCMA EVMS compliance reviews due to the Sept 2015 class deviation does not appear to have effected EV data integrity. The authors theorize that fluctuations in the percentage of WBS tripwires may correspond with re-baselining or re-scoping efforts, as changing any EV component of a WBS (duration, BCWS, BCWP, ACWP, EAC, etc.), may create a temporary tripwire condition.

C. PROGRAM B

The 2015 EVMS class deviation caused no impact to Program B as its TAB is less than $50M and has never required EVM System compliance audits. This program's EV metrics represents this contractor's "unmonitored" performance, as this program never underwent EVM System compliance audits. Program B has the same prime contractor as

Program A. Figure 4 shows Program B's CPI and SPI over a four-year period spanning the 2015 class deviation. The red vertical line reflects the effective date of the class deviation.

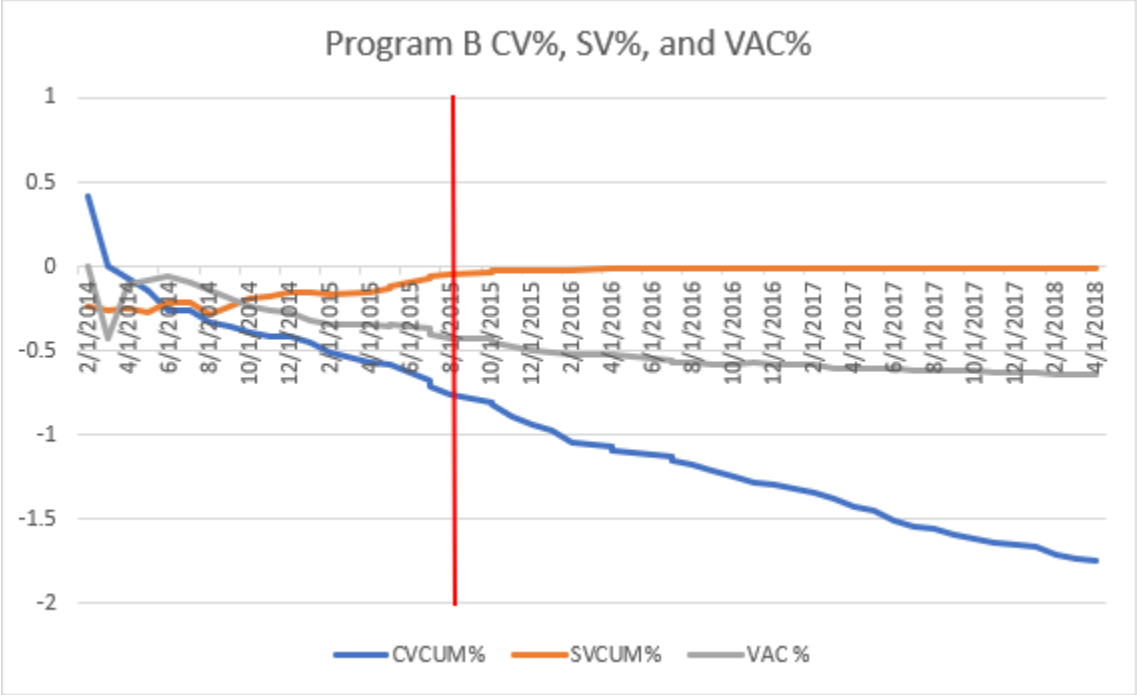


The red vertical line indicates the effective date of the class deviation.

Figure 4. Program B's CPI and SPI Over 4-Year Period Spanning the 2015 Class Deviation

Program B's CPI's was positive at program initiation, and quickly degraded over a span of four months. The authors speculate the abnormally high initial CPI may be due to late starts delaying accumulation of ACWP, thereby, not expending the planned amounts and skewing the data. The low SPI at the onset of data indicates that the contractor planned more work than what they were able to accomplish (BCWP/BCWS). As the contractor performed work and the cost of the work performed exceeded the plan, the CPI fell.

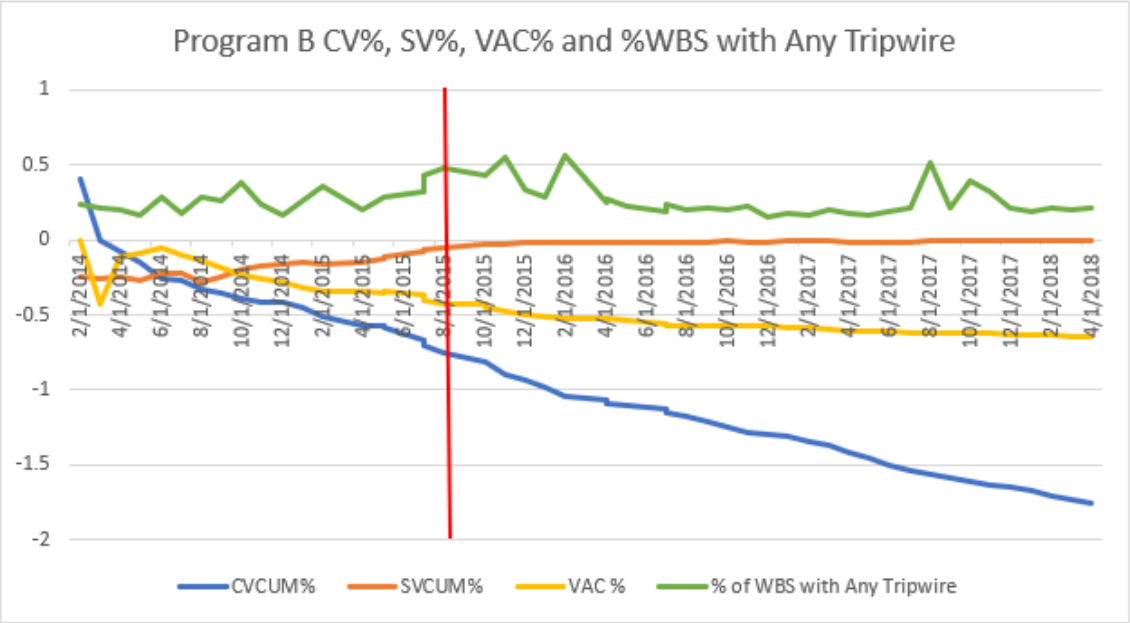
Figure 5 shows Program B's CV%, SV% and VAC% over the same timeframe. A vertical line indicates the effective date of the class deviation.



