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## Beyond Earned Value Management: A Graphical Framework for Integrated Cost, Schedule and Risk Monitoring

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### Abstract

In this paper, we propose an innovative and simple graphical framework for project control and monitoring, to integrate the dimensions of project cost and schedule with risk management, therefore extending the Earned Value methodology (EVM). EVM allows Project managers to know whether the project has overruns (over-costs and/or delays), but project managers do not know when deviations from planned values are so important that corrective actions should be taken or, in case of good performance, sources of improvement can be detected. From the concept of project planned variability, we build a graphical methodology to know when a project remains “out of control” or “within expected variability” during the project lifecycle. To this aim, we define and represent new control indexes and new cumulative buffers. Five areas in the chart represent five different possible project states. To implement this framework, project managers only need the data provided by EVM traditional analysis and Monte-Carlo simulation. We also explore the sensitivity of the methodology to control variables.

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### 1. Introduction

Earned Value Management (EVM) is one of the most widely used and known methodologies for project control and monitoring. EVM integrates scope, cost, time and schedule under the same framework. Developed by the U.S. Department of Defense during the sixties, it allows project managers to measure and verify the progress of the project and to detect deviations from the project planning phase,

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so that early corrective actions could be taken. New cost and time forecasts can also be computed taking into account deviations under different hypotheses.

A detailed explanation of the methodology and its implementation can be found in Anbari (2003), Fleming & Koppelman (2005) and PMI (2005). EVM is based on three basic variables: Planned Value (PV) or budgeted cost of work scheduled; Actual Cost (AC) or the actual cost of work performed; and Earned Value (EV) or the budgeted cost of the work performed. From the basic variables, four indexes are defined: Cost Variance ( $CV = EV - AC$ ), Schedule Variance ( $SV = EV - PV$ ), Cost Performance Index ( $CPI = EV / AC$ ) and Schedule Performance Index ( $SPI = EV / PV$ ). Whenever  $CV < 0$  and  $CPI < 1$  there are over costs, and whenever  $SV < 0$  and  $SPI < 1$ , the project is delayed. Positive values of  $SV$  and  $CV$  mean the project is in advance from plan and under budget respectively. Variables and variances can be represented graphically (see Figure 1), helping project managers to monitor project evolution. The graphical representation of PV is the project cost baseline.

Lipke (2003, 2004) proposed an extension of the methodology: the concept of Earned Schedule (ES). ES solves some problems faced by the methodology regarding its forecasting capabilities during the last phases of the project lifecycle. ES is the date when the current earned value should have been achieved. Schedule variance and performance indexes can be re-defined in terms of ES ( $SV(t) = ES - AT$  and  $SPI(t) = ES / AT$ , where  $AT$  is actual time).

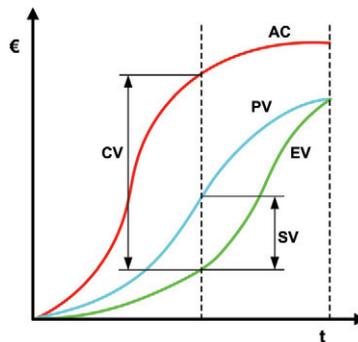


Fig. 1. EVM main variables and variances

The integration of risk analysis under the EVM framework represents an interesting step forward in the development of the methodology. EVM variables and variances talk about what happened in the past, whereas risk management is concerned about the future. Pajares & Lopez-Paredes (2011) proposed to integrate both perspectives under the same framework, so that project managers could enjoy new tools for taking better decisions.

Vanhoucke (2011) proposed to monitor the projects under two perspectives: a top-down approach based on earned value metrics and a bottom-up approach based on the schedule risk analysis method. He shows that the efficiency of the each approach depends on the features of the project network. Vanhoucke (2012) used Monte-Carlo simulations to explore why EVM and Schedule Risk Analysis provide good results in some projects and poor results in others. Hazir & Shtub (2011) used EVM measures to monitor projects and develop a simulation software to replicate uncertain environments. They explore the relation between information presentation and project control.

The approach by Pajares & Lopez-Paredes (2011) is based on the concept of “planned variability”: the variability the project has at any time according to the estimated variability (duration and costs) of project activities.

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