Available online at www.sciencedirect.com
SCIENCE DIRECT®
International Journal of Project Management 24 (2006) 289–302
INTERNATIONAL JOURNAL OF PROJECT MANAGEMENT
www.elsevier.com/locate/ijproman

A comparison of different project duration forecasting methods using earned value metrics

Stephan Vandevoorde [a,1], Mario Vanhoucke [b,c,*]

[a] *Fabricom Airport Systems, Rue Gatti de Gamond 254, B-1180 Brussels, Belgium*
[b] *Department of Management Information, Operations Management and Technology Policy, Faculty of Economics and Business Administration, Ghent University, Hoveniersberg 24, B-9000 Gent, Belgium*
[c] *Operations and Technology Management Centre, Vlerick Leuven Gent Management School, Reep 1, B-9000 Gent, Belgium*

Received 28 June 2005; received in revised form 13 September 2005; accepted 14 October 2005

Abstract

Earned value project management is a well-known management system that integrates cost, schedule and technical performance. It allows the calculation of cost and schedule variances and performance indices and forecasts of project cost and schedule duration. The earned value method provides early indications of project performance to highlight the need for eventual corrective action.

Earned value management was originally developed for cost management and has not widely been used for forecasting project duration. However, recent research trends show an increase of interest to use performance indicators for predicting total project duration. In this paper, we give an overview of the state-of-the-art knowledge for this new research trend to bring clarity in the often confusing terminology.

The purpose of this paper is 3-fold. First, we compare the classic *earned value* performance indicators SV and SPI with the newly developed *earned schedule* performance indicators SV(*t*) and SPI(*t*). Next, we present a generic schedule forecasting formula applicable in different project situations and compare the three methods from literature to forecast total project duration. Finally, we illustrate the use of each method on a simple one activity example project and on real-life project data.

Keywords: Earned value; Earned duration; Earned schedule; Project duration forecasting

1. Schedule performance indicators

Earned Value Management (EVM) is a methodology used to measure and communicate the real physical progress of a project and to integrate the three critical elements of project management (scope, time and cost management). It takes into account the work complete, the time taken and the costs incurred to complete the project and it helps to evaluate and control project risk by measuring project progress in monetary terms. The basic principles and the use in practice have been comprehensively described in many sources (for an overview, see, e.g. [1] or [2]).

Although EVM has been setup to follow-up both time and cost, the majority of the research has been focused on the cost aspect (see, e.g. the paper written by Fleming and Koppelman [3] who discuss earned value management from a *price*-tag point-of-view). Nevertheless, earned value management provides two well-known schedule performance indices, the schedule variance (SV) and the schedule performance index (SPI), to measure project progress. The SV is the difference between the earned value (EV) and the planned value (PV), i.e. SV = EV − PV (for a graphical

* Corresponding author. Tel.: +32 9 2643569/2109781; fax: +32 9 2644286/2109803.
E-mail addresses: stephan.vandevoorde@fabricom-gti.com (S. Vandevoorde), mario.vanhoucke@ugent.be, mario.vanhoucke@vlerick.be (M. Vanhoucke).
[1] Tel.: + 32 0 2 3703111; fax: + 32 0 2 3703222.

0263-7863/$30.00
doi:10.1016/j.ijproman.2005.10.004

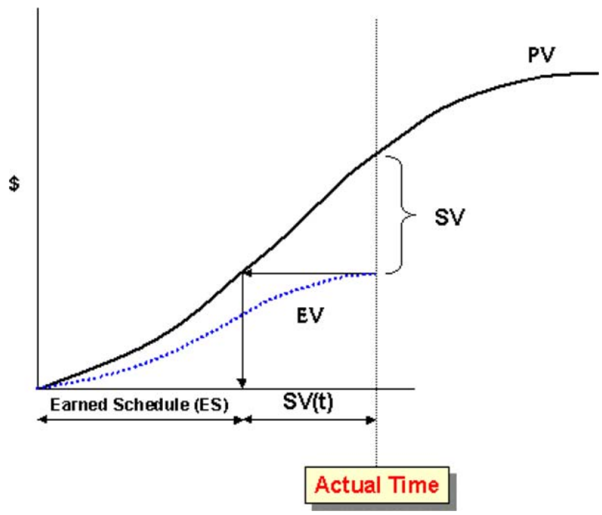

Fig. 1. SV versus SV(t).

