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Contract over Target Baseline (OTB) Effect on Earned Value Management's Cost Performance Index (CPI)

Dennis E. Jack

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THESIS

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AFIT/GCA/ENC/10-02

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Abstract

Cost growth is a problem in U.S. Department of Defense (DoD) acquisitions. A particular component of cost growth is a cost overrun or Over Target Baseline (OTB). In 2009, Trahan found that the Gompertz growth curve better predicted program Estimates at Completion (EAC) for OTB contracts. In 2010, Thickstun studied "the relationships between overruns and a variety of factors," but found OTB occurrences "random" and questioned the benefit of the OTB process (Thickstun, 2010). In this research, we study OTB's ability to effect improved program cost performance; we examine OTB's effect on the cumulative Cost Performance Index (CPI) slope after an OTB intervention. We find there is no statistically significant change in cumulative CPI slope after OTB. For the data studied, an OTB investment does not significantly improve management's ability to earn cost value as reflected in the cumulative CPI slope.

I dedicate the completion of this effort to Jesus Christ, my wife and my children. I love, because He first loved me (1 John 4:19). Amen.

Acknowledgements

To my wife and children, thank you for enduring this struggle with me; nothing can separate us from the love of God that is in Christ Jesus our Lord, nothing. I'm excited about the next chapter in our lives; Lord, your will be done. Amen.

A special thanks to each of my committee members. To Lt Col Unger, thank you for teaching this "budget guy" the cost discipline (I have a new found respect for the difficulty involved in producing a solid cost estimate) and most importantly, for providing my family and I top cover during difficult times. To Dr. White, thank you for the professional and personal encouragement throughout the thesis process. I know that I could not have done it without you; on many different levels, I appreciate your help very deeply. To Lt Col Wirthlin, thank you for taking a program management interest in this research and thank you for giving me the big picture of the Defense Acquisition System.

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GFA/GCA classmates; thanks for your help...I value our friendships and I look forward to serving with you in the future. To Col(r) Edwards, thank you for mentoring me...our prayerful discussions have been invaluable. To the AFIT Library staff; thank you for your patient support...a special thanks to Mr. Pat Colucci.

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Dennis E. Jack

Table of Contents

Page

Page

List of Figures

List of Tables

Page

CONTRACT OVER TARGET BASELINE (OTB) EFFECT ON EARNED VALUE MANAGEMENT'S COST PERFORMANCE INDEX (CPI)

I: Introduction

Background

The U.S. Department of Defense and our Nation face a timeless challenge: match finite financial resources to prioritized joint-capability requirements while earning the greatest capability value per acquisition dollar spent. The U.S. Government Accountability Office (GAO) has rated the Department of Defense's (DoD) Defense Acquisition System (DAS) as a "high-risk" area since 1990 for its costly and "fragmented" approach to identifying and acquiring materiel solutions to meet joint defense capability requirements (GAO, 2009).

The inability to acquire joint defense capabilities at contracted costs and within scheduled timeframes is a continuing DoD problem. As reported in fiscal year 2008 dollars (Table 1), the DOD's estimated total acquisition cost growth relating to its investment in 95 major defense programs is $295 billion; this cost growth is accompanied by an average schedule delay in delivering initial capabilities of 21 months (GAO, 2008).

Table 1: Analysis of DOD Major Defense Acquisition Programs (GAO-08-604CG)

Analysis of DOD Major Defense Acquisition Program Portfolio (fiscal year 2008 dollars)	
Portfolio status	**Fiscal year 2007 portfolio**
Number of programs	95
Change in total research and development costs from first estimate	40 percent increase
Change in total acquisition cost from first estimate	26 percent increase
Estimated total acquisition cost growth from first estimate	$295 billion
Share of programs with 25 percent or more increase in program acquisition unit cost	44 percent
Average schedule delay in delivering initial capabilities	21 months

Source: GAO analysis of DOD data.

A particular subcomponent of cost growth is a cost overrun or Over Target Baseline (OTB) contract; essentially, an OTB reflects a contractor's inability to produce a required capability at a specified contracted cost. Further, OTB signifies management's decision to establish a new Earned Value Management (EVM) Performance Measurement Baseline (PMB) "to improve managerial control over the execution of the remaining work in a project" (DAU, 2007). OTB is a very detailed, ten-step process that requires active commitment from all acquisition stakeholders assigned to that contract effort. Per the DAU guidebook, the OTB motto is "Do it once! Do it right!" (DAU, 2007).

In 2009, Trahan found that nonlinear growth modeling, specifically the Gompertz growth curve, better predicted program Estimates at Completion (EAC) for OTB contracts (Trahan, 2009). In 2010, Thickstun attempted to complement Trahan's research by producing an OTB prediction model based on logistic regression and found that OTB is a random occurrence for the data studied and questioned the value of the OTB process (Thickstun, 2010). Thickstun reports that "there have been over $17 billion in cost overruns related to OTBs since 2000" and for the dataset studied, "approximately twenty percent of all acquisition contracts in the DoD experienced cost overruns over the past 20 years" (Thickstun, 2010).

At the contract level, internal control aimed at producing program-level decision support was instituted by the DoD decades ago. Since the 1960's, the DoD has required major defense acquisition contractors to comply with Earned Value Management (EVM) standards and financial reporting as a means to control cost, schedule and performance (Fleming, 2000). The Cost Performance Index (CPI) is a critical EVM cost performance

metric. The CPI is not only a measure of cost performance health, it is a statistic utilized in predicting a program's Estimate at Completion (EAC). For its importance, the CPI has been a critical topic of academic research centered on EAC methods and CPI heuristics. In 2008, Henderson states “the widely reported CPI stability rule cannot be generalized even within the US Defense Department (US DoD) project portfolio” and referring to the goal of improving project performance, “an understanding of project characteristics, which result in progressively improving CPI would, if these characteristics could be emulated in other programs, be an extremely useful advance to practice” (Henderson, 2008). Identifying specific PM actions that improve the cumulative CPI, correspondingly increasing the value of the cumulative CPI slope, is the goal of our research.

As it relates to the CPI, an OTB intervention typically removes any cost variance associated with contract performance and resets the CPI to a value of one. Given the CPI is reset to one, the only method of determining OTB effectiveness on the CPI is to study the cumulative CPI trend or the cumulative CPI slope after OTB. The cumulative CPI slope change (comparing slopes before and after OTB) provides a generic measurement that can be examined for all types of programs regardless of technical risk, appropriation and programmatic content. The goal of OTB is to improve managerial control of a project's remaining work in terms of cost, schedule and performance; if effective, OTB should increase the cumulative CPI slope.

Purpose

Given “the DoD is entrusted with more taxpayer dollars than any other federal agency", it is incumbent upon management (at the enterprise and program levels) to identify and implement management actions that produce improved acquisition outcomes (GAO, 2009). Our research attempts to identify program management actions that produce a positive managerial cost effect; specifically, we examine OTB process actions (treatment) for a positive effect on the rate of earning cost value as measured by the cumulative CPI slope after OTB.

Research Questions and Methodology

Our research aims to answer the following questions:

1) Does the OTB process (treatment) improve the cumulative CPI's rate of change (cumulative CPI slope) after OTB?

2) Is the cumulative CPI slope after OTB sensitive to time and/or programmatic factors to include contract type, military service and the purpose of the appropriation?

To answer these questions, we examine the cumulative CPI rate of change, the slope of the line created by cumulative CPI data points before and after OTB. Similar to past OTB and EVM research, the DoD Defense Acquisition Executive Summary (DAES) database is the source of our data. Cumulative CPI is not distributed normally, therefore, we utilize a nonparametric test (Mann-Whitney Test) to determine whether there is a

statistically significant difference in the cumulative CPI slopes before and after OTB, which we describe in Chapter 3.

Chapter Summary

OTB seeks to gain managerial control over remaining work in terms of cost, schedule and performance. Earning greater capability value for every dollar spent is a timeless challenge that cuts across every DoD acquisition program regardless of life cycle stage, platform and program risk. As stewards of taxpayer funds, the DoD should exploit acquisition actions that produce improved cost, schedule and performance outcomes and divest itself of acquisition actions that fail to produce the same. Chapter II provides a review of past research concerning EVM and OTB. In Chapter III, we explain the source of our data, present the hypothesis test and explain the statistical test. In Chapters IV and V, we summarize the results of our analysis and provide policy implications based on our findings.

II: Literature Review

In this chapter, we expand on the EVM architecture, the historical body of EVM research and emphasize CPI characteristics. Additionally, we define the term OTB, discuss the OTB process and emphasize the stated purpose of OTB.

Earned Value Management (EVM) Overview

Since its inception, EVM has been a program management (PM) tool that ties cost, schedule and performance into an integrated program baseline; essentially, the EVM construct serves as a roadmap of execution and an internal control mechanism to assess project status and future completion. In a memorandum dated 3 Jul 07, USD AT&L Kenneth J. Krieg described EVM as a project management best practice that "provides a disciplined approach to managing projects successfully through the use of an integrated system to plan and control authorized work to achieve cost, schedule and performance objectives" (Krieg, 2007).

