

# Dynamic Scheduling: Integrating Schedule Risk Analysis with Earned Value Management

By Mario Vanhoucke - May 2012

**ABSTRACT** – The topic of this paper is dynamic project scheduling to illustrate that project scheduling is a dynamic process that involves a continuous stream of changes and is a never ending process to support decisions that need to be made along the life of the project.

The focus of this paper lies on three crucial dimensions of dynamic scheduling which can be briefly outlined along the following lines: (i) Baseline scheduling to construct a timetable that provides a start and end date for each project activity, taking activity relations, resource constraints and other project characteristics into account, and aiming to reach a certain scheduling objective, (ii) risk analysis to analyze the strengths and weaknesses of your project schedule in order to obtain information about the schedule sensitivity and the possible changes that undoubtedly occur during project progress and (iii) project control to measure the (time and cost) performance of a project during its progress and use the information obtained during the scheduling and risk analysis steps to monitor and update the project and to take corrective actions in case of problems.

The focus of the current paper is on the importance and crucial role of the baseline scheduling component for the two other components, and the integration of the schedule risk and project control component in order to support a better corrective action decision making when the project is in trouble.

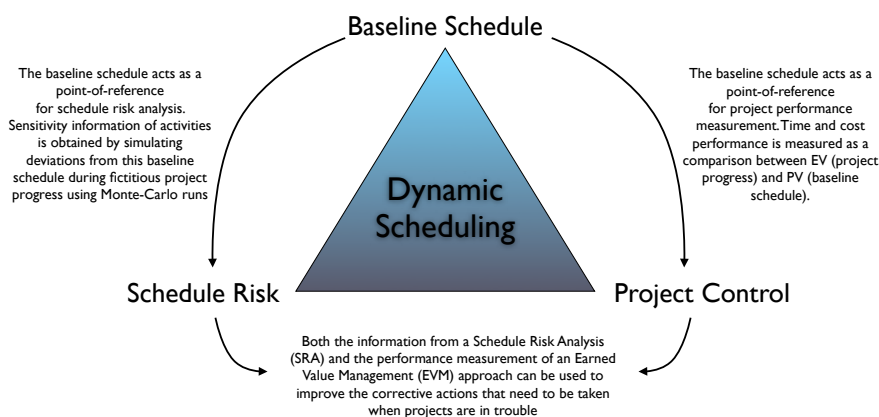


Figure 1: Dynamic scheduling: baseline scheduling, risk analysis and project control

## 1 Introduction

Dynamic scheduling is used to refer to dynamic interplay between its three components: baseline scheduling, schedule risk and project control. The construction of a baseline schedule plays a central role in a dynamic scheduling environment, both for measuring schedule risk and in a project control environment. Schedule Risk Analysis (SRA) is a technique to measure the sensitivity of project activities and to predict the expected influence of variability in activity durations/costs on the project objective. An SRA study is done based on Monte-Carlo simulations that repetitively simulate project progress and compare each project run with the baseline schedule. Earned Value Management is a project tracking and control technique that compares the project performance relative to the baseline schedule.

It is conjectured that baseline scheduling, schedule risk analysis and project tracking go hand in hand and each component is based on assumptions and results obtained by the other. Figure 1 shows the three building blocks of dynamic scheduling and shows the relevance

of the baseline schedule as a point of reference for both schedule risk and project control.

The topic of this paper is to discuss the missing link in the dynamic scheduling principle: can schedule risk analysis and earned value management be integrated into a single project tracking approach to better support the decision making process of corrective actions?

The outline of this paper is as follows. Section 2 reviews the basic principle of EVM in a project tracking environment and refers to this approach as a top-down project tracking approach. In section 3, the basic SRA principle is outlined as a so-called bottom-up project tracking approach. The two approaches are compared to each other in a large dynamic project control study and the main conclusions are summarized in section 4. Section 5 gives overall conclusions and highlights potential paths of future work.

