Can CPI be a suitable KPI?
Let's go deeper on EV and AC calculation.

Abstract

Key Performance Indicators help an organization to define and measure progress toward organizational goals.

Once an organization has analyzed its mission, identified all its stakeholders, and defined its goals, it needs a way to measure progress toward those goals. Key Performance Indicators are those measurements. Applied to project management, Cost Performance Index (CPI) pretend to be an indication of how efficiently the project manager is using its resources.

The purpose of this paper is to highlight the CPI index as a Project Control Indicator or Key Performance Indicator (KPI). CPI is an output of Earned Value Management System (EVMS) and we first need to have a clear on it is exactly before any try of analysis.

The term “Earned Value” is gaining in popularity around project management circles as if it is some wonderful new concept to be embraced. Yet, it has been in use since the 1960s when the Department of Defense adopted it as a standard method of measuring project performance. The concept was actually developed as early as the 1800s when it became desirable to measure performance on the factory floor. Today, it is both embraced and shunned, often in response to prior experience or stories told “in the hallway.” The opponents will generally cite the cost and effort to make it work, and the limited benefit derived from its implementation. The proponents will cite the cost savings to the project overall, the improved analysis, communication and control derived from its implementation. No doubt, the two camps have vastly different experiences to formulate their perceptions.

In this document, we will detail the different data necessary for its calculation.

In a first part we will have a look on the Earned Value with the different ways to calculate it. The actual cost will be the second part on this paper, with a focus on Activity Based Costing. Finally in the third part, we will see what the attributes of a KPI are and try to apply them to the CPI before to highlight the possible cause of mistakes in its utilization.

1. Earned Value

a. What is Earned Value?

When we speak of Earned Value, we generally are speaking of a methodology. While Earned Value is just one element of this methodology, it is the key element. The simplest way to think of Earned Value is to equate it with physical progress. As the name implies, it is something that is gained through some effort. In project management, this value is earned as activities are completed.[1]

Consequently, Earned Value is also a measure of progress. As we shall see later, there is a direct relationship between Earned Value and per cent complete. Earned Value is also a basis for cost performance analysis of a project.

Earned Value provides a uniform unit of measure for reporting progress of a project. The traditional units that are used include workhours and dollars. For labor intensive efforts, workhours are often considered adequate. In such instances, the financial details of the remaining project cost are controlled by the accounting system. These costs include subcontractors, overheads and other direct costs. When the entire project cost is to be controlled from the project control system, then it is more effective to use dollars as the unit of measure for Earned Value. Since each labor hour has a price, dollars can be used to control labor as well. However, when using dollars, additional factors enter into the performance evaluation. This includes salary rate differences, escalation, overhead adjustments and differences, for example. Consider the effect if the plan calls for team A to do the work, but the actual work is performed by team B, whose members have different salaries. The dollar measure will include the effect of the salaries. For project financial control, this is good information. However, for project performance control, this information muddies up the waters.

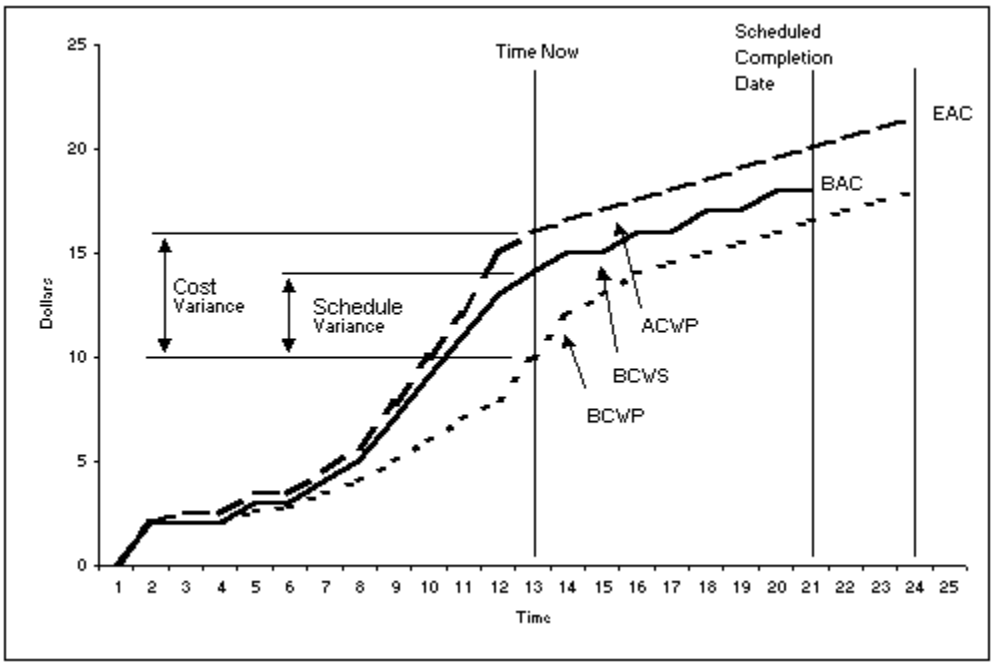
[1] Directly inspired from Department Of Defense - **Earned Value Management Implementation guide** - April 2005 and
Tammo T. Wilkens - **Earned Value, Clear and Simple** - Los Angeles County Metropolitan Transportation Authority - April 1999