Contractor earned value management systems (EVMS) rest on 32 guidelines or industry standards established by American National Standards Institute (ANSI)/Electronic Industries Alliance (EIA); "the DoD formally adopted ANSI/EIA-748 in August 1998 for application to major defense acquisition programs" (DCMA, 2006). The guidelines are not prescriptive, but give government contractors the flexibility to develop business information systems that accurately collect and report acquisition program execution data to enable resource decision-making (DCMA, 2006). OMB Circular No. A-11 (OMB A-11), Section 300, establishes policy for planning, budgeting, acquisition and management of Federal capital assets "to ensure scarce public resources

are wisely invested" (OMB, Jun 08). OMB A-11 references EVM contract criteria set forth in the Federal Acquisition Regulation (FAR). FAR 7.105(b)(10) discusses EVMS performance analysis and calls for EVMS compliance language in written acquisition plans. Further, FAR 34.201and 34.202 mandate EVMS for major development acquisition in accordance with agency procedures and ANSI/EIA-748 standards and calls for program Integrated Baseline Reviews (IBR) when EVMS is required. FAR 34.203 directs the insertion of an EVMS contract clause in solicitations requiring a contractor EVMS. In terms of agency procedures, the Defense Federal Acquisition Regulation Supplement (DFARS) 234.2 and the DoD Instruction 5000.2, Operation of the Defense Acquisition System, prescribe mandatory EVM requirements for cost and incentive contracts. These regulations require formal compliance validation of contractor EVMS with ANSI/EIA-748 for cost and incentive contracts ≥ $50 million. Further, for cost and incentive contracts from $20-50 million, a formal validation is not required, but ANSI/EIA-748 compliance is required. Finally, for any contract less than $20 million, PMs have discretion and can decide whether the cost of an EVMS is justified by its benefits (DAU, 2009).

Beyond the purpose and regulatory requirements, EVM is a simple and useful PM tool. The foundation of EVM is the Performance Measurement Baseline (PMB); Cukr describes it well by stating "the purpose of a performance measurement baseline is to capture the technical work and performance requirements, the time limitations, and the resource constraints of a project in a time-phased, dollarized plan for successfully accomplishing the project" (Cukr, 2000). The importance of an accurate and disciplined

PMB cannot be overstated. The DAU EVM "Gold Card" (Appendix A) provides a summary of EVM calculations and terms (DAU, 2009).

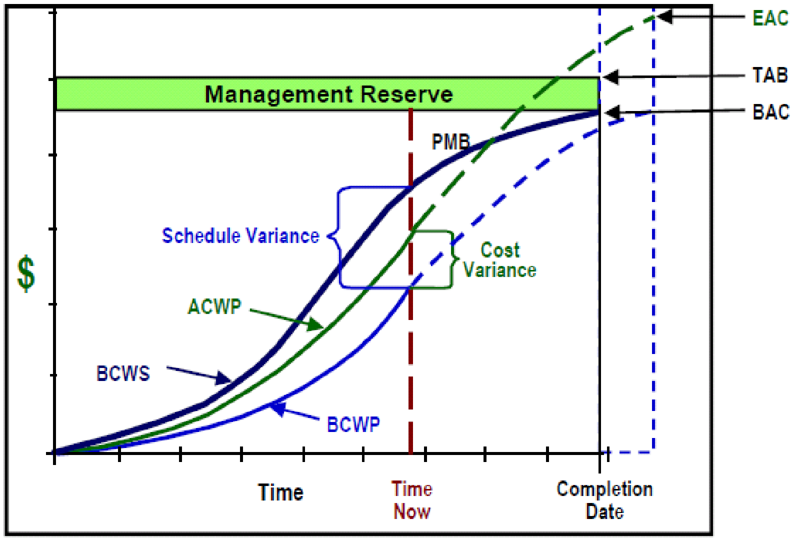


Figure 1: DAU Gold Card, 2009

The PMB, the Budgeted Cost of Work Scheduled (BCWS) or the Planned Value (PV) is the starting point of EVM analysis; "the focus of earned value has been consistent: the accurate measurement of physical performance against a detailed plan (or PV) to allow for the accurate prediction of the final costs and schedule results for a given project" (Fleming, 2000). As a program executes and data is collected from Contract Performance Reports (CPR), the Budgeted Cost of Work Performed (BCWP) or the Earned Value (EV) is compared to the Actual Cost of Work Performed (ACWP) or the Actual Cost (AC) and the Budgeted Cost of Work Scheduled (BCWS) or the Planned Value (PV) at "time now" to determine the Cost Variance (CV) and the Schedule

Variance (SV), respectively. These variances, positive or negative, provide program managers insight into the current cost and schedule status of the project. At "time now", two performance metrics can be generated by dividing EV by AC and EV by PV. The first calculation, EV/AC, produces the Cost Performance Index (CPI). The CPI is a "time now" metric that measures contractor cost performance. The second calculation, EV/PV, produces the Schedule Performance Index (SPI). The SPI measures contractor schedule performance. EVM cost analysts and PMs utilize the CPI, the SPI and various combinations of the two indices (SCI product and Composite additive weighting) as performance factors (Table 2) to calculate a range of Estimates at Completion (EAC).

Table 2: EVM Performance Indices (Thickstun, 2010)

$$\text{CPI} = \frac{\text{Budgeted Cost of Work Performed (BCWP)}}{\text{Actual Cost of Work Performed (ACWP)}}$$

$$\text{SPI} = \frac{\text{Budgeted Cost of Work Performed (BCWP)}}{\text{Budgeted Cost of Work Scheduled (BCWS)}}$$

$$\text{SCI} = \text{CPI} * \text{SPI}$$

$$\text{Composite Index} = (\text{w1}*\text{CPI}) + (\text{w2}*\text{SPI})$$

Once the performance factors are determined and the Budget At Completion (BAC) is known, index-based EACs are calculated by adding the AC to the quotient of remaining work divided by a selected performance factor (Table 2). Christensen provides an excellent example of EVM's simplicity and utility in calculating a range of

EACs. In the wake of the A-12 cancellation, Christensen developed Tables 3 and 4 to demonstrate the utility of the earned value management report (Christensen, 1999).

Table 3 (Christensen, 1999)

Cost Performance Data for A-12 Program
(April 1990, Millions of Dollars)

Month	BCWS	BCWP	ACWP	SV	CV	BAC	EAC	VAC
April	2,080	1,491	1,950	(589)	(459)	4,046	4,400	(354)

(See Appendix A for EVM acronym definitions and equations.)

Table 4 (Christensen, 1999)
A Range of Estimates at Completion for A-12 Program
(Derived from the Cumulative Performance Data in Table 2)

Performance factor	Performance factor value	EAC (Millions)
CPI x SPI	0.5481	$ 6,612
SPI	0.7168	$ 5,514
.8 CPI x .2 SPI	0.7551	$ 5,334
CPI	0.7646	$ 5,292

(See Appendix A for EVM acronym definitions and equations.)

Having calculated the index-based performance factors (Table 4) from the cost data (Table 3), Christensen effectively displayed a lower and upper bound range of Estimates at Completion (EAC) available to A-12 program leadership (Table 4). Christensen's example demonstrates the relative simplicity of EVM calculations, but highlights its usefulness in decision support.

Commenting on the large number of EAC calculation formulas, Fleming and Koppelman characterize the cumulative CPI based EAC calculations (Table 4) as "three of the more accepted formulas" (Fleming and Koppelman, 2000).

The Cost Performance Index (CPI)

Characterization of the CPI is particularly important to our research. Fleming and Koppelman characterize the CPI as a “delicate relationship between the value of the work physically completed and in process, related to the actual costs incurred for doing such work” (Fleming and Koppelman, 2000). Additionally, the CPI is a generic metric that accommodates all types of programs and levels of technical risk and “reflects the health of (a) project” (Fleming and Koppelman, 2000). Regardless of the specific program, the CPI highlights cost variance and directs management attention to negative trends.

By definition, the Cost Performance Index is BCWP/ACWP, the quotient of Budgeted Cost of Work Performed (BCWP) divided by the Actual Cost of Work Performed (ACWP); the CPI is a measure of cost efficiency or cost performance relating Earned Value (EV) to Actual Cost (AC). Cumulative CPI ($CPI_{cum)}$ relates total EV to total AC for “time now”, while CPI in general can relate EV to AC for any defined period. CPI values less than one indicate an unfavorable overrun condition and CPI values greater than one indicate a favorable underrun condition. In a scenario of perfect knowledge and perfect execution, the CPI is consistently a value of one. Figure 2 depicts all three scenarios.