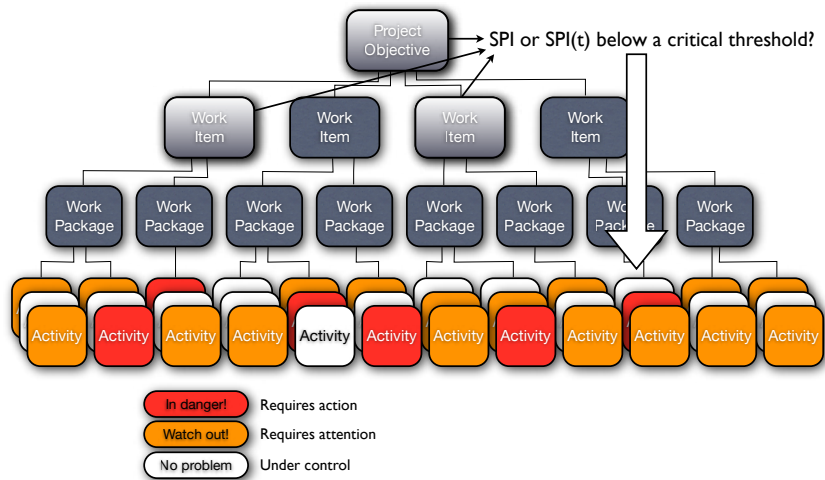
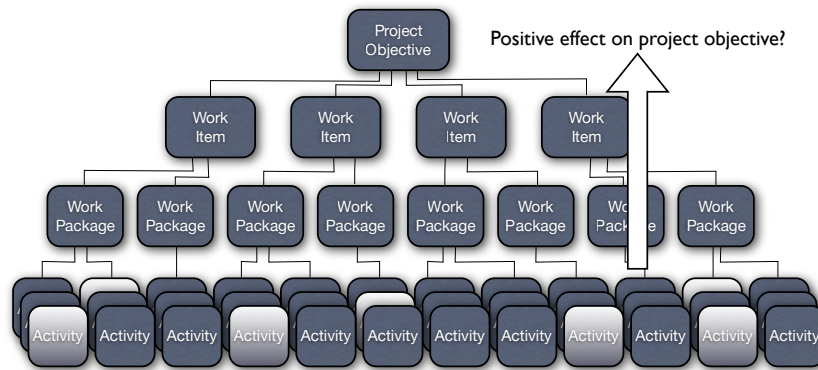


Figure 2: The top-down project-based tracking approach of earned value management

### 2 Top-down project tracking using EVM

Project tracking using earned value management should not be considered as an alternative to the well-known critical path based scheduling and tracking tools. Instead, the EVM methodology offers the project manager a tool to calculate a quick and easy sanity check on the control account level or even higher levels of the work breakdown structure (WBS). In this respect, an earned value management system is set up as an early warning signal system to detect problems and/or opportunities in an easy and efficient way, which is obviously less accurate than the detailed critical path based scheduling analysis of

each individual activity. However, this early warning signal, if analyzed properly, defines the need to eventually drill down into lower WBS levels. In conjunction with the project schedule, it allows taking corrective actions on those activities that are in trouble (especially those tasks which are on the critical path). In this paper, this top-down tracking approach is called a project-based tracking method. Figure 2 displays a fictitious work breakdown structure (WBS) to illustrate the project-based project tracking approach of earned value management.



Individual activity control as a trigger for corrective actions  
 = Obtain with the minimal effort the maximal return!

Figure 3: The bottom-up activity-based tracking approach of schedule risk analysis

### 3 Bottom-up project tracking using SRA

Figure 3 illustrates the bottom-up tracking approach of schedule risk analysis. The detection of activity sensitivity information is crucial to steer a project manager's attention towards a subset of the project activities that have a highly expected effect on the overall project performance. These highly sensitive activities are subject to intensive control, while others require less or no attention during project execution. This approach is referred to as an activity-based tracking approach to denote the bottom-up control and tracking approach to take corrective actions on those activities with a highly expected effect on the overall project objective.

Four well-known sensitivity measures have been tested on their usefulness to measure the degree of activity sensitivity and to reduce the effort of the project tracking process without losing the ability to take appropriate corrective actions with positive effects on the overall proj-

ect objective. The test results show that most sensitivity measures are able to measure the degree of sensitivity and can be used as identifiers of an activity's sensitivity when projects contain many parallel activities. However, for projects with a more serial network structure, most sensitivity measures are no longer able to distinguish between insensitive and sensitive activities, and hence, a careful selection of a subpart of the activity set that will be subject to a detailed tracking approach is more difficult or simply impossible. The overall conclusion is that the criticality index CI, the significance index SI and the cruciality index CRI perform well for parallel networks but fail in discriminating between low and high sensitivity for serial networks. The schedule sensitivity index SSI is the only sensitivity measure that is able to select a sensitive subset of activities for both parallel and serial networks, and hence, can be easily used to guide and simplify the bottom-up tracking process.