Earned Value establishes a particular method for determining what the plan to date is and what the progress actually achieved is.

Earned Value provides the basis for cost performance analysis. If you want to know what's happening to the cost of your project BEFORE it is completed, you need to know what the planned cost at any time was and also what the cost of the completed work is.

In order to understand Earned Value thoroughly, we must become familiar with all the elements of the Earned Value method. While many people shy away from the acronyms used to label the elements, they quite accurately describe the elements. The project management practitioner should be familiar with the "alphabet soup".

The basics of Earned Value can best be shown on the ubiquitous **'S-Curve'**. [2]



The S-curve in its simplest form is a graph showing how project budget is planned to be spent over time. We can complicate the graph by showing the actual costs of doing the work over the same period. And also on the same graph we can show how the value of the product of the project increases over the same period.

The three curves on the graph represent:

- Budgeted Cost for Work Scheduled (BCWS) - the budgets for all activities planned to be completed.

[2] Graph and explanation from www.projectmagazine.com – November 2000 Edition

- Actual Cost of Work Performed (ACWP) - the real costs of the work charged against the completed activities.
- Budgeted Cost of Work Performed (BCWP) - the planned costs of the work allocated to the completed activities. This is the Earned Value.

The BCWS curve is derived from the Work Breakdown Structure, the project budget and the Project Master Schedule. The cost of each Work Package is calculated and the cumulative cost of completed Works Packages is shown based on the planned completion dates shown in the Master Schedule.

The ACWP curve is found by actual measurement of the work completed. Actual costs recorded from invoices and workmen's time sheets. This appears a quite complicate task but it can be very simple with sufficient planning and organizing.

The BCWP (EV) is calculated from the measured work complete and the budgeted costs for that work. **Earned Value = *Percentage project complete* x *Project Budget***

Different Index can be calculated with these three basic data:[3]

- Schedule variance: the difference between the Earned Value and the planned budget.

  SV = BCWP - BCWS
- Cost Variance: the difference between the Earned Value and the actual costs of the works.

  CV = BCWP - ACWP
- Schedule Performance Index: a ratio of Earned Value and the planned value of completed works. SPI < 1 is not good

  SPI = BCWP / BCWS
- **Cost Performance Index:** a ratio of Earned Value and the actual costs of completed works. CPI < 1 is not good

  CPI = BCWP / ACWP
- Estimate At Completion: Gives an idea of the final costs of a project. It takes into account the original budget (BAC), the Earned Value and the Cost Performance Index of the already completed works.

  EAC = ACWP + ((BAC - BCWP)/CPI)

[3] **Practice Standard of EARNED VALUE MANAGEMENT** - PMI

b. Ten Benefits of EVMS

David Christensen's *The Cost and Benefits of the Earned Value Management Process* is an interesting paper that weighs the cost of implementing earned value versus the benefits. The following is the list of benefits for using an earned value management system:

- It is a single management control system that provides reliable data.
- It integrates work, schedule, and cost into a work breakdown structure.
- The associated database of completed projects is useful for comparative analysis.
- The cumulative cost performance index (CPI) provides an early warning signal.
- The schedule performance index provides an early warning signal.
- The CPI is a predictor of the final cost of the project.
- EVMS uses an index-based method to forecast the final cost of the project.
- The "to-complete" performance index allows evaluation of the forecasted final cost.
- The periodic (e.g., weekly or monthly) CPI is a benchmark.
- The management by exception principle can reduce information overload.

c. Measuring Work Progress - Per cent complete methods

Techniques for measuring work performed are selected during project planning and are the basis for performance measurement during project execution and control. The main measurement techniques are the following[4] :

- Units Completed

This method is applicable to tasks that involve repeated production of easily measured pieces of work, when each piece requires approximately the same level of effort. In most cases, subtasks are not mixed, but if so, they are accomplished simultaneously, and one of the subtasks can be used as the reference task.