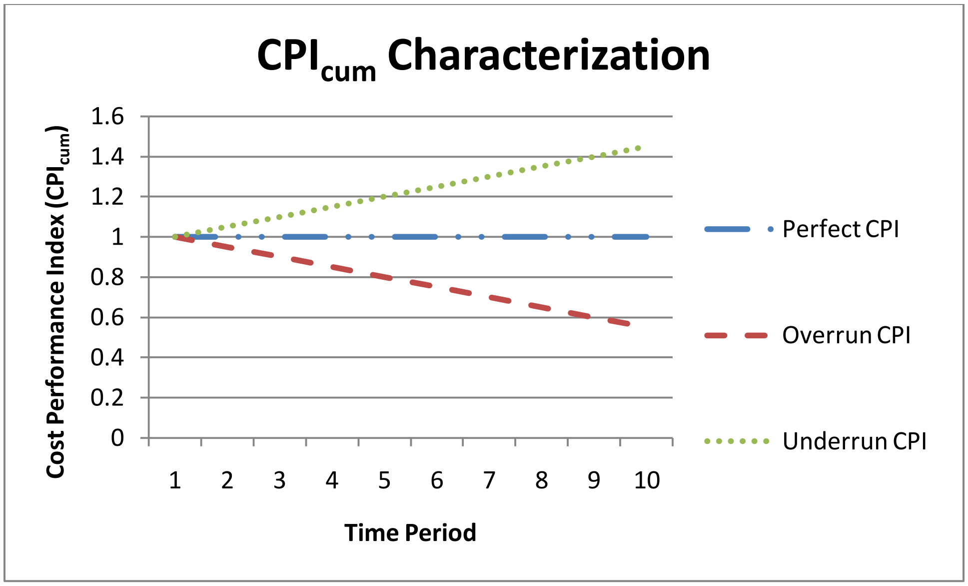


Figure 2: Characterization of the Cost Performance Index (CPI_{cum})

The CPI provides a great deal of programmatic insight, especially into the PMB's technical risk. Recall that the PMB is a "time-phased, dollarized plan" that represents the planned technical work packages for a particular program; it is an estimated plan (Cukr, 2000). With any estimated plan, there exists risk and uncertainty and that uncertainty is reflected in the actual execution of the program. In a "perfect knowledge" scenario, the program produces a capability exactly as planned; the program earns \$1 dollar of value for every \$1 dollar of actual cost. The program's CPI is perfectly constant at a value of one (Figure 2) and the cumulative CPI slope is horizontal. Depicted as the Overrun CPI slope, the program that lacks perfect knowledge and estimates optimistically will earn less than \$1 dollar of value for every \$1 dollar of cost. Conversely and depicted as the Underrun CPI slope, the program that lacks perfect knowledge and estimates conservatively will earn greater than \$1 dollar of earned value per \$1 dollar of cost. CPI

directly reflects the cost performance of the program and provides insight into program technical risk and/or the quality of the estimating process. Additionally, the slope of the cumulative CPI provides insight into management's ability or inability to actively improve its cost position and performance.

Historical EVM Research

EVM research centers on EAC prediction methods and cumulative CPI heuristics. In a comprehensive review of twenty-five proposed or comparative EAC studies that explored index, regression and other methods, Christensen concluded that "no one formula or model is always best" and "the accuracy of index-based formulas depends on the type of system, and the stage and phase of the contracts" (Christensen, 1995). Since that time, Tracy examined regression based EAC models and found that regression models only outperform index-based models at early stages of completion (Tracy, 2005). In 2009 Trahan produced three EAC models using the Gompertz growth curve and concluded that growth models, depending on model and phase, are "a more accurate estimating tool for identified OTB contract's EAC as compared to the CPI, SCI and Composite Index methods" (Trahan, 2009). Noted by Thickstun, these findings add further support to Christensen's 1995 research that there is no one EAC method that outperforms the others in all situations (Thickstun, 2010). Further, through logistic regression analysis of various OTB program factors, Thickstun attempted to complement Trahan's research by developing a model to predict OTB contracts. Thickstun concluded that "the ability to predict OTBs was no better than a coin flip" for the data studied and

“it suggests that OTBs may occur randomly”; she goes on to question the benefits of the OTB process (Thickstun, 2010).

Within EVM, the CPI is a central index utilized in almost every performance factor EAC calculation. Additionally, CPI research has developed rules of thumb (heuristics) that empower PMs to test EAC confidence and understand program stability. The following CPI heuristics are particularly useful in evaluating a contractor’s EAC.

- “Research has shown that the EAC derived from the CPI is a reasonable floor to the final cost” (Christensen, 1996).
- “When the cumulative CPI is significantly less than TCPI, it is highly doubtful that the contract will be completed at the EAC” (Christensen, 1999).
- “The smallest and largest EACs were derived from the CPI and the product of the CPI and SPI, respectively” (Christensen, 1999).

The PM’s ability to improve cost performance is particularly important to our research and directly tied to CPI stability. Concerning DoD cumulative CPI stability, defined by Christensen as “cumulative CPI does not change by more than plus or minus 0.10 from its value at the 20 percent completion point”, the following heuristics are cited.

- DoD research supports the fact that DoD programs are unable to change their cumulative CPI by +/- 10% once the 20% program completion point is achieved (Christensen and Payne, 1992).
- “A stable CPI is evidence that the contractor’s management control systems, particularly the planning, budgeting, and accounting systems are functioning properly” and “thus indicate that the contractor’s final costs of authorized work, termed ‘Estimate at Completion,’ are reliable” (Christensen and Payne, 1992).
- “Knowing that the CPI is stable may help the analyst evaluate the capability of a contractor to recover from a cost overrun by comparing the CPI with other key indicators” (Christensen and Payne, 1992).

- Cumulative CPI "does not change by more than 10 percent once the contract is 20 percent complete; in fact, it tends to decrease" (Christensen, 1993).
- "Recoveries from cost overruns on defense contracts are extremely rare, especially when the project is more than 20 percent complete" (Christensen, 1999).
- "Based on an analysis of 155 defense acquisition contracts, Christensen and Heise (1993) reported that the range of the cumulative CPI from the 20 percent completion point to contract completion was less than 0.20 for every contract. This result is usually interpreted to mean that the cumulative CPI does not change by more than plus or minus 0.10 from its value at the 20 percent completion point, and is used to evaluate the reasonableness of projected cost efficiencies on future work" (Christensen and Templin, 2002).

In 2008, Henderson and Zwikael re-examined CPI stability and found contrary evidence inside and outside of the DoD. In their study of twelve Israeli Hi-Tech projects, twenty United Kingdom construction projects and five Australian IT projects for cumulative CPI stability, they state "this research does not support the previously referenced generalizations that the CPI stability rule has universal applicability for all projects utilizing the EVM method" (Henderson, 2008). Specifically concerning the aforementioned international contracts, Henderson and Zwikael found "that (CPI) stability is usually achieved very late in the project lifecycle, often later than 80% complete for projects in these samples" (Henderson, 2008).

Further, Henderson cites contradictory evidence within the DoD. In 1996, Michael Popp, U.S. Naval Air Systems Command (NAVAIR), conducted a study concerning the confidence level of programs not breaching 10% over budget. To answer a question posed by NAVAIR's Program Executive Officer (PEO), Popp and staff developed "probability distributions of EAC's (based on Cost Performance Index at

Complete (CPI)) based on current CPI and % complete of programs based on history" (Popp, 1996). Simplifying the question, Popp asked, "given a program that has CPI of X and a percent complete of Y, what is the most likely finishing CPI" (Popp, 1996). Popp's charts display the correlation of cumulative CPI at a defined range of percent complete to final CPI. By 90-100% complete, the correlation is almost exactly one for all programs. The greatest deviation (from the correlation value of one) is seen in the 10-20% completion chart. Using Popp's correlation charts and a +/-10% CPI stability enclosure technique, Henderson concludes from Popp's data that "CPI stability was also achieved very late in the project lifecycle, often as late as 70-80% completion" and "this finding is consistent with late CPI stability findings for the (international) commercial sector" (Henderson, 2008).

The purpose of our research is not to dispute past CPI heuristics, but to inquire into PM actions that produce an increase in final cumulative CPI. At the 10-20% complete point, Popp's correlation chart does not display a straight line value of one, meaning DoD programs and program managers have the ability to effect final CPI change for better or for worse. Our research utilizes the OTB construct to define a set of PM actions to study for its treatment effect on cumulative CPI.

In a broader EVM sense, Fleming and Koppelman state that "final forecasted results are not necessarily preordained" and "final project results can often be altered, but only when aggressive management actions are taken" (Fleming and Koppelman, 2000). Consistent with EVM research and having noted several important tradeoff variables, Fleming and Koppelman stress that aggressive action, "if taken early," can change project outcomes (Fleming and Koppelman).

Over Target Baseline (OTB) Overview

All of EVM starts with the Performance Measurement Baseline (PMB); the PMB is an integrated cost, schedule and performance execution plan. In terms of changing the PMB, Cukr states, "the reasons fall into three major categories: authorized contract changes (negotiated changes and authorized unpriced work), internal replanning, and inadequate remaining budget in the contract with a resulting requirement for an OTB" (Cukr, 2000). From a requirements and funding viewpoint, authorized contract changes represent requirement growth with commensurate funding growth, internal replanning represents a reallocation of existing contract funds to existing contract requirements and OTB represents the contractor's need for additional funds to perform the unchanged contract budget base requirements (Cukr, 2000).

In summary, OTB reflects a contractor's inability to produce a required capability at a specified contracted cost and signifies management's decision to establish a new EVM Performance Measurement Baseline (PMB) "to improve managerial control over the execution of the remaining work in a project" (DAU, 2007). OTB (cost overrun) increases Total Allocated Budget (TAB) beyond a constant Contract Budget Base (CBB).