The red vertical line indicates the effective date of the class deviation.

Figure 5. Program B's CV%, SV% and VAC% Over 4-Year Period Spanning the 2015 Class Deviation

Program B's CV% and SV% performance track closely with CPI and SPI, respectively. VAC% fluctuates early, then settles into a shallow decline through the timeframe. Program B's performance trends are analogous to those of Program A, particularly with continued degradation of CV%. The authors postulate that, for Programs A and B, the contractor encountered unplanned work and re-work, causing worsening cost variances and trends. Figure 6 on the following page shows Program B's CV%, SV%, VAC% and %WBS with Any Tripwire. A vertical line indicates the effective date of the class deviation.



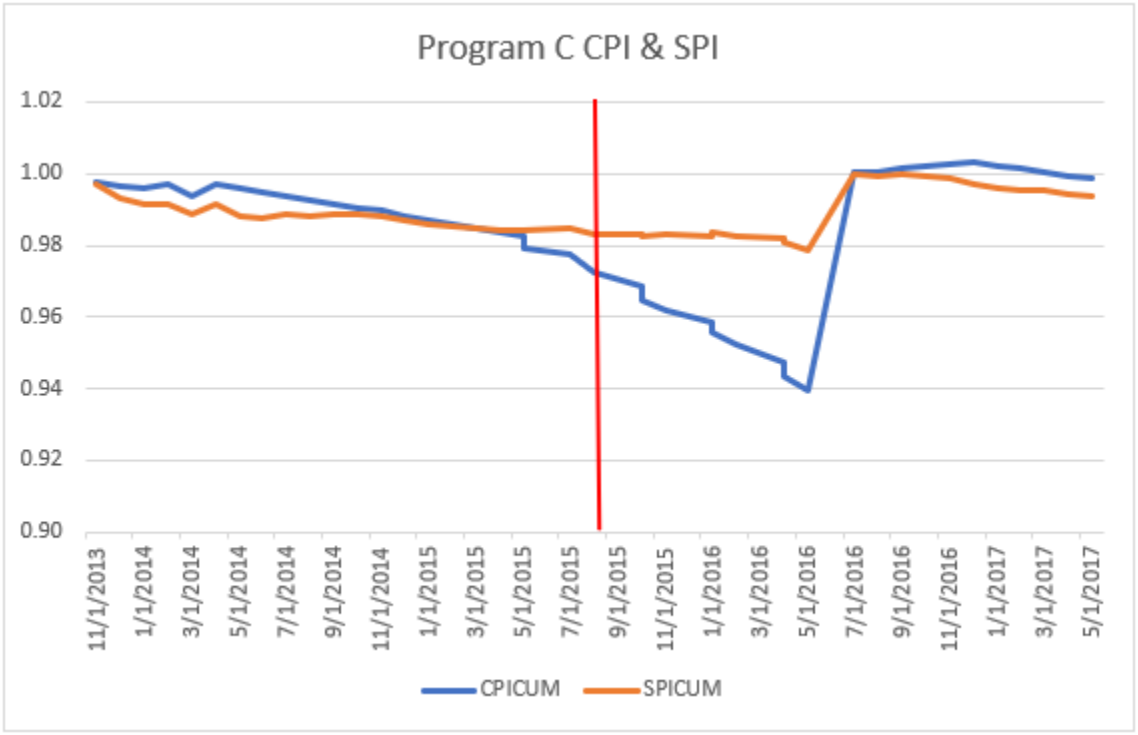
The red vertical line indicates the effective date of the class deviation.

Figure 6. Program B's CV%, SV%, VAC% and %WBS with Any Tripwire Over 4-Year Period Spanning the 2015 Class Deviation

Comparing Program B's CV%, SV%, VAC% and the percent of WBS elements with any tripwires reveals that the incidence of EV data integrity anomalies was generally steady throughout the program and do not appear to influence program performance. The authors theorize that fluctuations in the percentage of WBS tripwires may correspond with re-baselining or re-scoping efforts, as changing any EV component of a WBS (duration, BCWS, BCWP, ACWP, EAC, etc.), creating temporary tripwire increases.

D. PROGRAM C

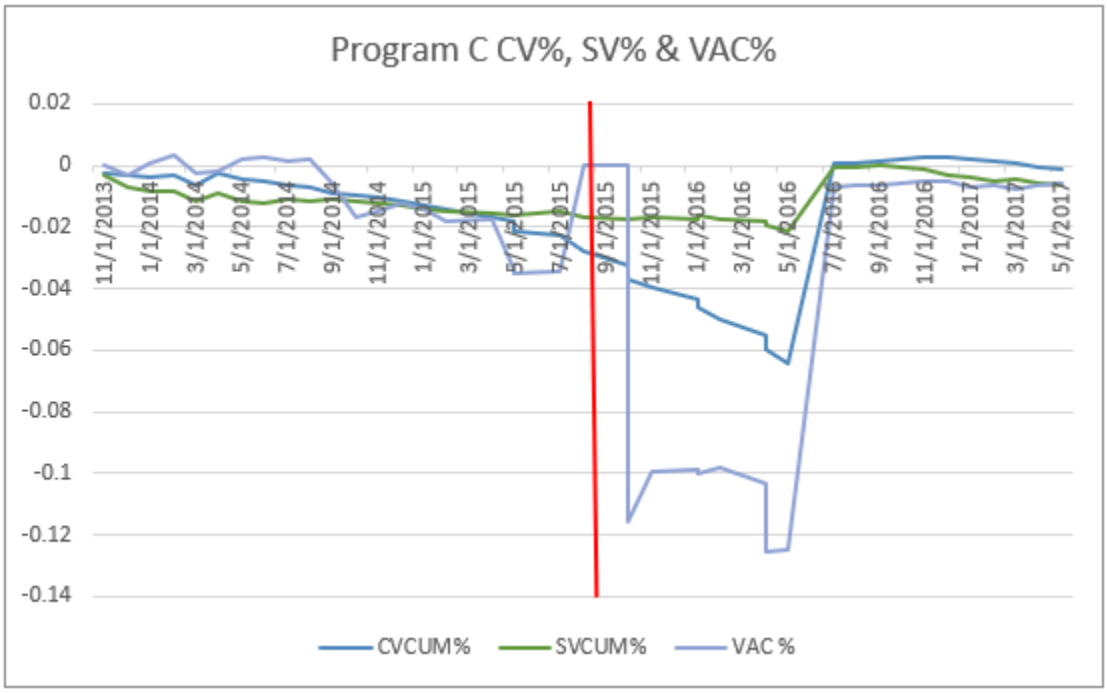
The 2015 EVMS class deviation did not affect Program C due to its large contract value and TAB exceeding $100M.This MDAP has undergone continual EVM System compliance audits since inception. Program C is a different contractor than Programs A, B and D. Figure 7 on the following page shows Program C's CPI and SPI over an approximate four-year period spanning the 2015 class deviation. Again, the red vertical line indicates the effective date of the class deviation.



