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International Journal of Project Management 29 (2011) 615 – 621

International Journal of Project Management

www.elsevier.com/locate/ijproman

An extension of the EVM analysis for project monitoring: The Cost Control Index and the Schedule Control Index

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Received 19 May 2009; received in revised form 20 April 2010; accepted 27 April 2010

Abstract

In this paper we propose two new metrics that combine Earned Value Management (EVM) and Project Risk Management for project controlling and monitoring. We compare EVM cost and schedule variances with the deviation the project should have under the risk analysis expected conditions.

These two indexes allow project managers to analyse whether the project over-runs are within expected variability or there are structural and systemic changes over the project life cycle. The new monitoring indexes we present are the Cost Control Index and the Schedule Control Index.

Keywords: Project management; Risk management; Earned Value Management

1. Introduction

Earned Valued Management (EVM) is a management technique for project performance monitoring. Recently, Morin (2009) has described the origins of this methodology, whose costs and benefits were described in Christensen (1998).[1] A detailed explanation of EVM basis can be found in Anbari (2003), Fleming and Koppelman (2005) and PMI (2005). More recently, Lipke et al. (2009) have reviewed the main concepts.

EVM integrates scope, cost and schedule control under the same framework and it provides performance variances and indexes which allow managers to detect over-costs and delays. Furthermore, under this methodology, new real data generated during project run time is used to describe trends for the future project total cost and finishing date (based on past performance).

In this paper, we extend EVM to integrate project variability and risk analysis into the earned value framework. Uncertainty and variability are common facts to all the activities in real projects. By means of quantitative risk analysis, we get the probability function and distribution of both project duration and cost, so that, for instance, we can get levels of maximum over-runs within a particular confidence level. In other words, we get a measure of the "planned" or "expected" variability of the project, assuming the probabilistic nature of activity costs and durations.

However some structural or systemic changes during project life cycle can alter the initial expected variability and lead the project outside confidence limits. Moreover some managerial decisions could change some initial conditions. Project managers should not wait until the end of the project to know whether over-runs are within the probabilistic expected levels or not. At every time during project life cycle we need to be confident whether over-runs are within expected variability.

In the EVM framework, variances and performance indexes inform project managers whether the project has over-cost or delays, but they do not inform whether the over-runs are within the bounds of the project expected variability.

In this paper, we adopt the concept of *risk baseline* in the sense described by Cagno et al. (2008): the risk baseline represents the residual risk (uncertainty) to fulfil the remaining activities of the project. We use the risk baseline to evaluate new

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[1] Dr. Christensen maintains a large repository of bibliographic references on EVM that is periodically updated: http://www.suu.edu/faculty/ChristensenD/EV-bib.html.

0263-7863/$ - see front matter
doi:10.1016/j.ijproman.2010.04.005

performance indexes which integrate the triple scope/schedule/cost with project risk. These new measures facilitate project managers the early adoption of corrective actions.

This paper is organised as follows. First we summarise the main features of EVM and its relationship with risk analysis. Next section provides an explanation of our methodological proposal to integrate EVM and residual risk (the project uncertainty in terms of its parameters variability). Finally, we show the application of these measures to a simple and theoretical case study which gives the reader the opportunity to replicate the results. We close this work with the main conclusions of our research.

2. Earned Value Management: Some extensions

EVM has been used with little changes since it was introduced in the 60s by the U.S. Department of Defense. EVM is based on three measures: planned value (PV) or budgeted cost of work scheduled; actual cost (AC) of work actually performed; and earned value (EV), or planned cost of the work actually completed.

There are some definitions already described in the literature we briefly summarise:

- Cost variance (CV = EV − AC)
- Schedule variance (SV = EV − PV)
- Cost performance index (CPI = EV / AC)
- Schedule performance index (SPI = EV / PV)
- BAC (budget at completion) is the budgeted cost of the project
- SAC (schedule at completion) is the initially planned duration of the project.