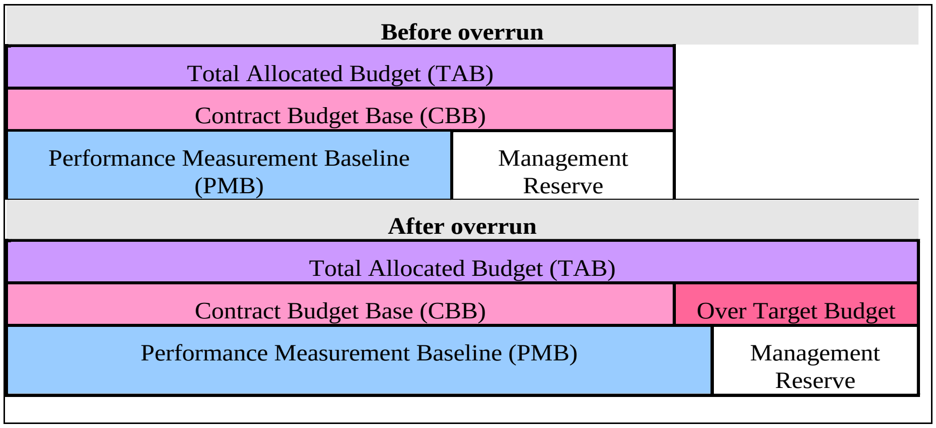


Figure 3: Over Target Baseline (DCMA, 2006)

The OTB process entails ten steps in which the contractor and the customer work together to establish a new bottoms-up estimate and integrated plan (PMB) for a program's remaining work. The process involves customer approval, consensus on work scope, consensus on the master schedule, a collaborative risk analysis and a detailed understanding of work packages tied to budget and time constraints at the Control Account Manager (CAM) level. The entire OTB process (Figure 4) aims at regaining managerial control of remaining work in terms of cost, schedule and performance.

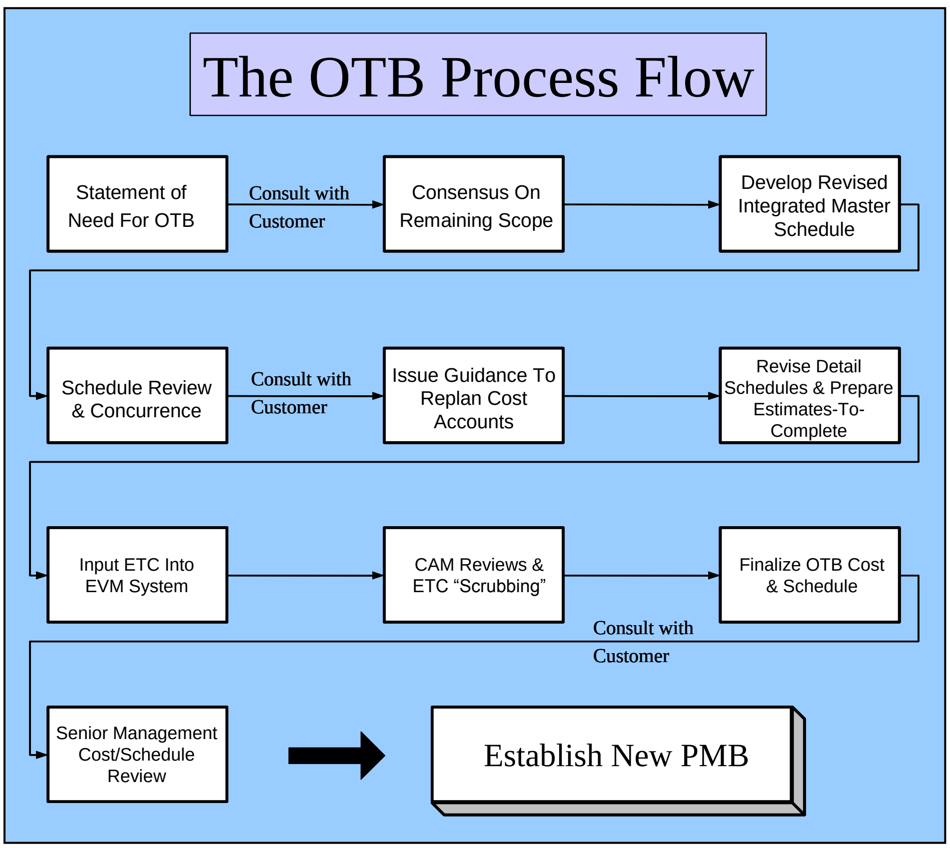


Figure 4: OTB Process Flow (DAU, 2007)

OTB and CPI Interaction

During the OTB process, program managers have the choice to remove all or some of the EVM variances; typically, elimination of all variances, "is the most common form of variance adjustment in an OTB situation" (DAU, 2007). Cukr states, "this action (eliminate variances) makes sense if you consider that the OTB essentially builds the past variance trend into the baseline through the contractor's estimate, upon which the OTB is built" (Cukr, 2000). In detail, elimination of the cost variance means setting the Budgeted Cost of Work Performed (BCWP) equal to the Actual Cost of Work Performed (ACWP), which adjusts the cumulative CPI value to one.

Adjusting the CPI to one is typical in OTB situations, but not necessary for our study. More generically, our research examines the slope of the cumulative CPI trend line (typically a negative slope or growing overrun) and is not necessarily interested in the level of the cumulative CPI metric. To clarify, Figure 5 depicts two CPI trend lines of equal slope value post an OTB intervention (OTB at Time Zero).

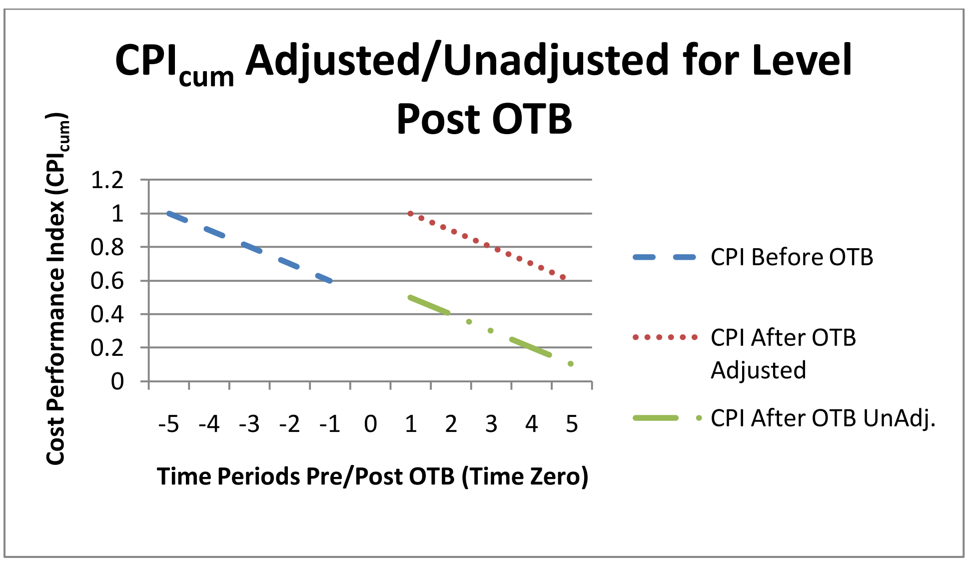


Figure 5: CPI_{cum} Trend Adjusted/Unadjusted for Level Post OTB (Equal Slopes)

In contrast to the equal pre- and post-slopes in Figure 5 above and consistent with the theory of our research, Figure 6 depicts CPI adjusted and unadjusted for level post OTB with a horizontal cumulative CPI slope. Figure 6 implies that the OTB process has positively affected the cumulative CPI slope and the program in question is now "perfectly" earning $1 dollar of earned value for every $1 dollar of actual cost regardless of CPI level. The theoretical program, having gone through the OTB process, has rightly assessed the remaining work, its associated risks and has properly reprogrammed a commensurate amount of funding to the remaining effort.

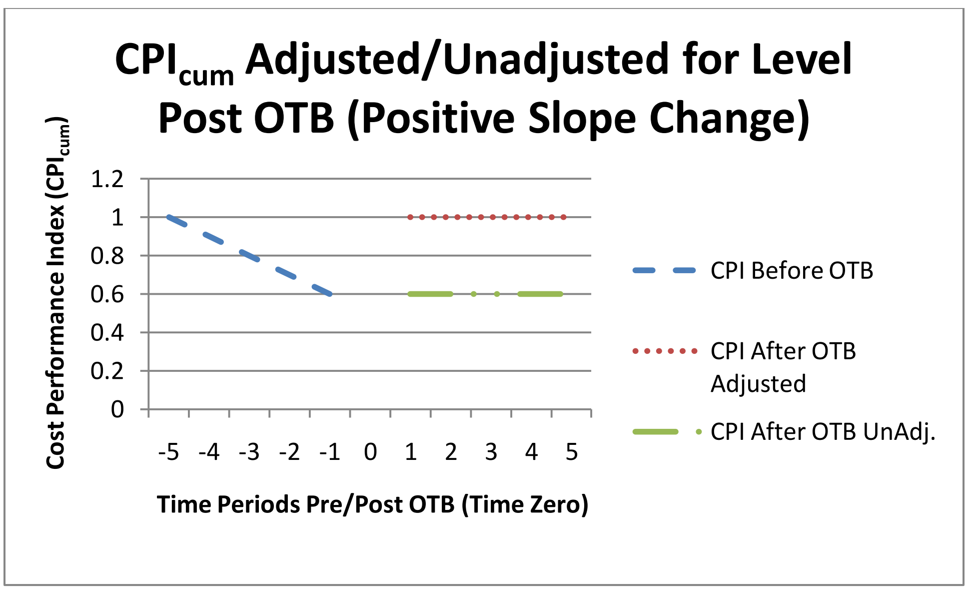


Figure 6: CPI_{cum} Trend Adjusted/Unadjusted for Level Post OTB (Positive Slope Chg.)