The red vertical line indicates the effective date of the class deviation.

Figure 7. Program C's CPI and SPI Over 4-Year Period Spanning the 2015 Class Deviation

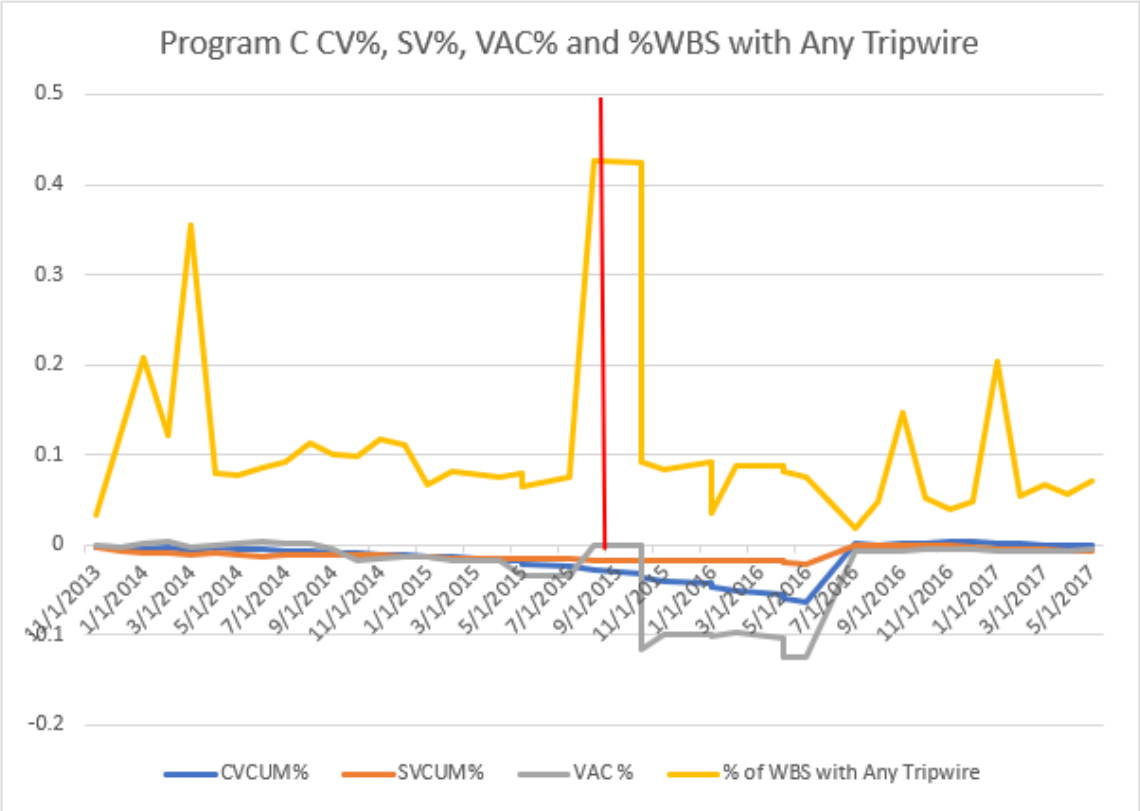
Program C's CPI and SPI were near optimal (1.0) at program initiation, trended downward for approximately 30 months, improved suddenly in July 2016, then slowly degrade through 2017. The authors note that the large CPI deviation and movement depicted in this chart is a mathematically small fluctuation (from near 1.0 to 0.94). A CPI of 0.94 indicates good performance, and this program overall appears to be performing very well in terms of EV performance metrics. The authors speculate that the sudden improvement is due to a program re-baseline, which effectively resets variances to zero and brings CPI and SPI to 1.0. The program appeared to encounter slight performance issues shortly after the July 2016 peak, as evidenced by declining CPI and SPI. Overall, this much larger and more technically complex program appears to perform much more favorably and consistently than the smaller programs (A & B). Figure 8 on the following page shows Program C's CV% SV%, and VAC%. A vertical line indicates the effective date of the class deviation.



The red vertical line indicates the effective date of the class deviation.

Figure 8. Program C's CV%, SV%, and VAC% Over 4-Year Period Spanning the 2015 Class Deviation

Program C's CV% and SV% performance track closely with CPI and SPI, respectively.VAC% fluctuates early, falls precipitously in Oct 2015, stabilizes, then quickly improves to near-zero in July 2016. The authors note that, although the decline and recover appear steep, it represents an approximate 13% VAC, which, although undesirable, is not indicative of serious cost performance issues. VAC% closely mirrors CV%, and indicates the recovery of both metrics may be due to a re-baselining effort. Figure 9 on the following page shows Program C's CV%, SV%, VAC% and %WBS with Any Tripwire. A vertical line indicates the effective date of the class deviation.



