

Practical Calculation of Delays and Cost Overruns

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Abstract

- We provide examples of practical calculations of delays and cost overruns in Earned Value Management (EVM).
 - We briefly visit EVM history and key methods.
 - We focus on the new EVM calculations as presented in PMBOK 4th Edition using two scenarios.

Introduction

- The Earned Value Management (EVM) concept was introduced almost five decades ago. What is Earned Value Management?
- PMBOK - "EVM integrates project scope, cost, and schedule measures to help the project management team assess and measure project performance and progress."

What is Earned Value Management?

- It is a project management technique that requires the formation of an integrated baseline against which performance can be measured for the duration of the project.
- Adopted in projects associated with the various agencies of the United States and other governments.

Ten Findings

- Details of the emerging earned value body of knowledge that has been accumulated by individuals working within the DOD Pentagon and the individual branches of the military has been synthesized to ten findings.

Early Warning Signals

- Earned Value Management (EVM) provides project managers with early warning signals of project trouble, and such indicators were found to be reliable as early as 15% into a project (Christensen & Heise, 1992).

CPI Trend

- DOD experience in more than 400 programs since 1977 indicates without exception that the cumulative CPI does not significantly improve during the period of 15% through 85% of the contract performance; in fact it tends to decline.

The EVM Practice Standard

- Provides a guide to the principles of EVM and its role in facilitating effective project management (Project Management Institute, 2005).

Literature Review: Value of EVM

- Marshall (2006) suggests that EVM is an effective project management methodology, and that EVM principles can be significant positive predictors of project success.
- EVM metrics were also shown to be important contributors to the successful administration of contracts (Marshall, Ruiz, & Bredillet, 2008).

Literature Review: Value of EVM

- Christensen (1994) demonstrated that performance measurement data are relevant and have predictive value, as well as the general accuracy of the estimate at completion, EAC.

Literature Review: Small Projects

- EVM was “not needed on small projects and that it was hard to apply.” (Kim, 2000)

Key Concept in EVM

- The key concept is the earned value (*EV*), which converts project accomplishments from physical units of measure (e.g., miles of roadway or deliverables completed) to financial units (e.g., dollars or labor hours).

Key Concept in EVM

- Value is typically considered to be “earned” by the completion of measurable deliverables.
- For example, if at some time, 4 deliverables were planned and 3 were actually completed (earning value), then the ratio of earned to planned value is 0.75.

Schedule Performance Index

- $SPI = EV/PV$
- A value of $SPI < 0$ represents a project that is behind schedule.
- The schedule variance (SV) is another measure of the conformance of the earned progress to the planned progress:

Resistance

- ...is not the fault of the technique itself, but rather of the implementation requirements, the terminology employed, and the countless rules and interpretations that have been perceived to be overly restrictive (Fleming & Koppelman, 2005).

Criticisms of EVM

- A general criticism of EVM is that it is difficult to find a proper balance between the utility of the earned value technique . . . versus the effort it takes to implement the concept (Quentin & Koppelman, 2005).

Specific Issues

- There are a number of specific issues associated with EVM as it is currently practiced.
- We review couple of them

Specific Issues

- *Time Dependence*
- *SV is in Cost Units*
- *Converting SV into time units.*
- *Measuring the time delay on the cumulative planned and earned value cost curves*
- *The Schedule Variance Method.*
- *Constancy Assumption for CPI and SPI.*

Cost and Schedule Performance Indices

- The cost performance index (*CPI*) is a measure of the conformance of the actual work completed (measured by its earned value) to the actual cost incurred.
- The schedule performance index (*SPI*) is a measure of the conformance of actual progress (earned value) to the planned progress.

CPI and SPI

$$CPI = \frac{EV}{AC}$$

$$SPI = \frac{EV}{PV}$$

Estimates of Cost and Time to Complete

- The estimated cost to complete the remainder of the activities is called the estimate to complete (*ETC*).
- The estimate of the final cost at completion is called the estimate at completion (*EAC*).

Calculating EAC

- Methods for calculating *EAC* depend on the assumptions made about the future performance of the project versus the historical, established performance to date.

Three Approaches (PMBOK)

- When the assumptions underlying the original estimate are flawed
- When past performance is not a good predictor of future performance
- When past performance is a good predictor of future performance

Case Studies

- We introduce two case studies that illustrate our practical approach to EVM using the To-Complete-Performance-Index (TCPI).

TCPI

- TCPI index is the calculated projection of cost performance that must be achieved on the remaining work in order to meet the financial goals as set by the management's current authorized budget, and the project manager's estimate at completion (EAC).