Whenever CV < 0 and CPI < 1, the project has over-costs (otherwise, if CV > 0 and CPI > 1 the project is under budget). If SV < 0 and SPI < 1, the project is delayed (otherwise, if SV > 0 and SPI > 1 the project is ahead of schedule). When CV = 0 (CPI = 1) and/or SV = 0 (SPI = 1) the project is respectively on cost and/or timely.

By means of monitoring the evolution of these indexes over the project life cycle, managers can detect deviations from plan, so that they can take early corrective actions.

In Fig. 1 we show the evolution of cumulative values of AC, EV and PV over time. As most of the project effort is usually performed in the middle of its life cycle, commonly, the curves are S-shaped. PV line is the project *cost baseline*, that is, the expected accumulated cost if the project is performed as planned.

EVM not only informs us about the performance of the project, but gives us new estimates about project cost and finishing date which depend on the assumptions concerning the future evolution of the project.

When the project is close to its end, all the planned activities will be nearly finished, so the budgeted cost of scheduled work will equal to the planned cost of performed work. EV will tend to PV, and as a consequence, SV will converge to zero and SPI will tend to 1, even if the project has serious delays from planned schedule. It means that SV and SPI cannot give relevant information at the late stages of the project.

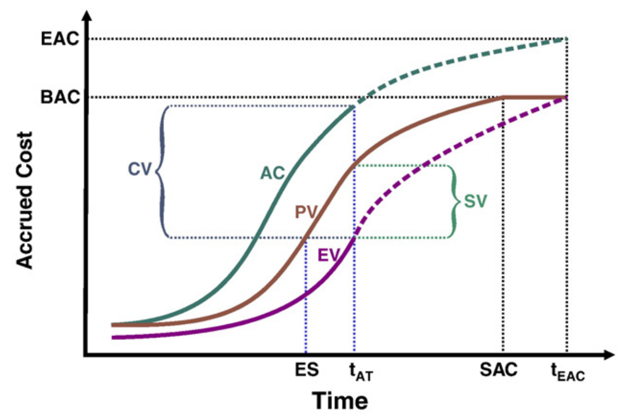

Fig. 1. Earned value and earned schedule figures.

To overcome this limitation Lipke (2003, 2004) propose the use of Earned Schedule (ES). ES is the date when the current earned value should have been achieved. To compute ES (see Fig. 1) at time (t_{AT}), we first calculate the earned value. We use this value on the PV line (cost baseline) to compute the date when EV equals PV. This date is the Earned Schedule (ES).

Some researchers have proposed extensions to the basic procedures, mainly related to forecasting improvement: Zwikael et al. (2000) evaluate five forecasting methods; Vandevoorde and Vanhoucke (2006, 2007) summarise some of the cost and schedule forecasting methods and study their accuracy in real and simulated projects; Christensen and Templin (2002) or Lipke et al. (2009) have studied statistical confidence limits to improve estimates at completion and Byung-cheol and Reinschmidt (2009) have proposed a new probabilistic forecasting method based on Bayesian inference and the Beta Distribution which integrates original estimates with observations of new actual performance.

Other researchers have extended the earned value management report to provide a final cost estimation. Christensen (1994) proposed new indexes to assess the accuracy of the estimated final cost (Estimation At Completion, EAC). Christensen and Templin (2002) justify the usability of two EAC evaluation methods by means of statistical evidence from a sample of defense acquisition contracts.

Our proposal is in a new direction: integrating risk management within the EVM framework.

3. Integrating EVM and risk management: The risk baseline and buffers

EVM does not take into account project risk analysis and variability. There are several methodologies to deal with project risks in terms of uncertainty.[2]

PERT (US Navy, 1958a,b) methodology allowed a first approach to deal with project risk (duration variability): the expected project duration and its variance are computed as the sum of durations and variances of the activities belonging to the critical path (being the activities statistically independent).

[2] See Cagno et al. (2007) for a detailed analysis and classification of risks.