The red vertical line indicates the effective date of the class deviation.

Figure 9. Program C's CV%, SV%, VAC% and %WBS with Any Tripwire Over 4-Year Period Spanning the 2015 Class Deviation

Program C's percentage of WBS elements is generally consistent with several large exceptions/ large fluctuation through the data set. Several factors may contribute to these fluctuations, including frequent manipulation or correction of WBS EV elements (ACWP, BCWP, etc.) or re-scoping of work. The short-duration peaks, with nearly 40% of all WBS elements containing at least one anomaly, do not appear to effect EV performance metrics. Much like the findings for Programs A and B, the incidence of EV data integrity anomalies do not appear to influence program performance, regardless of the degree of incidence.

E. PROGRAM D

Program D serves primarily as a control sample unaffected by the 2015 EVMS class deviation due to its large contract value (TAB exceeding $100M) and period of performance concluding prior to the 2015 class deviation. This MDAP has undergone

continual EVM System compliance audits since inception. Program D is a different contractor than Programs A, B and C. Figure 10 shows Program D's CPI and SPI performance over a six-year period preceding the 2015 Class Deviation.

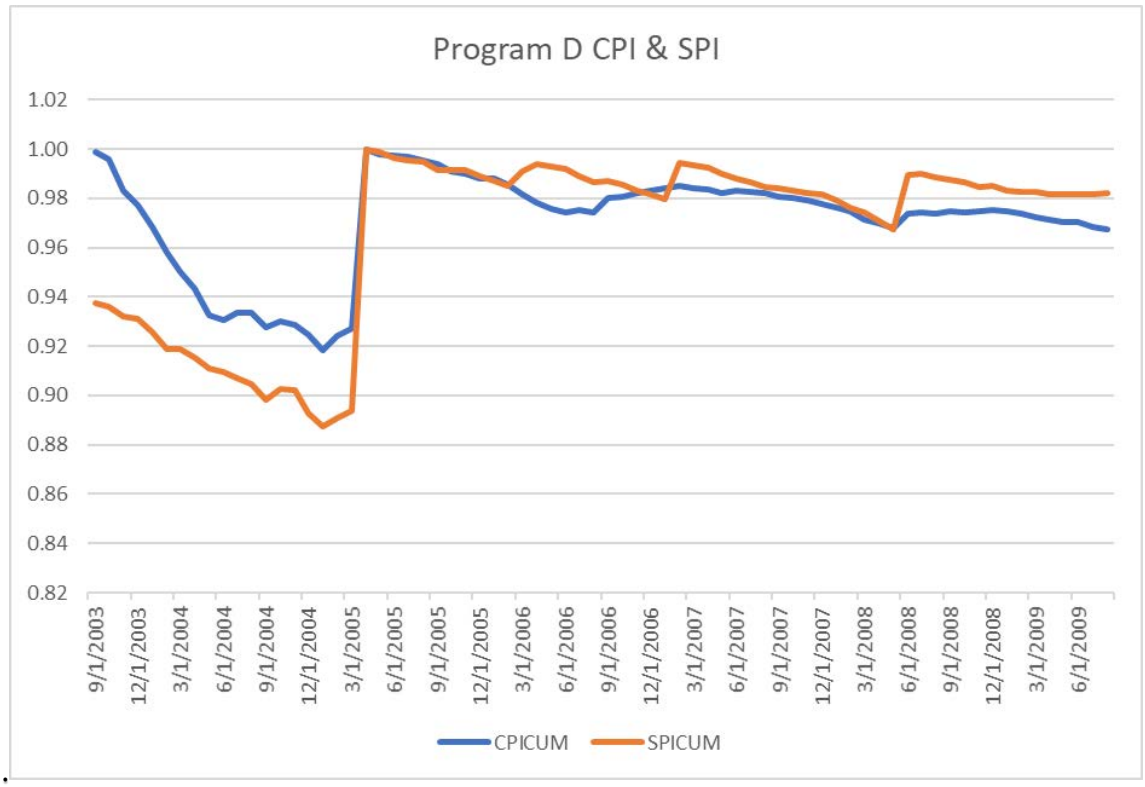


Figure 10. Program D's CPI and SPI Over 6-Year Period Preceding the 2015 Class Deviation

Program D's CPI was optimal (near 1.0) at program initiation, degraded steadily over a one-year period, then rebounded and remained at near-optimal levels (.095-1.0) for the remainder of the timeframe. SPI began low (near 0.94), trended negatively in near parallel to CPI, and then improved quickly to 1.0 around May 2005, again in parallel with CPI. The authors speculate the sudden recovery of both metrics in the May 2005 timeframe reflect total program re-baselining effort, which brings variances to zero. This high-dollar, technically complex MDAP program's CPI and SPI indicate more favorable and consistent performance than the lower-dollar, less complex program (Programs A and B). Figure 11 shows Program D's CV%, SV% and VAC%.