- Incremental Milestone

This method is applicable to any control account that includes subtasks that must be handled in sequence. Completing any subtask or operation is considered to be the achievement of a

[4] Definitions from Dr. Joseph J. Orczyk, PE CCE - **Skills & Knowledge of Cost Engineering 5th Edition (14.)** - AACE INTERNATIONAL

milestone, and each incremental milestone completed represents a certain percentage of the total installation. The percentage chosen to represent each milestone is normally based on the number of workhours estimated to be required to that point in relation to the total.

- Start/Finish

This method is applicable to tasks that lack readily definable intermediate milestones or those for which the effort/time required is very difficult to estimate. In the start/finish approach, a percent complete is arbitrarily assigned to the start of a task, and 100 percent is recorded when the task is finished. A starting percentage of 50 percent is equivalent to a task completed at a constant rate over time, and is reasonable for short duration, lower-value tasks. For tasks with a longer duration or a higher value, a lesser percentage (20-30 percent) would probably be used. This is because the percentage directly affects progress payments, and an owner will hesitate to recognize too much completion in advance. For very short tasks, the start/finish percentages are usually 0 percent/100 percent.

- Supervisor Opinion

In this method, the supervisor simply makes a judgment of percent complete. The major problem with this approach is that some supervisors are optimists and some are pessimists; thus, there could be major differences of opinion as to the progress reported for the same or similar tasks. This is a subjective approach and should be used only for relatively minor tasks and only where developing a more discrete status is not feasible. Dewatering, temporary construction, architectural trim, and landscaping are candidates for application of this approach.

- Cost Ratio

This method is applicable to tasks that involve a long period of time or that are continuous during the life of a project, and which are estimated and budgeted on bulk allocations of dollars and workhours rather than on the basis of production. Project management, quality assurance, contract administration, and project controls are areas where the cost ratio method may be applied.

- Weighted or Equivalent Units

This method is applicable when the task being controlled involves a long period of time and is composed of two or more overlapping subtasks, each with a different unit of work measurement. To handle this, each subtask is weighted according to the estimated level of effort (usually workhours) that will be dedicated to that subtask. These weights are called "rules of credit." As quantities of work are completed for each subtask, the quantities are converted into equivalent units.

2. Actual costs

a. Traditional Cost Status

A contractor will surely be interested in employing the project's workhour statistics as a major cost-tracking tool, and will use the cost performance index (CPI), productivity index (PI), and cost variance (CV) for workhours as indicators.
Cost in terms of dollars also should be statused. Certain costs, particularly materials furnished and installed by the contractor and labor, are tracked on a control-account-by control-account basis. Equipment costs and the cost of construction materials and supplies (materials consumed, but not incorporated, in the final product) may be tracked as part of the work control account[5], but are more likely to be tracked in separate accounts. The CPI and CV for dollars can be calculated for whatever cost items are tracked. Typical costs summaries are as follows:

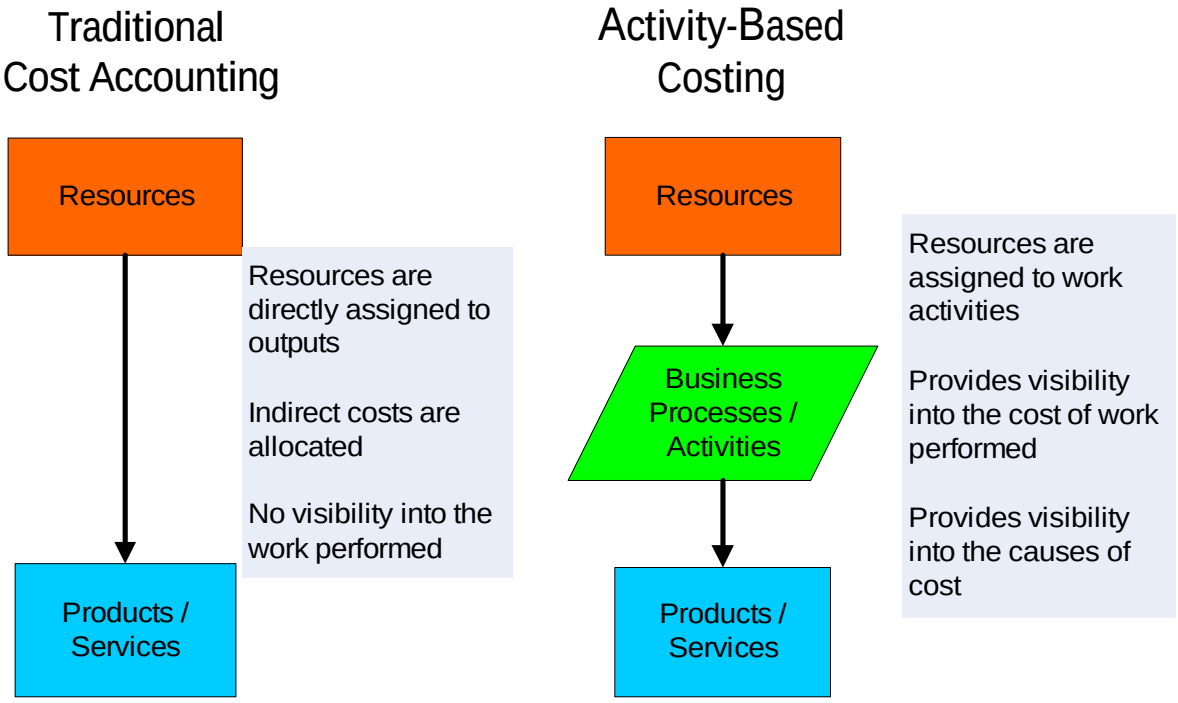
- A cost summary for each account showing the Original Budget, Current Budget, this period Actuals, job-to-date Actuals, remaining to-completed, Estimate At Completion / Forecast, and Variance.
- A labor rate report for each craft and control account showing the original control figures for dollars, workhours, and dollars per workhour, and providing for each category the current control, experience this period, job-to-date experience, estimate-at-completion, and variances.
- A quantity and workhour report showing the original control work quantities, workhours, and the workhours per unit of work for each control account, and providing comparable information under the headings of current control, current period, job-to-date, and estimate-at-completion. This report also can show the earned workhours this period, earned workhours to date, and the labor CPI.

The first two reports are usually under responsibility of Financial Control, whereas the last one should be responsibility of Cost Control.

[5] DoD - **Earned Value Management Implementation guide 3.3.f.** - April 2005

b. ABC methodology

Activity Based Costing (ABC) is a method for developing cost estimates in which the project is subdivided into discrete, quantifiable activities or a work unit. The activity must be definable where productivity can be measured in units[6] (e.g., number of samples versus workhours). After the project is broken into its activities, a cost estimate is prepared for each activity. These individual cost estimates will contain all labor, materials, equipment, and subcontracting costs, including overhead, for each activity. Each complete individual estimate is added to the others to obtain an overall estimate. Contingency and escalation can be calculated for each activity or after all the activities have been summed. ABC is a powerful tool, but it is not appropriate for all cost estimates.



[7]

ABC methodology is used when a project can be divided into defined activities. [8] These activities are at the lowest function level of a project at which costs are tracked and performance is evaluated. Depending on the project organization, the activity may coincide

[6] Jorge F. Valenzuela - José D. Porter - Robin M. Monk - Kim LaScola Needy - Narcyz Roztocki - **A Procedure for Smooth Implementation of Activity Based Costing in Small Companies** - Unpublished
[7] Figures inspired from U.S. Fish and Wildlife Service - **Implementing ABC/M** - February 2003
[8] DoE **G 430.1-1** - US Department Of Energies directive

with an element of the work breakdown structure (WBS) or may combine one or more elements of the WBS. However, the activities must be defined so there is no overlap between them. After the activity is defined, the unit of work is established. All costs for the activity are estimated using the unit of work.

The estimates for the units of work can be done by performing detailed estimates, using cost estimating relationships, obtaining outside quotes for equipment, etc. All costs including overhead, profit, and markups should be included in the activity cost.

3. CPI: a KPI or just an index

a. Role of KPIs

Key Performance Indicators are quantifiable measurements that reflect the critical success factors of a project or an organization[9]. They will differ depending on the organization. For instance, a school may focus its Key Performance Indicators on graduation rates of its students. A Customer Service Department may have as one of its Key Performance Indicators, in line with overall company KPIs, percentage of customer calls answered in the first minute. A Key Performance Indicators for a social service organization might be number of clients assisted during the year.

Whatever Key Performance Indicators are selected, they must reflect the organization's goals, they must be key to its success, and they must be quantifiable (measurable). Key Performance Indicators usually are long-term considerations. The definition of what they are and how they are measured do not change often. The goals for a particular Key Performance Indicator may change as the organizations goals change, or as it get closer to achieving a goal.