This type of pre- and post-OTB analysis is consistent with Cukr's direction to OTB analysts concerning the elimination of cost and schedule variances as discussed above. Cukr states "as a result (of eliminating past variances), analysts can adjust their trend analysis by focusing on the cost and schedule trends since the OTB, and comparing pre- and post-OTB" (Cukr, 2000). Analysts should allow "several months" of reporting to occur prior to performing post OTB analysis based on cumulative indices (DAU, 2007). Consistent with this guidance, our analysis of post-OTB cumulative CPI slopes begins at six months and includes all cumulative CPI points pre-OTB.

Chapter Summary

In Chapter II, we reviewed fundamental EVM and OTB concepts to include past research and established the relationship between EVM and OTB. Specifically, we discussed OTB's effect on cumulative CPI and characterized cumulative CPI heuristics. Historical DoD research supports the validity and importance of index-based EAC calculations and displays the value of CPI heuristics in evaluating contractor EACs. Of particular importance to our current study is cumulative CPI stability. The vast majority of DoD research (Christensen et al) finds that cumulative CPI is stable at the 20% completion point, meaning that cumulative CPI will not deviate by +/- 10% through program completion, but recent research provides evidence against CPI stability with the intent of finding program actions that produce progressive cumulative CPI improvement (Henderson, 2008). In Chapter III, we explain the source of our data, provide the cumulative CPI slope calculation, present an OTB hypothesis test that examines OTB's effect on cumulative CPI slope after OTB and explain the Mann-Whitney Test

(nonparametric statistical test). In Chapters IV and V, we summarize the results of our analysis and provide policy implications based on our findings.

III: Data and Methodology

Data Source

Consistent with previous EVM research, we utilized cumulative and summary EVM reports contained in the Defense Acquisition Executive Summary (DAES) database, retrieved through the Defense Acquisition Management Information Retrieval (DAMIR) system, for all DoD Major Defense Acquisition Programs (MDAP) as our source data. Specifically, we compiled the cumulative and summary EVM reports of all DAES-identified OTB contract efforts categorized by appropriation purpose (RDT&E or Procurement), service component (Air Force, Army, DoD, Navy) and contract type (Cost Plus and Fixed). To increase data validity, we chose "system-identified" OTB contract efforts (OTB date data field populated in DAMIR) as the focus of our study to increase assurance that the contractor and customer acknowledged OTB status. Our decision to utilize "system-identified" OTB contract efforts differs from Thickstun's choice to use DAU's definition (TAB > CBB) (Thickstun, 2010); the DAES database contained instances of TAB exceeding CBB without the OTB data field being populated. Given the fact that this study analyzes an OTB "treatment effect", we chose the more narrow system query of OTB occurrences to support the assumption of contractor and customer agreement. Once compiled, we applied four data exclusions to arrive at our final dataset.

Data Exclusions

1.) <u>Data Purification:</u> The dataset contained duplicate OTB dates, consecutive OTB dates and OTB dates greater than one per quarter. To adjust, we removed duplicate dates by sorting chronologically, combined consecutive dates to facilitate study and removed OTB date occurrences greater than one per quarter to allow the time necessary

to implement the OTB process. Given the number of steps in the OTB process and inexact time definition in literature, we assumed three months as the minimum amount of time necessary to implement an OTB. DCMA states "one to two full accounting periods after written authorization to proceed is received should provide the contractor with sufficient time to fully implement an OTB/OTS in required reports" (DCMA, 2006). Given OTB written approval is required within 30 days and typical accounting periods are monthly, the assumption of three months is consistent with the aforementioned exclusion.

2.) Unstable Contract Budget Base (CBB): Concerning OTB implementation, “it is usually best to isolate and separately implement the changes associated with reprogramming (OTB)" (DAU, 2007). As discussed in our literature review, OTB is "within-scope" reprogramming, meaning that the contract requirement is unchanged; OTB reflects a contractor's inability to produce a defined requirement at a contracted cost, namely an overrun. To control for requirement growth and to ensure we studied similar requirements on either side of OTB for treatment effect, we implemented a CBB stability rule based on mean CBB. We excluded all contract efforts that experienced CBB change greater than +/-10% of the mean CBB ((Max CBB of effort - Min CBB of effort) / Avg CBB of effort).

In terms of single-group research design, this exclusion increases internal validity by removing an historical threat; if CBB has fluctuated consistently throughout the history of the program, this fluctuation of requirement contributes to a diminished effect and threatens internal validity (Trochim, 2008). Essentially, it is important to have a

stable or similar requirement on either side of the OTB treatment to measure its incremental effect on the cumulative CPI slope.

3.) Insufficient Reports (Reports count <5): Including the OTB date, if an OTB contract effort had less than five reports (data points), it was excluded for insufficient data. We were unable to calculate a slope before and after OTB.

4.) Multiple OTBs Removed: After applying the previous exclusions, only six contract efforts contained two or greater OTB occurrences. Given the small sample size, and low percentage of total OTBs studied, we excluded these OTBs from our study. Referencing the contractor's understanding of the overrun problem and the contractor's ability to produce a valid plan for remaining work, DCMA states that multiple OTBs "may indicate significant underlying management problems that should be investigated" (DCMA, 2006). Knowing that second OTBs are problematic, including this data in our study would skew our results.

Table 5 accounts for our data exclusions. Our final dataset contains 40 contracts, with 47 contractual efforts having 47 "system-identified" first OTBs (OTB 1s).

Table 5: OTB Data Exclusion Accounting

Data Pull/Exclusion	Contracts (C)	Efforts (E)	OTBs	OTB Delta
DAMIR/DAES (Nov 09)	2267	3231	n/a	n/a
OTB Initial Data Pull (Nov 09)	177	220	392	n/a
Exclusion 1: Data Purification	177	220	318	-74
Exclusion 2: Unstable CBB	71	89	143	-175
Exclusion 3: Insufficient Reports	40	47	53	-90
Exclusion 4: OTB 2s removed	40	47	47	-6
Final OTB Dataset	40	47	47	n/a

Slope Calculation

Since program managers typically adjust cumulative CPI to a level or value of one during the OTB process (Figure 6), our test is only concerned with OTB's effect on the cumulative CPI slope before and after OTB; essentially, we are looking for a positive increase in the cumulative CPI slope. A positive slope change indicates an improvement in management's ability to earn value or otherwise stated, management's ability to reverse a progressively growing overrun.

We utilized simple linear regression, method of least squares, to calculate the slopes pre- and post-OTB. With the cumulative CPI (continuous variable) on y-axis and Time (in months) on the x-axis, we calculated the cumulative CPI slopes for all 47 OTB occurrences with the following Least Squares Line equation (McClave, 2008).

(1)

Given the sum of errors is zero and the sum of squared errors is minimized, where (beta zero) is the y-intercept and (beta one) is the slope of the line (McClave, 2008).

Additionally, using equation (1), we calculated cumulative CPI slopes for all 47 OTBs broken out by programmatic factors of appropriation purpose (RDT&E or Procurement), service component (Air Force, Army, DoD, Navy) and contract type (Cost Plus, Fixed). Further, we calculated each slope by factor and time period post-OTB. Varying time post-OTB, we utilized six post-OTB timeframes to include six, nine, twelve, eighteen, twenty-four and all-months. Consistent with DAU guidance, we utilized all pre-OTB cumulative CPI data points to calculate the cumulative CPI slope before OTB and varied time after OTB starting at six months (typically two consecutive reporting periods) to examine the time effect. These categorical and time breakouts enabled further sensitivity analysis; essentially, we tried to determine if OTB's effect on cumulative CPI post-OTB was sensitive to time and/or the noted programmatic factors.

Hypothesis Test

The hypothesis test, performed at the 95% confidence level (alpha 0.05), examines OTB's effect on cumulative CPI slope before (b) and after (a) OTB. More specifically, we compare the median (m) location of two population probability distributions relating to Cumulative CPI Slopes Before OTB (m_b) and Cumulative CPI Slopes After OTB (m_a). The Null Hypothesis, Ho (2), states that m_b is equal to m_a. The Alternative Hypothesis, Ha (3), states that m_b is less than m_a; since we are testing for a

positive change in the cumulative CPI slope after OTB, it is a one-tailed test. If OTB has an effect on the cumulative CPI median slope location, we will reject Ho and conclude that Ha is true (median before is statistically less than the median after). If OTB has no effect, we will fail to reject Ho and conclude that Ho is true (median locations are statistically equal).

Null Hypothesis (Ho): $m_b = m_a$ (2)

Alternative Hypothesis (Ha): $m_b < m_a$ (3)

The variable of interest, cumulative CPI slope, is a continuous random variable, not normally distributed (Figures 7 and 8). We ran Minitab® Kolmogorov-Smirnov (KS) test to determine normality; given a KS value greater than 0.05 (alpha level) and visual inspection of the plotted data, we reject the assumption of normality. Given normality fails, we must employ a nonparametric test to compare the median locations.