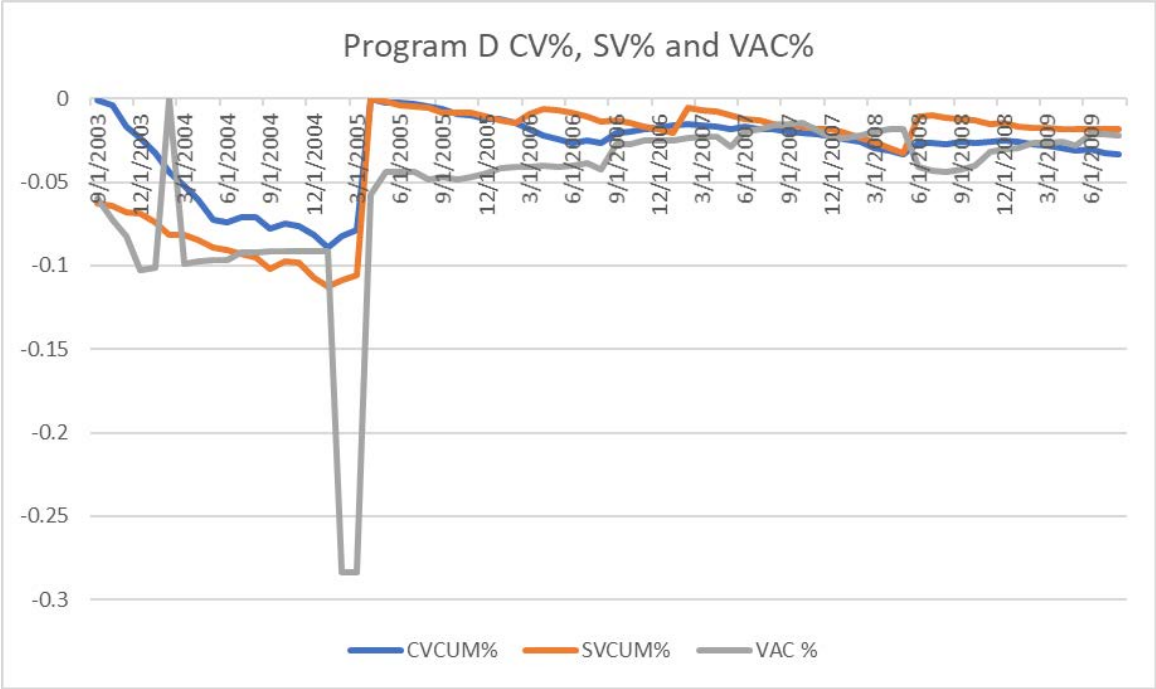


Figure 11. Program D's CV%, SV% and VAC% Over 6-Year Period Preceding the 2015 Class Deviation

Program D's CV% and SV% performance track closely with CPI and SPI, respectively.VAC% fluctuates early, falls precipitously around Mar 2005, then improves in parallel with CV% and SV% around Apr 2005. Although VAC% stayed negative, the variance is minor (less than 5% VAC).The movement and recovery of CV%, SV% and VAC% may indicate a re-baselining effort. The authors surmise that consistently good performance of these metrics (all less than 5% variance) indicates a well-planned and executed program re-baseline. Figure 12 on the following page shows Program D's CV%, SV%, VAC% and %WBS with Any Tripwire preceding the 2015 class deviation.

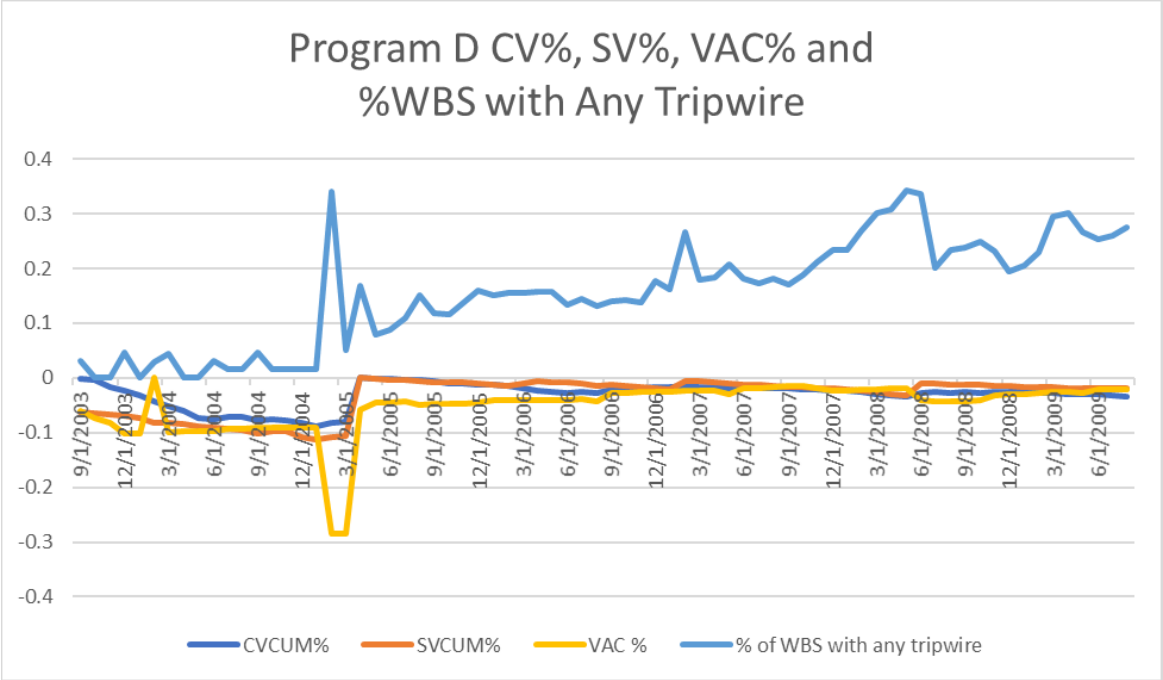


Figure 12. Program D's CV%, SV%, VAC% and %WBS with Any Tripwire Over 6-Year Period Preceding the 2015 Class Deviation

Program D's percentage of WBS elements with tripwires generally increased, with one significant deviation in Feb-Mar 2005. The large increase in this timeframe mirrors the noticeable decline in CV%. Following the stabilization of metrics in Mar 2005, program performance remained steady despite the increasing percentage of WBS elements with data integrity anomalies. As with the findings for Programs A, B, and C, the incidence of EV data integrity anomalies do not appear to influence program performance, regardless of the degree of or frequency of incidence.

IV. SUMMARY AND RECOMMENDATIONS

The purpose of this analysis is to determine if a correlation exists between a contractor's performance and data integrity metrics with the class deviation for Earned Value Management System (EVMS) compliance reviews. There are no known analyses that attempt to reveal any similar correlations due to the recency of the class deviation implementation. The data used throughout the analysis originated from random contracts with available EMV performance data, with varying contract values, and spanning the period when the class deviation went into effect. Data Integrity Tripwires, Cost and Schedule Performance Indices and Variances served as the primary metrics for analysis.