The objective of a project manager is to ensure that the project meet all objectives. The objectives generally include Performance, Cost, Time and Scope. As CPI is related to the cost, the only objective it will be able to measure is related to the project cost, also called Budget, including materials, labor and capital equipment.[10]

b. KPI Attributes applied to CPI

- Key Performance Indicators Must Be Quantifiable

[9] *Setting business targets* - Business Link © Crown 2005

If a Key Performance Indicator is going to be of any value, there must be a way to accurately define and measure it. "Generate More Repeat Customers" is useless as a KPI without some way to distinguish between new and repeat customers. [11] "Be The Most Popular Company" won't work as a KPI because there is no way to measure the company's popularity or compare it to others. And at the time you have a quantifiable index; you also need to set targets for this indicator.

- Key Performance Indicators Reflect The Organizational Goals

An organization that has as one of its goals "to be the most profitable company in our industry" will have Key Performance Indicators that measure profit and related fiscal measures. "Pre-tax Profit" and "Shareholder Equity" will be among them. However, "Percent of Profit Contributed to Community Causes" probably will not be one of its Key Performance Indicators.

- Key Performance Indicators Must be Key To Organizational Success

Many things are measurable. That does not make them key to the organization's success. In selecting Key Performance Indicators, it is critical to limit them to those factors that are essential to the organization reaching its goals. It is also important to keep the number of Key Performance Indicators small just to keep everyone's attention focused on achieving the same KPIs.

The three criteria see above can be applied to the CPI. We have seen in a previous part that CPI is calculated based on EVM system, which mean that it is measurable. We have also gone over that one of the project manager goals is to be able to manage the cost of his project, so it meets the second condition. In a same way, a project success quite often mean that it have been done with the given budget, but not only of course.
In this way, we can say that CPI fulfills all condition to be admitted as a relevant KPI for a project.

[10] James P. Lewis - **The Project Manager Pocket Survival Guide** – Mc Graw Hill - 2003
[11] F. John Reh - *Key Performance Indicators* - http://management.about.com/

c. Accuracy dilemma: how to interpret this Index

- Analysis Techniques Requirements

Each KPI has significance in itself, but it usually takes a combination of items for the total situation to be shown. For example, poor labor cost performance (CPI less than 1.0) is certainly a problem, but the CPI does not point to the cause of that problem, which could be low productivity, a bad quantity estimate, excessive staffing, higher crew rates, or any combination of these. Thus, report data must be available in each of those areas to enable the manager to isolate the problem and take remedial action.

- Cost reporting: Identification of Activities in ABC methodology

When defining an individual activity, the cost estimator must balance the need for accuracy with the amount of time available to prepare the estimate. An estimator may be able to develop an extremely accurate cost estimate by defining smaller and smaller activities; however, the amount of time required to prepare ABC estimates for each of these activities may not justify the increased accuracy. The total estimated project cost may be sufficiently accurate if 10 activities are used instead of 15. On the other hand, reliable cost information may not be accessible if the activity categories are too general. Since the activity is the basis for the estimate, it is very important that the activity be selected correctly.

In this document, we saw how to calculate the CPI based on Earned Value Management System. Then, after a quick view of what define a KPI, we have seen that the CPI has all the necessary attributes to be part of such indicators. But like every KPI, there are some limits in the lecture of this indicator, due to the way to calculate it in a first hand, with all the possible approximation, and the energy necessary to obtain accurate results in the other hand.
CPI is the result of Progress and Cost booking, which can vary upon the organization. This mean that it should not be used alone, but in complement to other indicators, as explained in the last part of this paper.

References

Department Of Defense - **Earned Value Management Implementation guide** - April 2005

Tammo T. Wilkens - **Earned Value, Clear and Simple** - Los Angeles County Metropolitan Transportation Authority - April 1999

www.projectmagazine.com – November 2000 Edition

Practice Standard of EARNED VALUE MANAGEMENT - PMI

Dr. Joseph J. Orczyk, PE CCE - **Skills & Knowledge of Cost Engineering 5th Edition** - AACE INTERNATIONAL

Jorge F. Valenzuela - José D. Porter - Robin M. Monk - Kim LaScola Needy - Narcyz Roztocki - **A Procedure for Smooth Implementation of Activity Based Costing in Small Companies** - Unpublished

U.S. Fish and Wildlife Service - **Implementing ABC/M** - February 2003

Department Of Equipment - **G 430.1-1** - US Department Of Energies directive

Setting business targets - Business Link © Crown 2005

James P. Lewis - **The Project Manager Pocket Survival Guide** – Mc Graw Hill - 2003

F. John Reh - *Key Performance Indicators* - http://management.about.com/

PMBOK - 2004 Edition PMI

http://ceh.nasa.gov/