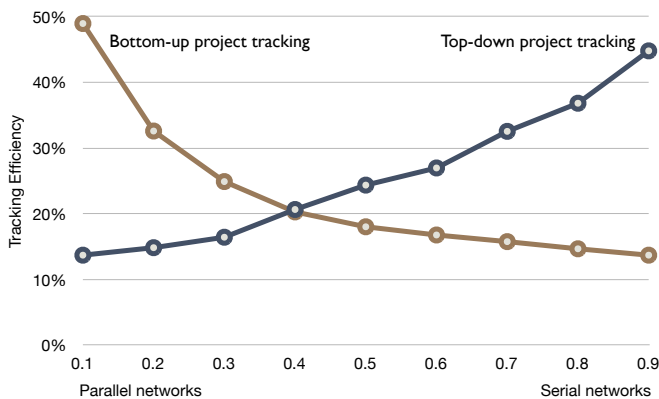


Figure 4: The tracking efficiency of a bottom-up and top-down tracking approach

#### 4 Research summary

Vanhoucke (2010a) has experimentally validated the efficiency of the two alternative project tracking methods of figures 2 and 3 in his book titled "Measuring Time - Improving Project Performance using Earned Value Management". In this study, the efficiency of corrective actions taken on projects in trouble is measured for various projects, ranging from parallel to serial projects. Those corrective actions are triggered by information obtained by a schedule risk analysis (bottom-up) or an EVM warning signal (top-down). Figure 4 shows an illustrative graph of this tracking efficiency for both tracking approaches. The graph clearly demonstrates that a top-down project-based tracking approach using the EVM performance measures provides highly accurate results when the project network contains more serial activities. This top-down approach lies in the heart of the earned value management philosophy and has been tested in detail throughout the book. The bottom-up activity-based tracking approach using sensitivity information of activities obtained through a standard schedule risk analysis is particularly useful when projects contain a lot of parallel activities. This bottom-up approach requires subjective estimates of probability distributions to define the activity risk profiles, but simplifies the tracking effort by focusing on those activities with a highly expected effect on the overall project objective. Table 1 summarizes the main conclusions of this research study, and more information can be found in Vanhoucke (2011).

Table 1: Overall summary of the tracking efficiency study

	Activity-based project tracking (bottom-up)	Project-based project tracking (top-down)
Parallel networks	<p>✓</p> <p>Focus only on highly sensitive activities</p>	<p>✗</p> <p>Inaccurate time predictions</p>
Serial networks	<p>✗</p> <p>Detection of sensitive activities often impossible</p>	<p>✓</p> <p>Accurate time predictions (using earned schedule)</p>

#### 5 Conclusions

In this paper, two alternative project tracking methods are compared and validated on the set of fictitious project data using Monte-Carlo simulations. The top-down project tracking method relies on EVM project performance data that are used as early warning signals and triggers to the need for corrective actions. The bottom-up tracking method is based on schedule risk analysis that reveals sensitivity information of each activity and hence the need to focus on only the highly sensitive parts of the project.

The basic conclusions of a large project study have been summarized and highlighted throughout this paper. The tracking efficiency is high for a top-down project tracking approach using EVM information when the project contains many serial activities. This is completely in line with

the forecast accuracy study of Vanhoucke and Vandevoorde (2007). The tracking efficiency is high for a bottom-up tracking approach using SRA information when the project contains many parallel activities. These results confirm the results and conjectures made in Vanhoucke (2010b) and are published in Vanhoucke (2011).

#### 6 Acknowledgements

We acknowledge the support by the Research Collaboration fund of PMI Belgium received in Brussels in 2007 at the Belgian Chapter meeting, the support for the research project funding by the Flemish Government (2008), Belgium as well as the support given by the Fonds voor Wetenschappelijk Onderzoek (FWO), Vlaanderen, Belgium under contract number G.0463.04. This research is part of the IPMA Research award 2008 project by Mario Vanhoucke who was awarded at the 22nd world congress in Rome (Italy) for his study "Measuring Time - An Earned Value Simulation Study".

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