



A comparison of the performance of various project control methods using earned value management systems



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ABSTRACT

Recent literature on project management has emphasised the effort which is spent by the management team during the project control process. Based on this effort, a functional distinction can be made between a top down and a bottom up project control approach. A top down control approach refers to the use of a project control system that generates project based performance metrics to give a general overview of the project performance. Actions are triggered based on these general performance metrics, which need further investigation to detect problems at the activity level. A bottom up project control system refers to a system in which detailed activity information needs to be available constantly during the project control process, which requires more effort. In this research, we propose two new project control approaches, which combines elements of both top down and bottom up control. To this end, we integrate the earned value management/earned schedule (EVM/ES) method with multiple control points inspired by critical chain/buffer management (CC/BM). We show how the EVM/ES control approach is complementary with the concept of buffers and how they can improve the project control process when cleverly combined. These combined top down approaches overcome some of the drawbacks of traditional EVM/ES mentioned in the literature, while minimally increasing the effort spent by the project manager. A large computational experiment is set up to test the approach against other control procedures within a broad range of simulated dynamic project progress situations.

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1. Introduction

In this paper we focus our research on the control process during the execution of a project. Among the different approaches published in the project management literature, substantial distinctions exist with respect to the work breakdown structure (WBS) level at which the control process is performed, and consequently the effort which is spent during the process and the accuracy of potential actions triggered by such a process. We will restrict our attention to schedule control in this research.

Ultimately, the objective of the control process is finishing the project within a given deadline. It is assumed that the level of detail that has to be available for the project manager during project control corresponds to the effort spent during the control process. This research will not focus on the possible actions to be

taken to bring the project back on track, we therefore refer to Herroelen and Leus (2001), Bowman (2006) and Vanhoucke (2011) for an illustration of possible actions that can be incorporated into a dynamic project control experiment. Rather, we will discuss the project control process itself and analyse its performance based on whether or not it produces correct warning signals. We consider the project baseline schedule to be a given and will not discuss different objective functions that can be taken into account during project planning (Liang, 2010) under the availability of limited resources. The reader is referred to a recent survey written by Hartmann and Briskorn (2010) on that topic.

Fig. 1 shows a classification of project control procedures according to the effort invested by the project manager during the project control process. The purpose of this figure is not to give an exhaustive list of the control procedures published in literature or to provide a bullet-proof classification for these control methods. Rather, we wish to express the reduced effort spent by a project manager when only high WBS level information needs to be recorded and processed at each review period during the top down project control process. This *top down* and *bottom up* classification

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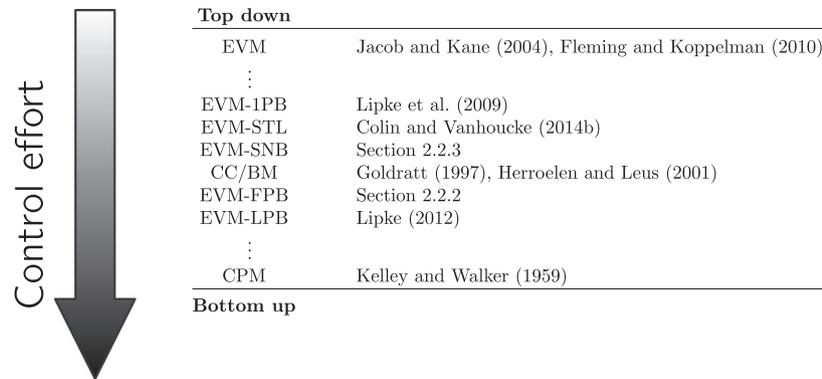


Fig. 1. Control process effort classification.

was previously used in the research of Vanhoucke (2011). A *bottom up* procedure requires an intensive and detailed control on all the activities at the lowest WBS level. With this information, a reliable estimate for the final project duration can be calculated and actions can be taken accordingly to meet a given project deadline. Alternatively, a *top down* procedure will only consider a single aggregate performance metric calculated at the top level of the WBS during project control. Only if necessary, additional effort can be spent by drilling down the WBS, in search of those activities that need actions, to ensure a timely completion of the project.