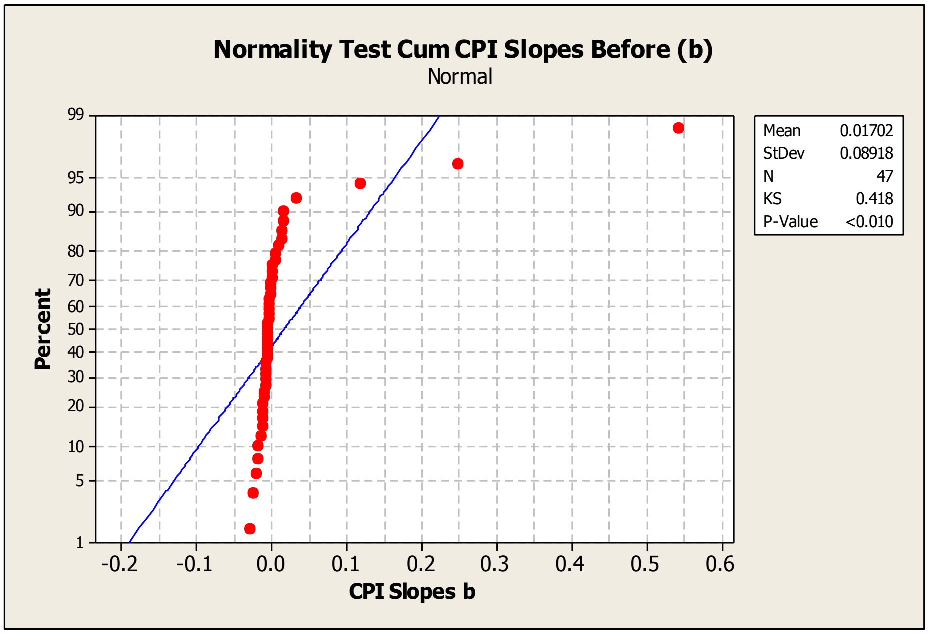


Figure 7: Normality Test for Cumulative CPI Slopes Before OTB

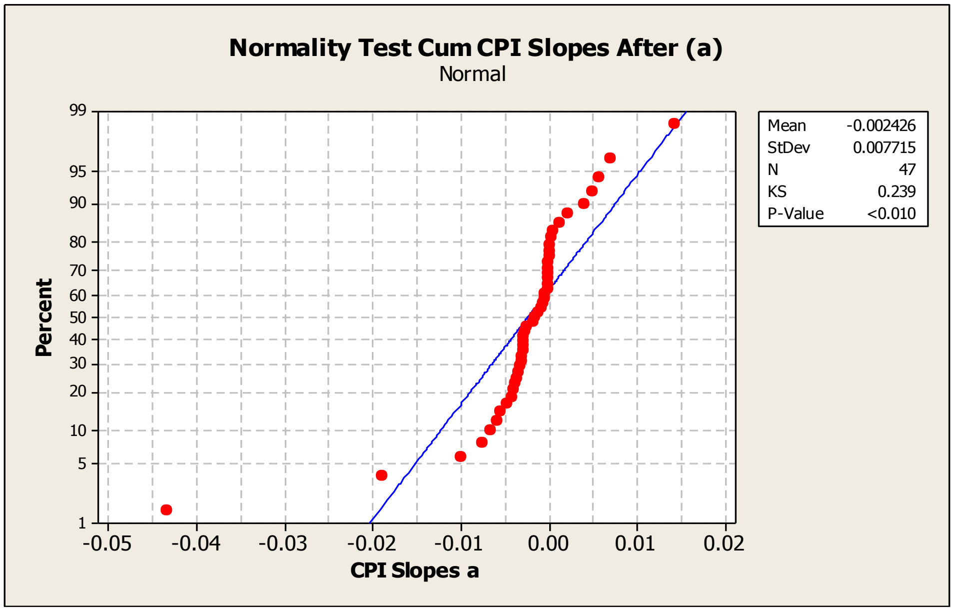


Figure 8: Normality Test for Cumulative CPI Slopes After OTB

Mann-Whitney U-Test

"Nonparametric methods (distribution-free tests) focus on the location of the probability distribution of the population, rather than on specific parameters of the population, such as the mean (hence, the name nonparametrics)" (McClave, 2008). Specifically, the Mann-Whitney U-Test utilizes a research design involving two independent samples that represent two populations with different median locations (Sheskin, 2007). In our research, the Mann-Whitney U-Test ranks the cumulative CPI slopes before and after OTB and calculates a U-statistic to determine if there is a significant difference in the median location of the samples tested.

In instances where the Minitab® Mann-Whitney test did not produce a p-value, the JMP® Wilcoxon Rank Sums "2-Sample Test, Normal Approximation, Prob>|Z|" value is halved to calculate a one-tailed p-value. Concerning the Wilcoxon Rank Sum Test, McClave notes "another statistic used for comparing two populations based on independent random samples is the Mann-Whitney U-statistic. The U-statistic is a simple function of the rank sums. It can be shown that the Wilcoxon rank sum test and the Mann-Whitney U-test are equivalent" (McClave, 2008).

The following assumptions apply to the use of the Mann-Whitney U-Test (Sheskin, 2008). First, the samples must be randomly selected from the population they represent (Sheskin, 2008); in 2010, Thickstun found that the occurrence of OTB was in fact "random". Our research pulls these random occurrences from the DAES database via DAMIR retrieval.

Further, the two samples must be independent. Not only are the programs independent (different capabilities, technical risk, schedule, funding and management,

etc...), the slopes before and after OTB are independent for having gone through the OTB treatment; "cumulative indices will only reflect the performance since the new baseline was implemented" (DAU, 2007).

Beyond independence, the variable of interest must be a continuous random variable (Sheskin, 2008). Cumulative CPI slope is a continuous random variable in that slope can take on any value and this variable quality mitigates the risk of ranking ties.

As a final assumption, Sheskin notes that "the underlying distributions from which the samples are derived are identical in shape" (Sheskin, 2008). Figure 9 depicts similarity in shape with the exception of outliers; the Mann-Whitney U-Test adjusts for outliers in comparison to other parametric tests.

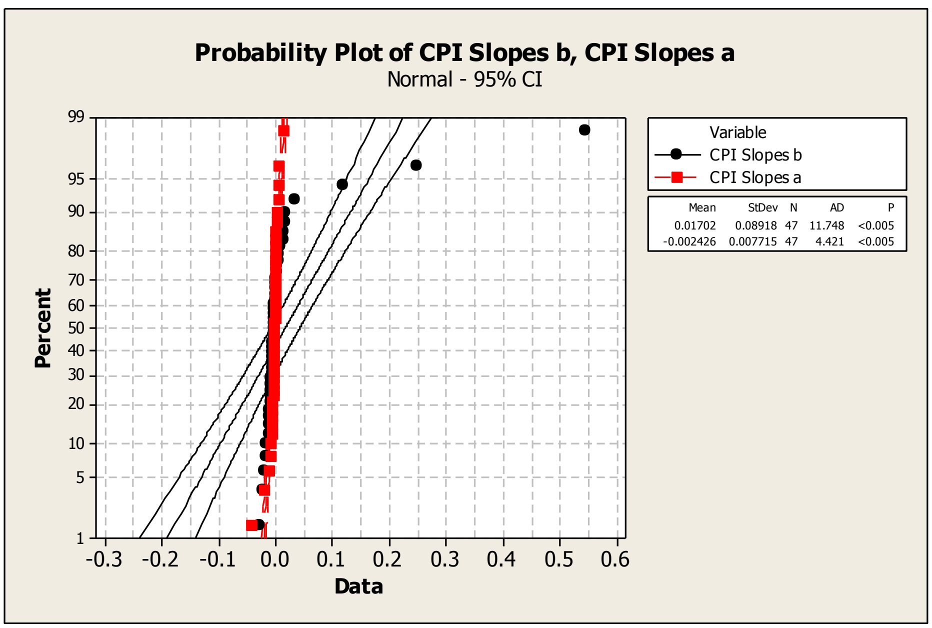


Figure 9: Similar Distribution Shapes; Cumulative CPI Slopes Before, After OTB

Past researchers utilized the Mann-Whitney U-Test to assess the effectiveness of acquisition reform legislature. Christensen found reform efforts from 1960 to 1999 ineffective in reducing average cost growth of 20 percent during that timeframe (Christensen, 1999). In 2003, Holbrook "discovered that cost performance for contracts completed after reform initiative implementation was no different than cost performance on contracts completed before implementation" (Holbrook, 2003).

Chapter Summary

In Chapter III, we explained the source of our data, provided the cumulative CPI slope calculation, presented the hypothesis test and discussed the assumptions of the Mann-Whitney U-Test. Having established the validity of the test and calculations performed, we present the results of our statistical tests in Chapter IV and stress our data limitations. In Chapter V, we draw conclusions based on our results, discuss the policy implications of our findings and recommend topics of further study.

IV: Results and Analysis

In Chapter IV, we present the results of our statistical tests, analyze the outcomes and discuss our data limitations. In Chapter V, we conclude with policy implications and recommended topics of further study.