Case Study:

Project “Book Contract”

- We present our analysis using two case studies both involving a simple “Book Contract” project from a Publisher.
- Case Study I: Book Contract with Deterministic Estimates
- Case Study II: Book Contract with Large Uncertainties in Cost Estimates

Case Study:

Project “Book Contract”

- The “Book Contract” project involves ten clear deliverables or work packages--ten chapters negotiated to be delivered at an estimated cost of \$100 each, and delivered one per month.

Case Study: Project “Book Contract”

- The project should therefore be completed in 10 months.
- The BAC is \$1,000.
- PV is \$100 each month.

TCPI

$$\text{Time - to - Complete Performance Index} = \frac{\text{Work Remaining}}{\text{Funds Remaining}} = \frac{\text{BAC} - \text{EV}}{\text{BAC} - \text{AC}} \quad (1)$$

Why pick TCPI?

- The TCPI focuses on the remaining project tasks.
- It is effectively the mirror opposite of the cumulative CPI, in that it reflects what it will take in future performance to recover from a negative actual cost position.

Why pick TCPI?

- The TCPI takes the work remaining (the total budget less the Earned Value accomplished) and divides that amount by the funds remaining (the latest management financial goal less funds spent) to determine what performance results it will take to meet such goals.

We've all been there.

- You're a few months into a project and the first few deliverables have been completed. You diligently calculate the $CPI = 0.9$. Your customer asks you about your plans for the cost overrun.
- “No problem, we'll make it up” you say.

Back to the Case Study..

Month	1	2	3
Planned Value	\$100	\$100	\$100
Earned Value	\$100	\$100	\$100
Actual Cost	\$110	\$110	\$110
Cumulative Earned Value (EV)	\$100	\$200	\$300
Cumulative Actual Cost (AC)	\$110	\$220	\$330
<i>CPI = EV/AC</i>	<i>0.89</i>	<i>0.89</i>	<i>0.89</i>

Let's add the TCPI calculation

- The work remaining is

$$\text{BAC} - \text{EV} = \$1,000 - \$300.$$

- This is actually an estimate of the earned value remaining: the total earned value for the project is \$1,000 (the BAC), while we have completed 3 deliverables, and so earned the value of \$300.

TCPI Calculation

- The funds remaining are $BAC - AC = \$1,000 - \330 .
- This is the remaining budget if we are to deliver as promised.

$$TCPI = \frac{BAC - EV}{BAC - AC} = \frac{1,000 - 300}{1,000 - 330} = \frac{700}{670} = 1.04$$

Three More Chapters ...

Month	1	2	3	4	5	6
Planned Value	\$100	\$100	\$100	\$100	\$100	\$100
Earned Value	\$100	\$100	\$100	\$100	\$100	\$100
Actual Cost	\$110	\$110	\$110	\$110	\$110	\$110
Cumulative Earned Value (EV)	\$100	\$200	\$300	\$400	\$500	\$600
Cumulative Actual Cost (AC)	\$110	\$220	\$330	\$440	\$550	\$660
<i>CPI = EV/AC</i>	<i>0.89</i>	<i>0.89</i>	<i>0.89</i>	<i>0.89</i>	<i>0.89</i>	<i>0.89</i>

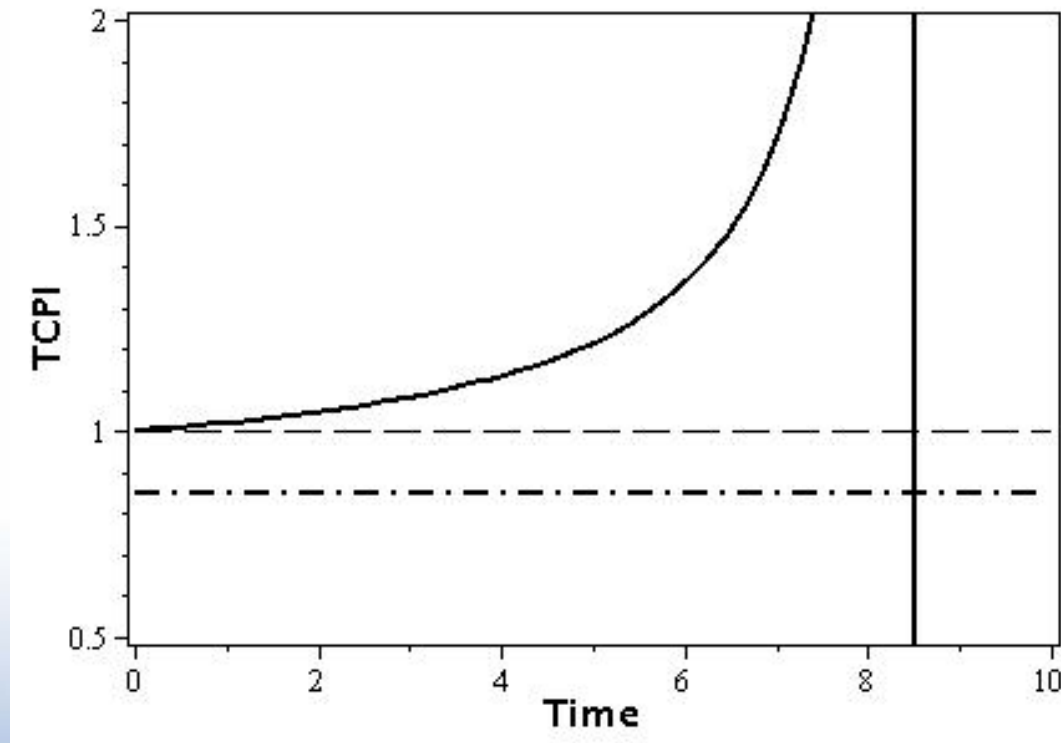
Three More Chapters ...

