PM WORLD TODAY – FEATURED PAPER – JANUARY 2011

Adding Value to Earned Value Analysis

By Mario Vanhoucke, PhD
Ghent University and Vlerick Leuven Gent Management School,
Gent, Belgium
and
Avraham Shtub, PhD
Technion Israel Institute of Technology
Haifa, Israel

Abstract

The non-repetitive nature of projects leads to uncertainty that is present to some degree in every project. Our limited ability to accurately forecast future values of parameters that are used as input to plan projects affect every project. Due to uncertainty and the resulting risk, project planning is in fact a starting point in the project management process that consists of planning, monitoring and control. Risk management techniques are also used in project management for the very same reason. Understanding the dynamic, stochastic nature of projects and the tools and techniques that can help us cope with this environment is the focus of this paper.

In this paper we discuss some ideas, tools and techniques that may help project managers cope with uncertainty. We focus our discussion on two new ways to teach students and practitioners the Earned Value concept, which is discussed in the PMBOK and is supported by many of the commercial project management software packages: the Project Team Builder (PTB) and ProTrack's Assistant. PTB is a training tool that won the PMI product of the year award for 2008. ProTrack's Assistant is an automatic tool added on the ProTrack software tool that integrates lessons learned from an Earned Value research study awarded by the IPMA research 2008 award.

Keywords: Earned value, project uncertainty, project risk, training, project monitoring, project control.

1   <u>Introduction</u>

Uncertainty is a key factor affecting all kinds of projects. In an ideal world where the future is known for sure, a good project plan could guarantee project success. In such an ideal world the task of the project manager is simply to develop a good plan and to execute the project according to the plan. Furthermore, in such an ideal situation,

project success factors are limited to the quality of the plan and the adherence of the project execution to the original plan.
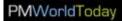
Unfortunately uncertainty is present to some extent in every project, due to the non-repetitive nature of projects and the resulting limited ability to accurately forecast future values of the input parameters needed as input for the project plan. The best plan is based on forecasts and is subject to forecasting errors. Uncertainty generates the risk that the actual results will deviate from the plan and therefore project planning should be viewed only as a starting point in the project management process. One methodology developed to deal with uncertainty is *risk management*. Techniques for identifying and mitigating risk as well as techniques for risk monitoring and control are used by project managers facing uncertainty, but even with proper risk management many projects are late or over budget as they are sensitive to changes in the dynamic stochastic project environment.

A second methodology designed to help project managers in dealing with the project stochastic, dynamic environment is *project monitoring and control*. Project control is based on the comparison of the plan (the plan is a baseline for comparison) with the actual results in an effort to identify deviations and to alert management attention to the need to take corrective actions.

A major issue in the design of project control systems is how to measure actual progress and how to compare the actual progress to the baseline plan. A wide variety of control parameters exists. On one extreme there are very simple parameters like the start time of an activity or its finish time captured in the baseline schedule Gantt chart. By comparing the planned start time (or finish time) of an activity to its actual start time (or finish time) one can tell if the activity is starting (or finishing) on time. On the other extreme there are more sophisticated control methodologies. Some of these control methodologies like the Earned Value methodology are supported by standards and commercial software for project management.

This paper is focusing on the Earned Value Management (EVM) systems. These systems are based on integration of cost and schedule control within a well defined project structure consisting of the Work Breakdown Structure (WBS) and the Organizational Breakdown Structure (OBS). The requirements from these two structures and the other components of the EV system are defined in the United States standard ANSI/EIA-748A published in May 1998 and reaffirmed in August 2002. The standard defines 32 criteria for EV system compliance.

The relative complexity of the earned value system and the mixed results of its implementation (Vanhoucke 2010) suggest that some open questions still exists with respect to the Earned Value concepts and the way these concepts should be taught and implemented.

In this paper we discuss some new insights into the Earned Value system and propose two new ways that support teaching and training in this important area.

2   Earned Value Insights

In a simulation study by Shtub (1992), the performances of the Earned Value Management control system are compared to the simple CPM based control by simulating a stochastic dynamic environment typical to R@D projects. The conclusion of the study was that each method has its pros and cons. The main advantage of the earned value system is its ability to detect deviations at any level from the activity level up to the project level using the same performance measures throughout the whole project WBS and OBS framework. The main disadvantage of the Earned Value system is its inability to distinguish between critical and non-critical activities, and hence, the schedule analysis based on Earned Value may generate misleading results as non-critical activities that are ahead of schedule may hide the fact that some critical activities are beyond schedule. A similar simulation study by Vanhoucke (2007) confirmed this potential error and has measured the impact of this potential flaw on the accuracy of EVM metrics and forecasting techniques.

The most significant impact of this shortcoming of Earned Value analysis is the limited ability of the system to forecast the duration of the project based on its current progress. While the Estimate At Completion (Estimated total budget) is less sensitive to the difference between progress made on critical activities vs. progress made on non-critical activities, the updated Estimate At Completion for Time (Estimated total project duration) may be very sensitive to this difference.