Results

To summarize the hypothesis and tests (95% confidence; alpha 0.05), utilizing Minitab® Mann-Whitney U-Test and JMP® Wilcoxon Rank Sums, we examine the distribution of cumulative CPI slopes before and after OTB for a change in median location. Table 6 summarizes the P-Value results for the number of OTB efforts tested in a given time period after OTB and for the factor in question. Given our data limitations, the most reliable results rest in the "All" row. We performed further sensitivity analysis by varying time after OTB by factor, but the results are limited by small sample sizes (n) and percentages of the total number of OTB efforts.

Concerning table interpretation (Table 6), P-Value is defined as "the observed significance level, or p-value, for a specific statistical test is the probability (assuming Ho is true) of observing a value of the test statistic that is at least as contradictory to the null hypothesis, and supportive of the alternative hypothesis, as the actual one computed from the sample data" (McClave, 2008). Essentially, if the P-Value is less than alpha (0.05), we reject Ho and accept Ha; if the P-Value is greater than alpha, we fail to reject Ho. Considering our hypothesis and our test procedure, failing to reject Ho means that OTB has no effect on changing the median location of the cumulative CPI slopes before and after OTB; the median locations are equal (2). Additionally, the Service factor of "DoD" consistently had Insufficient Data Points (IDP); one data point did not enable testing.

Table 6: Results of OTB's Effect on Cumulative CPI Slope After OTB

		+6 mos	n	+9 mos	n	+12 mos	n	+18 mos	n	+24 mos	n	All	n
Category	RDTE	0.0414	8	0.0667	9	0.0789	9	0.0927	9	0.0927	9	0.0927	9
	Procurement	0.0929	10	0.4885	12	0.4426	12	0.41995	12	0.4426	12	0.4655	12
Service	Air Force	0.0867	6	0.0639	8	0.0946	8	0.1351	8	0.1592	8	0.1351	8
	Army	0.1345	8	0.056	9	0.0558	9	0.0666	9	0.0666	9	0.0666	9
	DoD	IDP	1	IDP	1	IDP	1	IDP	1	IDP	1	IDP	1
	Navy	0.4108	27	0.25165	29	0.2048	29	0.21605	29	0.24935	29	0.24935	29
Type	Cost Plus	0.0547	20	0.0795	22	0.1025	22	0.1004	22	0.1004	22	0.1004	22
	Fixed	0.4026	22	0.3525	25	0.4155	25	0.4729	25	0.4884	25	0.4884	25
All	All	0.1119	42	0.1389	47	0.1943	47	0.2092	47	0.2225	47	0.2092	47

Note: P-Values for "n" efforts (Vary Time After OTB Only, OTB 1s Only, Alpha 0.05, Mann Whitney U Test)

Analysis

With the exception of RDTE at +6 months, all p-values (Table 6) are greater than alpha (0.05). Given our results, we fail to reject the Ho (2) and conclude that the median location of the cumulative CPI slope distribution before OTB is equal to the median location of the cumulative CPI slope distribution after OTB. OTB treatments have no effect on the cumulative CPI slope after OTB. Further, OTB's effect on the cumulative CPI slopes after OTB is not sensitive to time and/or the programmatic factors chosen in this study.

Borderline significance is noted in the RDTE category at +6 months (p-value of 0.0414, Table 6), but the size of the sample (n = 8) and limitations of the data do not

allow us to confidently reject the Ho and state that OTB has an effect on the Cumulative CPI slope after OTB. Given our data limitations and the skepticism that surrounds early CPI index use after OTB, we are not willing to commit a Type I error and incorrectly state that "OTB increases the cumulative CPI slope for RDTE contracts".

At the 90% confidence level (alpha 0.10), there appears to be significance in the rows of RDTE, Army and Cost Plus contracts (Table 6). Given data limitations, we are unwilling to commit a Type I error and state that OTB has an effect. In percentage of total sample, RDTE, Army and Cost Plus represent 19%, 19% and 47%, respectively. Again, we have consciously decided to risk a Type II error vs. a Type I error given the small percentages and relatively high p-values.

Additionally, when comparing "Service" p-values and "Type" contract p-values (Table 6), we note large differences between the row factors. Again, any significance that could potentially be drawn from these differences is diminished by small sample size and percentages at the factor level and further diminished by our insignificant finding in "All".

Limitations

We summarize our limitations by type risk of statistical error. Concerning the risk of a Type I error (risk of rejecting a true null hypothesis or “incorrectly stating there is an effect”), the most obvious limitation is our small sample size of 47 (Table 6). Within our table of results, it is apparent that some factor and time intersections have a very small percentage of the final dataset, the largest being "Navy" at approximately 62%. The majority of factor percentages are less than 26% of the sample total. The most

significant row in Table 6 is the "All" row; it represents all 47 OTBs being tested for treatment effect across time and we are unable to reject Ho due to p-values greater than 0.05 and 0.10.

Additionally, concerning the risk of committing a Type I error, we note the small percentage of OTB contract efforts being studied within the DAMIR database and within the population of system-identified OTB contract efforts (Table 5). By the numbers, approximately 7% of contract efforts maintained in DAMIR are reported as OTB. After necessary exclusions (Table 5), our 47 OTB contract efforts represent approximately 1.5% of total DAMIR contract efforts and 21% of initially-identified OTB contract efforts.

To summarize the Type I limitations, these are small, purified numbers (Table 5) and percentages that support the validity of the test and design; we should have seen an effect, but we did not (Table 6). We are unwilling to conclude that OTB has a borderline effect on the cumulative CPI after OTB and risk a Type I error.

Concerning the limitations surrounding a Type II statistical error (risk of rejecting a true alternative hypothesis or “letting an effect go free”), our attention turns to the slope data content. In our research, we studied cumulative CPI data. The cumulative CPI data is historical in nature and based on “time now” totals (EV and AC) from program inception. This quality anchors performance to the past, meaning cumulative CPI is very difficult to change. Our data selection increases the risk of a Type II statistical error, meaning that we may have let an “effect go free” by choosing averaged performance data. In Chapter V, we will recommend a within-scope data remedy to address this issue.

V: Discussion and Conclusion

OTB is a subset of cost growth. At the contract effort level, the stated goal of an OTB EVM intervention is to gain managerial control of a project's remaining work; for any program, in any status, gaining managerial control of remaining work is a worthwhile goal. The OTB process is a bottoms-up, collaborative assessment of remaining work that is centered on risk analysis in which cost and schedule variances are typically removed and funding is added in excess of the original contract budget base. The OTB guide states, "it is important that the project managers recognize that a robust risk analysis for the remaining project has resulted in a realistic schedule and budget baseline…it is now more important than ever to have a risk management strategy that encompasses integrated risk analysis and risk mitigation" (DAU, 2007).

Research Questions, Results and Limitations

Our research studied two specific questions concerning OTB's effect on cumulative CPI slope after OTB:

1) Does the OTB process (treatment) improve the cumulative CPI's rate of change (cumulative CPI slope) after OTB?

2) Is the cumulative CPI slope after OTB sensitive to time and/or programmatic factors to include contract type, military service and the purpose of the appropriation?

For the data studied, we find there is no statistically significant change in cumulative CPI slope after an OTB intervention; OTB does not gain managerial cost control of remaining work with respect to the cumulative CPI slope. Further, we conducted sensitivity analysis to determine if time and programmatic factors affect OTB's effect on cumulative CPI. We find borderline significance in the factors of RDTE, Army

and Cost Plus contracts, but given the data limitations, we remain unwilling to state that OTB has an effect on gaining managerial control of cost with respect to the cumulative CPI slope. We conclude that OTB does not increase the cumulative CPI slope after OTB.

Concerning data limitations, in order to validly utilize the design of our research and perform the statistical methods discussed, we excluded a large percentage of OTB data from the original data pull (Table 5). Having utilized only 21% of the OTB data and its small percentage of the total contract efforts maintained in DAMIR, we limit our finding that OTB has no effect the cumulative CPI slope after OTB. Additionally concerning results presented in Table 6, our "borderline" factor significance is very unreliable due to small sample sizes and small percentages of the total OTB contract efforts studied. Consistent with these limitations, we avoid Type I errors by failing to reject Ho in all instances. Finally, our choice to study cumulative CPI dampens our ability to see the effect of current management actions and raises our probability of making a Type II statistical error; essentially, our cumulative data selection has raised our risk of incorrectly stating “no effect.”

Policy Implications

Qualified by our limitations, our research empirically characterizes OTB as ineffective in improving cost performance as it relates to improving the cumulative CPI slope after OTB. As such, we recommend disallowing the implementation of a formal OTB unless explicitly justified by a more robust and standardized OTB cost/benefit analysis. Per DCMA’s 2006 EVM implementation guide, once the contractor has submitted an OTB request, the customer has 30 days to approve or disapprove the

request. If disapproved, “the PM should provide specific reasons as to why it was denied and what is required to obtain approval”; PMs should utilize this approval process to require a more stringent cost/benefit analysis of the contractor to justify the OTB investment.

From the cumulative CPI slope viewpoint, the contractor should not remove historical variances, add funding to the existing requirement and continue to overrun the program at the same cumulative CPI rate pre- and post-OTB. The cumulative CPI slope, normally a negative slope that denotes a progressively growing overrun, should improve for having gone through the OTB process. At a minimum, we should see some impact within the first six months after OTB; this time period mitigates the cumulative CPI data anchoring effect. Further, the contractor’s justification should include a discussion of increasing the cumulative CPI slope after OTB and the difference in estimated overrun costs if OTB actions are not taken.