The results of the analysis reflect similar patterns in three of the four datasets on schedule performance, each experiencing a 16- to 20-month stabilization period where schedule performance is negative, but trends upwards until it remains near 1.0 for the remainder of the analyzed period. Conversely, cost performance on all four programs show an initial decline; however, Programs A and B never recover their cost deficits. When comparing the performance indices with cost and schedule variances, as well as the tripwires, the authors found no trends or similarities. Except for Program D, the remaining programs revealed a cyclic, standard percentage of WBS elements with tripwires. Program D reveals a constant upward trend of increasing percentage of WBS items with EV data integrity issues, but never exceeds an out-of-family anomaly.

The results of this study indicate there is no correlation or effect of EVMS compliance reviews on program performance, nor on EVM data integrity. Program performance appears more dependent on the type of program, and the contractor's ability to accurately plan and schedule work, than on the presence or absence of DCMA EVM system compliance reviews. DCMA's performance of EVMS compliance reviews, driven by the dollar thresholds in DFARS 234.2, does not necessarily influence a contractor's ability to adhere to their performance measurement baseline.

These findings also indicate data integrity metrics are not influenced by the presence, or absence, of DCMA EVM system compliance reviews. Program A's data

integrity metrics were not affected after DCMA ceased performing EVM system compliance reviews, while Program C's data integrity metrics varied significantly despite continual DCMA EVM system surveillance. While data integrity is an important indication of EVM data validity, EVM system compliance reviews do not appear to influence data integrity. These results may also imply that data integrity metric measurement may not be the most effective means of linking EVM system compliance reviews to program performance.

The results of this research imply limited value-added for basing EVM system compliance reviews primarily upon dollar thresholds. EVM system compliance reviews should be driven more by risk-based evaluation of contractors' overall current and past performance, and consistency of applying EVM principles. EVM system reviews apply to contractors, not specific programs; therefore, a wholistic evaluation of contractors' ability to schedule and perform work should be a primary determinant of the need for compliance reviews.

The authors hypothesize that improved overall EV performance on larger, higher-visibility, technically complex programs is likely due to contractors assigning their "top performers" for high-profile program, project, and EV management, rather than DCMA's performance of DFARS 234.2-required EVM system compliance reviews. Conversely, a lack of EV management experience and decreased emphasis on lower-dollar, lower-visibility efforts by contractor personnel adversely affects program performance to a greater degree. As such, the data analysis suggests that the 2015 DFARS class deviation had no discernible impact on contractors' EV performance, EVM data integrity, nor on their ability to perform in accordance with their Acquisition Program Baselines and associated plans.

APPENDIX A. DEFINITIONS

All information in Appendix A is directly quoted from Defense Contract Management Agency (*DCMA) Manual 3101–02: Program Support Analysis and Reporting.*

ACAT I. Programs categorized as Major Defense Acquisition Program (MDAP) or Major Automated Information Systems (MAIS) programs that have been designated ACAT I by the Milestone Decision Authority.

ACWP. The total dollars spent on labor, material, subcontracts, and other direct costs in the performance of the contract SOW. These costs are controlled by the accounting general ledger and should reconcile between the accounting system and EVMS. ACWP is independently reported by the contractor's accounting system. Simply stated: "actuals."

BCWP. Dollarized value of all work actually accomplished in a given time period or Earned Value. This is equal to the sum of the budgets for completed WPs, completed portions of open WPs, apportioned effort earned on the base tasks, and the value of LOE activities. BCWP is not realized until the work is completed.

BCWR. Represents that portion of the budget for work not yet accomplished within a Control Account. It is the difference between the BAC and the BCWPCUM.

BCWS. Dollarized value of all work scheduled to be accomplished in a given time period or Planned Value. The sum of the performance budgets for all work scheduled to be accomplished within a given time period. This includes detailed WPs, apportioned effort, LOE packages, planning packages, and Summary Level Planning Packages.

BEI. The BEI metric is an IMS-based metric that calculates the efficiency with which tasks have been accomplished when measured against the baseline tasks at a Status

Date. BEI tasks do not include Summary or LOE tasks.

CPI. CPI is an efficiency factor representing the relationship between the performance accomplished (BCWP) and the actual cost expended (ACWP). CPR/IPMR Format 1 contains the BCWP and ACWP data. CPI can be calculated for current period (monthly) or cumulative (to date).

Critical Path. Critical path is a sequence of discrete lower level tasks/activities in the network that add up to the longest overall duration through an end point. The critical path determines the shortest time possible to compete the contract. Any delay of an activity on the critical path directly impacts the baselined completion date; i.e., there is no float on the critical path. Lower level tasks/activities along the critical path have the least amount of float/slack (scheduling flexibility) and cannot be delayed without delaying the finish time of the end point effort.

CV. The difference between BCWP and ACWP. It can be measured using cumulative (CUM) or current (CUR) values at either the WP or the contract level. CPR/IPMR Format 1 contains the BCWP and ACWP data as well as the correlating CVs. The CV% metric quantifies the magnitude of the CV by dividing CV by BCWP and multiplying by 100.

DAES. Principal mechanism for tracking programs between milestone reviews. It is both a reporting and review process serving two primary purposes: (1) Provide awareness of the execution status of all reporting programs, and (2) Provide assessments that enable identification of emerging execution issues that warrant the attention of senior leadership.

MAIS. DoD acquisition program for an automated information system that is either designated by the Milestone Decision Authority as a MAIS, or estimated to exceed certain dollar levels.

Major Programs. A term used by DCMA to identify those programs with specific reporting requirements. Major Programs include (unless approved by exception):

- ACAT I/MDAPs
- DAES programs (excluding MAIS)
- Missile Defense Agency Ballistic Missile Defense System programs
- Strategic Systems Program
- Additional programs or sub-programs designated by the PM&BI Executive Director.