presentation, see Fig. 1). Note that the PV is often denoted as the BCWS (Budgeted Cost for Work Scheduled) and the EV as the BCWP (Budgeted Cost Work Performed). The SV measures a volume of work done (i.e. earned) versus a volume of work planned. However, the SV does not measure time but is expressed in a monetary unit. If SV < 0, a lower volume of work has been earned as planned, and the work is behind plan. If SV > 0, a higher volume of work has been earned as planned, and the work is ahead of plan. If SV = 0, the earned work is exactly as planned. At the end of a project, the EV = PV = BAC (budget at completion), and hence, the SV always equals 0. The SPI is the ratio between the earned value and the planned value, i.e. SPI = EV/PV, and is a dimensionless indicator to measure the efficiency of the work. If SPI < 1 (=1, >1), the schedule efficiency is lower than (equal to, higher than) planned. At the end of a project, the SPI is always equal to 1.

The interpretation and the behaviour of the earned value management performance indicators SV and SPI over time have been criticized by different authors [4]. First, the SV is measured in monetary units and not in time units, which makes it difficult to understand and is therefore often a source of misinterpretations. Secondly, a SV = 0 (or SPI = 1) could mean that a task is completed, but could also mean that the task is running according to plan. Thirdly, towards the end of the project, the SV always converges to 0 indicating a perfect performance even if the project is late. Similarly, the SPI always converges to 1 towards the end of the project, indicating a 100% schedule efficiency even in the project is late. As a result, at a certain point in time the SV and the SPI become unreliable indicators, and this "grey time area" where these indicators loose their predictive ability usually occurs over the last third of the project (expressed in percentage completion, see [4]). However, this is often the most critical period where the forecasts need to be accurate, since upper management wants to know when they can move up to the next project stage.

In order to overcome the anomalies with the earned value schedule performance indicators, Lipke [4] introduced the concept of earned schedule (ES). In this method, the earned value at a certain (review) point in time is traced forwards or backwards to the performance baseline (S-curve) or PV. This intersection point is moved downwards on the X-axis (the time scale) to calculate the earned schedule ES (see Fig. 1). Hence, the ES is found by identifying in which time increment of PV the EV occurs. It translates the EV into time increments and measures the real project performance in comparison to its expected time performance. The corresponding schedule performance metrics are:

$$\mathrm{SV}(t) = \mathrm{ES} - \mathrm{AT}, \tag{1}$$

$$\mathrm{SPI}(t) = \mathrm{ES}/\mathrm{AT}, \tag{2}$$

where AT is used to refer to the Actual Time.

In contrast to the SV, the SV(t) is expressed in time units, which makes it easier to interpret. A SV(t) < 0 (>0) indicates the number of time units that the project lags (is ahead of) its expected performance. The behaviour of SV(t) over time results in a final SV(t) that equals exactly the real time difference at completion (while the SV always ends at zero). The same holds for the SPI(t) indicator, which has a final value reflecting the final project schedule performance (while the SPI always equals 1).

2. A generic project duration forecasting formula

Earned value metrics have been widely used to monitor the status of a project and forecast the future performance, both in terms of time and cost. The use of the metrics to forecast a project's final cost is numerous and is outside the scope of this paper (for an overview, see, e.g. Christensen [5] who reviews different cost forecasting formulas and examines their accuracy). In this section, we elaborate on the use of the metrics to forecast a project's final duration by different methods. A generic project duration forecasting formula is given by:

$$\mathrm{EAC}(t) = \mathrm{AD} + \mathrm{PDWR}, \tag{3}$$

where EAC(t) is the estimated duration at completion, AD the actual duration and PDWR is the planned duration of work remaining.

We use the EAC(t) metric to refer to any forecasting metric for a project's total *duration* (note that the abbreviation EAC – without (t) – is usually used in the literature to refer to the *cost* estimate at completion) and the AD metric to refer to the actual duration of the project at the current time instance. Moreover, the PDWR metric is the component that has to be estimated, and heavily depends on the specific characteristics and the current status of the project [1]. In Table 1, we distinguish between six different project situations based on the classification described in [1].