Thickstun notes that OTB costs are in addition to TAB; essentially, there is an incremental cost of doing OTB business (Thickstun, 2010). That incremental OTB cost should produce a quantifiable return on investment. The customer PM should be able to assess the “impact if OTB is not funded.” We believe this is a more quantifiable way of achieving and justifying an OTB investment. Cukr states it's "possible just to continue" (Cukr, 2000); if not justified, just continue and save the time, the additional work, the historical information and the financial resources.

Future Research

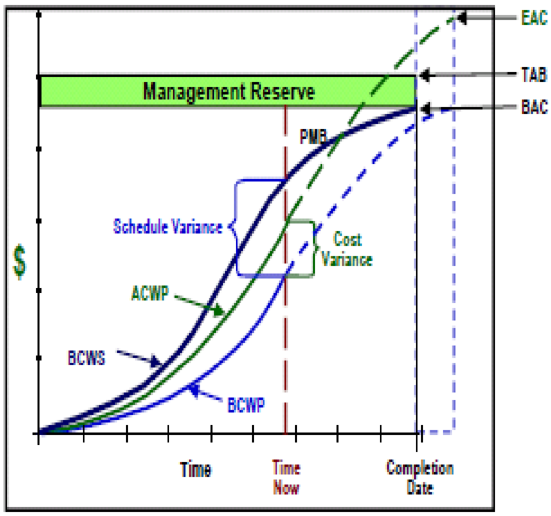
Our research did not quantify the potential cost savings of such a policy decision, but future research should attempt to determine potential savings.

In terms of disallowing OTB completely, we recommend gathering additional evidence of "OTB not increasing CPI slope" within the scope of this study based on current period CPR data only, not cumulative. This approach to data selection will provide greater insight into current or more near-term PM actions. The cumulative data is anchored in historical performance, meaning it is very difficult to change and limits our finding and correspondingly, the policy implication of disallowing OTB. However, this limitation does not eliminate the recommendation to better justify an OTB investment.

Additionally, the acquisition community should identify "treatment"-type processes in the acquisition life cycle, perhaps rolling Integrated Baseline Reviews (IBR) or EVMS surveillance activities tied to ANSI guidelines, to implement standardized, repeatable assessments at the contract level. Obtaining this data in a systematic and objective nature will allow the acquisition community to research meaningful relationships between program actions and superior contract performance. Once identified, program managers can build their execution plans centered on the most effective actions to effect improved cost, schedule and performance outcomes.

Appendix A: DAU EVM 'Gold Card'

Earned Value Management 'Gold Card'



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

OVERALL STATUS

% Schedule = ($BCWS_{CUM}$ / BAC) * 100
% Complete = ($BCWP_{CUM}$ / BAC) * 100
% Spent = ($ACWP_{CUM}$ / BAC) * 100

DoD TRIPWIRE METRICS Favorable is > 1.0, Unfavorable is < 1.0

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

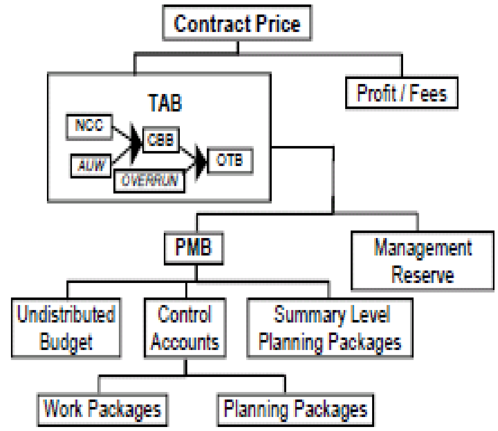
BASELINE EXECUTION INDEX (BEI) (Schedule Metric)
BEI = # of Baseline Tasks Actually Completed / # of Baseline Tasks Scheduled for Completion

CRITICAL PATH LENGTH INDEX (CPLI) (Schedule Metric)
CPLI = (Critical Path Duration + Float Duration $_{\text{(to baseline finish)}}$) / Critical Path Duration

TO COMPLETE PERFORMANCE INDEX (TCPI) ‡ §
$TCPI_{EAC}$ = Work Remaining / Cost Remaining = (BAC – $BCWP_{CUM}$) / (EAC – $ACWP_{CUM}$)

ESTIMATE AT COMPLETION ‡
EAC = Actuals to Date + [(Remaining Work) / (Efficiency Factor)]
EAC_{CPI} = $ACWP_{CUM}$ + [(BAC – $BCWP_{CUM}$) / CPI_{CUM}] ≡ BAC / CPI_{CUM}
$EAC_{Composite}$ = $ACWP_{CUM}$ + [(BAC – $BCWP_{CUM}$) / (CPI_{CUM} * SPI_{CUM})]

‡ To Determine a Contract Level TCPI or EAC; You May Replace BAC with TAB
§ To Determine the TCPI $_{\text{BAC or LRE}}$ Replace EAC with BAC or LRE



TERMINOLOGY

NCC	Negotiated Contract Cost	Contract price less profit / fee(s)
AUW	Authorized Unpriced Work	Work contractually approved, but not yet negotiated / definitized
CBB	Contract Budget Base	Sum of NCC and AUW
OTB	Over Target Baseline	Sum of CBB and recognized overrun
TAB	Total Allocated Budget	Sum of all budgets for work on contract = NCC, CBB, or OTB
BAC	Budget At Completion	Total budget for total contract thru any given level
PMB	Performance Measurement Baseline	Contract time-phased budget plan
MR	Management Reserve	Budget withheld by Ktr PM for unknowns / risk management
UB	Undistributed Budget	Broadly defined activities not yet distributed to CAs
CA	Control Account	Lowest CWBS element assigned to a single focal point to plan & control scope / schedule / budget
WP	Work Package	Near-term, detail-planned activities within a CA
PP	Planning Package	Far-term CA activities not yet defined into WPs
BCWS	Budgeted Cost for Work Scheduled	Value of work planned to be accomplished = PLANNED VALUE
BCWP	Budgeted Cost for Work Performed	Value of work accomplished = EARNED VALUE
ACWP	Actual Cost of Work Performed	Cost of work accomplished = ACTUAL COST
EAC	Estimate At Completion	Estimate of total cost for total contract thru any given level; may be generated by Ktr, PMO, DCMA, etc. = $EAC_{Ktr / PMO / DCMA}$
LRE	Latest Revised Estimate	Ktr's EAC or EAC_{Ktr}
SLPP	Summary Level Planning Package	Far-term activities not yet defined into CAs
TCPI	To Complete Performance Index	Efficiency needed from 'time now' to achieve an EAC

EVM POLICY: DoDI 5000.02, Encl 4. Table 5. EVMS in accordance with ANSI/EIA-748 is required for cost or incentive contracts, subcontracts, intra-government work agreements, & other agreements valued ≥ \$20M (Then-Yr \$). EVMS contracts ≥ \$50M (TY \$) require that the EVM system be formally validated by the cognizant contracting officer. Additional Guidance in Defense Acquisition Guidebook and the Earned Value Management Implementation Guide (EVMIG). EVMS is discouraged on Firm-Fixed Price, Level of Effort, & Time & Material efforts regardless of cost.

EVM CONTRACTING REQUIREMENTS:

Non-DoD FAR Clauses – Solicitation – 52.234-2 (Pre-Award IBR) or 52.234-3 (Post Award IBR)
– Solicitation & Contract – 52.234-4

DoD(≥ \$20M) DFAR Clauses - 252.234-7001 for solicitations and 252.234-7002 for solicitations & contracts

Contract Performance Report – DI-MGMT-81466A * 5 Formats (WBS, Organization, Baseline, Staffing & Explanation)

Integrated Master Schedule – DI-MGMT-81650 * (Mandatory for DoD EVMS contracts)

Integrated Baseline Review (IBR) – Mandatory for all EVMS contracts

* *See the EVMIG for CPR & IMS tailoring guidance.*

EVM Home Page = https://acc.dau.mil/evm eMail Address: EVM.dau@dau.mil
DAU POC: (703) 805-5259 (DSN 655)
Revised January 2009

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14. ABSTRACT

Cost growth is a problem in U.S. Department of Defense (DoD) acquisitions. A particular component of cost growth is a cost overrun or Over Target Baseline (OTB). In 2009, Trahan found that the Gompertz growth curve better predicted program Estimates at Completion (EAC) for OTB contracts. In 2010, Thickstun studied “the relationships between overruns and a variety of factors,” but found OTB occurrences “random” and questioned the benefit of the OTB process (Thickstun, 2010). In this research, we study OTB’s ability to effect improved program cost performance; we examine OTB’s effect on the cumulative Cost Performance Index (CPI) slope after an OTB intervention. We find there is no statistically significant change in cumulative CPI slope after OTB. For the data studied, an OTB investment does not significantly improve management’s ability to earn cost value as reflected in the cumulative CPI slope.

15. SUBJECT TERMS

Over Target Baseline (OTB), Earned Value Management (EVM), Cost Performance Index (CPI), Mann-Whitney Test, cost overrun

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