MDAP. ACAT I programs are MDAPs. Programs estimated by the OUSD(AT&L) to require eventual expenditure for Research, Development, Test and Evaluation of more than $365 million (FY 2000 constant dollars) or procurement of more than $2.19 billion (FY 2000 constant dollars), or those designated by the OUSD(AT&L) to be MDAPs

Percent Complete. Percent complete is the percentage of the amount of completed work to date to the PMB or BAC.

Predictive Analysis. The collection, examination, and synthesis of information and data from our on-site presence which states (in terms of future cost, schedule, and performance) what we forecast will happen based on our special knowledge of the supplier and program

SPIX. The Schedule Performance Index (SPIX) is an efficiency factor representing the relationship between the performance achieved or Earned Value or BCWP and Planned Value or BCWS. CPR/IPMR Format 1 contains the BCWP and BCWS data. SPI can be calculated for current period (monthly) or cumulative (to date).

SV. SV is the difference between BCWP and BCWS. CPR/IPMR Format 1 contains the BCWP and BCWS data as well as the correlating SVs. SV can be measured using cumulative (CUM) or current (CUR) values at either the WP or the contract level. The SV% metric quantifies the magnitude of the SV by dividing SV by BCWS and

multiplying by 100

TCPI. TCPI is the ratio of work remaining (BCWR) and future cost of work remaining (ETC).

APPENDIX B. CONTRACT DATA EVALUATION METRICS

All information in Appendix B is directly quoted from Defense Contract Management Agency (*DCMA) Manual 3101–02: Program Support Analysis and Reporting.*

COST DATA INTEGRITY INDICATORS. CPR/IPMR Data Integrity Indicators are metrics designed to provide confidence in the quality of the data being reviewed instead of providing insight into the performance of a contract. The EVM Analyst should report any WBS elements with one of the following conditions being tested for by these metrics.

BCWSCUM > BAC. The Budgeted Cost for Work Scheduled (BCWS) is the contract budget time-phased over the period of performance. The summation of BCWS for all reporting periods should equal the BAC. In other words, BCWS summation for all reporting periods (BCWSCUM) should equal BAC on the month the contract is planned to complete. Both of these values can be found on the IPMR/CPR Format 1. Due to this relationship, the value of BCWSCUM should never exceed BAC. Errors may exist in EVM data resulting in this condition, thereby making it necessary to perform this metric. Compare the value of BCWSCUM to the value of BAC; if BCWSCUM is greater than BAC, consider this an error in the EVM data. There is no plausible explanation. There may be no issue if the value of BCWSCUM is less than BAC.

BCWPCUM > BAC. The Budgeted Cost for Work Performed (BCWP) is the amount of BCWS earned by the completion of work to date. Like the BCWSCUM, the Budgeted Cost for Work Performed, cumulative (BCWPCUM), cannot exceed the value of BAC. The contract is considered complete when BCWPCUM equals BAC. Compare the value of BCWPCUM to BAC. If BCWPCUM is greater, then this is an error, otherwise there is no issue.

ACWP with No BAC. The Actual Cost of Work Performed (ACWP) is the total dollars spent on labor, material, subcontracts, and other direct costs in the performance of the contract statement of work (SOW). These costs are controlled by the accounting general ledger and should reconcile between the accounting system and EVMS. Work should only be performed if there is a clear contractual requirement. The BAC is required to be traceable to work requirements in the contract SOW. If work is performed and the ACWP incurred without applicable BAC, there may be a misalignment between the work and the requirements of the contract. To test for this condition, simply review the IPMR/CPR Format 1 data for WBS elements containing any instance of current or cumulative ACWP but no BAC. If there are elements that meet these criteria, the contractor should provide justification. If this did not occur, consider this an error.

Negative BAC or EAC. BAC is the total budget assigned to complete the work defined within the contract. Likewise, EAC is the Estimate at Completion of the work. A negative total budget is not logical. To test for this condition simply examine the IPMR/CPR Format 1 data for a BAC or EAC less than zero. This test should be performed at the reported WBS levels as well as the total program level. A BAC or EAC less than zero should be considered an error.

Negative BCWSCUM or Negative BCWSCUR. The BCWS is the time-phased contract budget. The summation of BCWS for all reporting periods equals the total contract BAC. When the initial baseline is established there should be no instances of negative BCWS. However, as work progresses there may be legitimate reasons for re-planning of budget. Changes to the baseline may result in a negative value for budget in the current reporting period (BCWSCUR). It is not possible to re-plan more budget than has already been time-phased to date. Therefore, there should not be an instance of negative BCWSCUM. To test for this condition simply examine the current and cumulative sections of the IPMR/CPR Format 1 for BCWSCUM or BCWSCUR less than zero.

Negative BCWPCUM or Negative BCWPCUR. There may be negative BCWP due to wrong consideration for "Earned Value." To test for this condition, simply examine the current and cumulative sections of the IPMR/CPR Format 1 for BCWPCUM or BCWPCUR less than zero.

BCWP with No ACWP. Since work or materials must be paid for, it is not possible to earn BCWP without incurring ACWP. This condition may occur for elements using the Level of Effort (LOE) Earned Value Technique (EVT). In this case, it would signify the support work that was planned to occur is not occurring due to some delay. This metric can be calculated using the IPMR/CPR Format 1 data. Inspect the elements on the report for any instance of current or cumulative BCWP with a corresponding current or cumulative ACWP equal to zero.

Completed Work with Estimate To Complete (ETC). Since work is considered complete when an element's BCWPCUM equals the element's BAC, the ETC is the to complete portion of the EAC. The ETC should be zero if the work is complete, as there should be no projected future cost left to incur. Look for completed elements (BCWPCUM = BAC) with an ETC other than zero. This condition may exist if labor or material invoices are lagging behind and haven't been paid yet. Be sure to adjust your EAC forecast to accommodate this error and refer the issue to the EVMS Center.

Incomplete Work without ETC. If work has yet to be completed, there should be a forecast of the remaining costs to be incurred. Determine if there are any elements that are incomplete (BCWPCUM < BAC) and contain an ETC of zero. If this condition exists, consider it an error.