At the bottom of Fig. 1, the critical path method (CPM) is classified as requiring much project control effort by the project manager. CPM is one of the earliest reported approaches for project planning which can also be used in practice to form a basis for prediction of the total project duration and to check progress against a produced baseline during project execution (Kelley & Walker, 1959). At each review period during project control, progress details on all the activities need to be reported. If the CPM algorithm is updated with actual durations for those activities that have been finished, expected finish times for the activities that are in progress and the baseline estimates for the other activities, it produces a reliable estimate for the final project duration. Updating the information for all individual activities can become a cumbersome and disruptive task for project teams in projects with a large number of activities (Lipke, Zwikael, Henderson, & Anbari, 2009).

At the top of Fig. 1, earned value management is classified as demanding less project control effort by the project manager. EVM was originally developed in the 60's by the U.S. Department of Defence as a project cost and schedule control procedure that evaluates and reports performance metrics calculated at high levels of the WBS. Fleming and Koppelman (2010) brought EVM under the attention of researchers, and recent publications have produced the earned schedule method (ES; Lipke et al. (2009)), new project cost and duration forecasting methods using artificial intelligence (Cheng & Wu, 2009; Cheng & Roy, 2010; Wauters & Vanhoucke, 2014) and fuzzy logic (Moslemi Naeni & Salehipour, 2011), and dynamic EVM systems for monitoring (Lee, Peña-Mora, & Park, 2006) and visualisation (Chou, Chen, Hou, & Lin, 2010) of the performance of a project. Jacob and Kane (2004) argue that an aggregate look of the project performance at the highest level of the WBS might lead to misinterpretations of the real project performance and errors in the reported warning signals, and state that the EVM performance measures should be used at lower WBS levels, obviously leading to an increased effort for the project manager. On the contrary, Lipke et al. (2009) argue that the use of EVM on lower levels of the WBS is a cumbersome and often disruptive tasks for the project manager and EVM/ES needs to be applied at high levels of the WBS. These conflicting views on the optimal

level for project control using EVM/ES have inspired the work in this paper.

More precisely, we will propose control points for a project at a level of the WBS in-between the top level of traditional EVM and the bottom level of the CPM. These can be interpreted as intermediate levels of the WBS at which the EVM/ES performance measures are calculated. In doing so, they replace the use of control accounts (CA) in an EVM system. Control accounts are natural management points for planning and control, since they represent the work assigned to one responsible organisational element in the WBS. However, since the WBS ordering in control accounts is brought forth by organisational or practical considerations, these control accounts have little or no correspondence to the baseline schedule, i.e. the logic followed during the execution. The proposed control points in this research can also be interpreted as locations in the project activity network. We will therefore frequently refer to the placement of a control point in the network, as calculated from the baseline schedule. The reader should note, that the timing of control points is not discussed in this research (Partovi & Burton, 1993; Raz & Erel, 2000). Each discussed control approach will have an equal number of observations, distributed uniformly over the duration of the project. While the research on the timing of control points is concerned with minimising the number of observation points during the execution of the project (Golenko-Ginzburg & Laslo, 2001), our objective is to investigate the effect of grouping activities into subsets. These subsets are then controlled separately, which should minimise the probability that a deviation from the baseline schedule goes unnoticed and endangers the project deadline. We will propose control points for different control approaches in this research, while incorporating the concept of buffers from the critical chain/buffer management (CC/BM) methodology into the EVM/ES control process to include project baseline information in a structured manner:

- Two new EVM/ES approaches will be introduced in this paper. Similar to the CC/BM approach, buffers are added as control points to the project in each feeding path that enters the critical path (EVM-FPB). EVM/ES performance measures will then be used to monitor the progress of both the critical path and all the feeding paths. While this can lead to a high number of control points, a second approach will also be presented to reduce the number of control points by adding buffers on subnetworks instead of on all feeding paths (EVM-SNB).
- We will test these newly proposed control approach against three additional EVM/ES procedures found in the literature. The traditional EVM/ES control methodology makes use of a single control point at the top level of the WBS, and is therefore labelled as EVM-1PB (1 project buffer). This control methodology can be extended by statistical tolerance limits (EVM-STL)

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