$$TCPI = \frac{BAC - EV}{BAC - AC} = \frac{1,000 - 600}{1,000 - 660} = \frac{400}{340} = 1.18$$

Uphill...

- To complete the project within budget, we now have to work at a rate 18% greater than we proposed.
- In fact, we need a 29% improvement in our expenditure rate (from 89% to 118%)!

TCPI and CPI



Analysis

$$TCPI = \frac{BAC - EV}{EAC - AC} = \frac{BAC/AC - EV/AC}{EAC/AC - 1}$$

We again use $P(t) = AC/BAC$, and $CPI = EV/AC$. We also use the fact that $EAC = BAC/CPI$

$$TCPI = \frac{1/P(t) - CPI}{BAC/(CPI \times AC) - 1} = \frac{1/P(t) - CPI}{1/(CPI \times P(t)) - 1}$$

If we now multiply by $P(t) \times CPI$, we get:

$$TCPI = \frac{CPI(1 - P(t) \times CPI)}{1 - P(t) \times CPI} = CPI$$

Analysis

- If we own up to the cost overrun and calculate the new EAC then the TCPI, the efficiency that is required for the rest of the project, is simply the CPI.

Conclusion

- That is, the TCPI has the remarkable property that if we own up to the cost overrun and use the TCPI with the EAC in the denominator, then we can proceed at our current efficiency (defined by our current CPI) and hit the new cost target.

Case Study II: Book Contract with Large Uncertainties in Cost Estimates

- R and D projects fit this profile.
- They have high levels of uncertainties.
- Also high tech projects with technical development fits this profile.

Three Point Method

- The project manager could use the three-point estimate technique to come up with the Expected Value for the budgeted numbers.
- Good tool for estimation for such projects.

Getting the Expected Value..

	Optimistic	Likely	Pessimistic	Expected Value
Chapter 1	\$20	\$100	\$300	\$120
Chapter 2	\$90	\$100	\$200	\$115
Chapter 3	\$50	\$100	\$200	\$108
Chapter 4	\$70	\$100	\$150	\$103
Chapter 5	\$90	\$100	\$200	\$115
Chapter 6	\$50	\$100	\$200	\$108
Chapter 7	\$85	\$100	\$250	\$123
Chapter 8	\$90	\$100	\$200	\$115
Chapter 9	\$50	\$100	\$200	\$108
Chapter 10	\$85	\$100	\$250	\$123

The First Milestone...

Month	1	2	3
Planned Value	\$120	\$115	\$108
Earned Value	\$120	\$115	\$108
Actual Cost	\$150	\$150	\$150
Cumulative Earned Value (EV)	\$120	\$235	\$343
Cumulative Actual Cost (AC)	\$150	\$300	\$450
<i>CPI = EV/AC</i>	<i>0.8</i>	<i>0.77</i>	<i>0.72</i>

Two Perspectives

- Bad News: Actual Cost is greater than the planned value.
- Good News: Actual Cost is comfortably within the upper boundary of the estimated range of \$300 using the three-point method.
- Should we panic?

Is this project going to go over budget?

- Assuming similar packages and progress as in case study one.. at the given productivity rate we are going to go over the budget.
- So how do we manage this?

Use the Following Practical Guidelines

- Determine the standard deviation that is acceptable to the customer. Use Random numbers to simulate!
- Hit the panic button if the package in question is on the critical path. Use a tighter standard deviation.

Practical Guidelines

- If the CPI is outside the acceptable standard deviation, *Equation 7* will be used for computation.
- Once again own up to the cost overrun and use the TCPI with the EAC in the denominator.

Conclusion

- EVM provides project managers with early warning indicators of project trouble.
- It has been widely used in government projects as it is a good tool for a wide variety of application domains.
- We focused on To-Complete Performance Index (TCPI) and provided some practical illustrations for its use.

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