ACWP on Completed Work. There may be valid reasons to incur cost (ACWP) following the completion of work (BCWPCUM = BAC). However, this should not be considered the norm. Review the IPMR/CPR Format 1 for the following:

- BCWPCUM = BAC
- BCWPCUR = 0
- ACWPCUR $\neq 0$

Keep in mind there may be costs incurred in the month the element of work is complete. That is why it is necessary to check for BCWPCUR. This insures the work was completed in a prior period and if ACWPCUR returns a value other than zero the metric is flagged.

BCWP with No BCWS. Since all budgeted work performed should have been scheduled, occurrences of BCWP without BCWS should be commensurate with early starts in the IMS. The values do not have to be equal since actual work will rarely match the baseline work during project execution, but the values will equal at project completion. This metric can be calculated using the IPMR/CPR Format 1 data. Inspect the elements on the report for any instance of current or cumulative BCWP with a corresponding current or cumulative BCWS equal to zero.

ACWPCUM > EAC. The EAC consists of two components, the actual costs incurred to date (ACWPCUM) and the estimate of future costs to be incurred or the ETC. The ACWPCUM can only be greater than EAC if the ETC is negative or extra cost incurred/recorded due to correction of accounting, management, or ledger errors. There may be limited cases that would require a negative ETC. Using the IPMR/CPR Format 1, examine the elements for any condition of ACWPCUM greater than EAC. If this condition exists, adjust your EAC forecast to accommodate the condition and refer the issue to the EVMS Center.

SCHEDULE DATA INTEGRITY INDICATORS. To begin the analysis, exclude Completed tasks, LOE tasks, Subprojects (called Summary tasks in MS Project), and Milestones. These metrics provide the analyst with a framework for asking educated questions and in support of forecasting schedule completion and estimates at complete. Identified concerns may be issues of compliance and will be referred to the EVMS Center for follow-up.

Logic. This metric identifies incomplete tasks with missing logic links. It helps identify how well or poorly the schedule is linked together. Any incomplete task that is missing a predecessor and/or a successor is included in this metric.

Hard Constraints. This is a count of incomplete tasks with hard constraints in use. Using hard constraints (e.g., Must-Finish-On [MFO], Must-Start-On [MSO], Start-No-Later- Than [SNLT], and Finish-No-Later-Than [FNLT]) may prevent tasks

from moving with their dependencies and, therefore, prevent the schedule from being logic-driven. Soft constraints such as As-Soon-As-Possible (ASAP), Start-No-Earlier-Than (SNET), and Finish-No-Earlier-Than (FNET) enable the schedule to be logic-driven.

Invalid Dates. This area of analysis includes planned tasks that have a forecast start/finish date prior to the IMS status date, completed tasks that have actual start/finish dates beyond the IMS status date, incorrectly statused finish dates when a task is not complete, and tasks that have riding start dates. There should not be any invalid dates in the schedule.

Critical Path Test. The purpose is to test the integrity of the overall network logic and, in particular, the critical path. If the contract completion date (or other milestone) is not delayed in proportion (assuming zero float) to the amount of intentional slip that is introduced into the schedule as part of this test, then there is broken logic somewhere in the network. Broken logic is the result of missing predecessors and/or successors on tasks where they are needed. The IMS passes the Critical Path Test if the project completion date (or other task/milestone) show a negative total float number or a revised Early Finish date that is in proportion (assuming zero float) to the amount of intentional slip applied.

Milestones with Duration. Includes milestones that are planned or in-progress whose duration is greater than zero. Per the Earned Value Management System Interpretation Guide (EVMSIG), milestone tasks should not have a duration.

Missing WBS. Activities without WBS values indicate poor planning and cause problems in reporting information about that task. This metric includes only normal activities and milestones that are planned, in-progress, or complete.

LIST OF REFERENCES

Bruchey, W. J. (2012). *A comparison of Earned Value and Earned Schedule Duration Forecast methods on Department of Defense Major Defense Acquisition programs.* [Master's thesis, Naval Postgraduate School]. NPS Archive: Calhoun. http://hdl.handle.net/10945/17329

Defense Acquisition University. (n.d.). *Earned Value Management (EVM)*. Retrieved July 7, 2020, from https://www.dau.edu/acquipedia/pages/articledetails.aspx#!368

Defense Contract Management Agency. (2017). *DCMA Manual: Program Support Analysis and Reporting* (3101–02). https://www.dcma.mil/Portals/31/Documents/Policy/DCMA-MAN-3101-02.pdf

Department of Defense. (2019). *Department of Defense Earned Value Management implementation guide (EVMIG).* https://www.acq.osd.mil/evm/assets/docs/DOD%20EVMIG-01-18-2019.pdf

DFARS 234. (n.d.). Retrieved September 14, 2019, from http://farsite.hill.af.mil/reghtml/Regs/FAR2AFMCFARS/FARDFARS/DFARS/Dfars234.htm#P109_5286

Dwivedi, U. (2009). *Earned Value Management explained.* Project Smart. http://alecoledelavie.com/accueil/vie_uploads/Portfolio_Programs_Projects_and%20BAU/PortFolio_stuff/Courses%20resources%20stuff/0_PMP/PMP_resources/4_Cost/Earned_value_management_explained.pdf

Grady, C. (2015). *Letter from USD AT&L changing EVMS threshold*. Undersecretary of Defense, Acquisition, Technology & Logistics (USD(AT&L). https://www.acq.osd.mil/dpap/policy/policyvault/USA004395-15-DPAP.pdf

Members, I., Jones, M., Knox, E., & Traczyk, J. (2017). *Better Earned Value Management System implementation.* Joint Space Cost Council.

United States Government Accountability Office. (2009). *GAO cost estimating and assessment guide: Best practices for developing and managing capital program costs*. https://www.gao.gov/assets/80/77175.pdf

THIS PAGE INTENTIONALLY LEFT BLANK

INITIAL DISTRIBUTION LIST

1. Defense Technical Information Center
   Ft. Belvoir, Virginia

2. Dudley Knox Library
   Naval Postgraduate School
   Monterey, California