To overcome this problem, several researchers proposed modifications to the Earned Value analysis: Lipke (2003) proposed the earned schedule method, Anbari (2003) proposed the planned value method and Jacob, (2003) proposed the earned duration method. Rresearchers from the academic world as well as managers dealing with real-world practical projects have critically analyzed the forecasting power of the original EV and its modified new methods and concluded that the earned schedule method can better predict the total duration of a project (Vandevoorde and Vanhoucke 2006); Henderson (2004, 2005), Vanhoucke and Vandevoorde (2007b, 2007a)). These studies show that the earned schedule method outperforms, on average, the two other new methods [the planned value method (Anbari, 2003) and the earned duration method (Jacob, 2003)].

3   Teaching Earned Value and the Forecasting methods

Unlike researchers who use sophisticated simulation studies to evaluate the different forecasting methods, practitioners and students are having difficulties understanding these differences, and most importantly when it is best to use each of the different methods. Although the relevance of these studies is not put into question in this article,

this section discusses two ways to translate these research findings into practical tips and tricks and lessons learned for both students and project managers. In section 3.1, a teaching and training tool developed to teach project management is discussed which was found very effective for teaching the concepts of Earned Value analysis and the differences between the different forecasting methods. In section 3.2, an assistant add-on to a commercial software tool is discussed that integrates various lessons learned from a big research study in order to guide project management software users towards the best and most promising earned value management and project control approach.

3.1   Project Team Builder

The Project Team Builder (PTB) is now available from Sandbox Model (2010). It applies recent developments in the area of simulation-based training. The PTB is designed to support training and to provide an environment for practicing teamwork in managing dynamic stochastic projects.

The PTB won the 2008 Product of the year Award (PMI) and is based on the following principles:

– A simulation approach—the Project Team Builder simulates one or more projects. The simulation is controlled by a simple user interface and no knowledge of simulation or simulation languages is required.

– A case study approach—the Project Team Builder is based on a simulation of case studies. Each case study is a project or a collection of projects performed under schedule, budget and resource constraints, in a dynamic stochastic environment. The details of these case studies are built into the simulation and all the data required for analysis and decision-making is easily accessed by the user interface. A user-friendly case study generator facilitates the development of new case studies as required.

– A dynamic approach—the case studies built into the Project Team Builder are dynamic in the sense that the situation changes over time. A random effect is introduced to simulate the uncertainty in the environment, and decisions made by the user cause changes in the state of the system simulated.

– A model-based approach—a decision support system is built into the Project Team Builder. This system is based on project management concepts. The model base contains well-known models for scheduling, budgeting, resource management and monitoring and control. These models can be consulted at any time.

– To support decision-making further, a database is built into the Project Team Builder. Data on the current state of the simulated system is readily available to

the users. Furthermore, it is possible to use the data as input to the models in the model base to support decision-making.

– An integrated approach—several projects can be managed simultaneously on the PTB. These projects share the same resources and a common cash flow.

– User friendliness and GUI—the Project Team Builder is designed as a teaching and training tool. As such, its Graphic User Interface (GUI) is friendly and easy to learn. Although quite complicated scenarios are simulated, and the decision support tools are sophisticated, a typical user can learn how to use the Project Team Builder within an hour.

– Integration with commercial project management tools—the Project Team Builder is integrated with commercial project management software so that the users can analyze the scenario on the commercial project management software and support decisions with tools that are actually used in his organization.
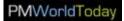
The Project Team Builder provides a supporting setting for training in Project Management and for developing, evaluating and testing new methods for project management like the techniques developed for estimating the project duration.

The effectiveness and efficiency of the Project Team Builder were tested in controlled experiments [Davidovitch et al 2006, 2008, 2009, 2010]. The findings show that with the Project Team Builder, there was a significantly better learning process. Confucius the Chinese philosopher & reformer (551 BC - 479 BC) said: "I hear and I forget. I see and I remember. I do and I understand." This is the essence of using PTB- to teach and practice project management techniques and to understand the value of the Earned Value methodology.

The PTB can be used as a stand-alone system as it contains models for scheduling, budgeting, resource management, cash management, monitoring and control. It can be used with commercial project management software like Microsoft Project. The experience gained after more than five years of teaching, training and experimenting with PTB motivated the development of a new course based on PTB (Shtub, 2010).

3.2   ProTrack's Assistant

ProTrack (acronym for Project Tracking) is a project scheduling and tracking software tool developed by OR-AS (www.or-as.be) to offer a straightforward yet effective alternative to the numerous project scheduling and tracking software tools. The software has been completely built based on the results of the research study discussed in the awarded book "Measuring Time" by Vanhoucke (2010) and the many discussions with practitioners using earned value management. The scheduling and tracking approach is
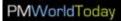
based on the current best practices of earned value management and the novel concepts introduced and tested in this book.

ProTrack's Assistant is an add-on on ProTrack which incorporates most research results of the research study. It's intention is to offer tips, tricks and guidelines to the user which are applicable for their particular project, rather than to offer general information drawn from the research study. In doing so, the user can immediately translate this information to practical actions for his/her project, leading to a better understanding of the various tools and techniques available and possibly leading to a better project control approach and project success.

The research study incorporated in ProTrack's assistant won the 2008 IPMA Research Award, and its specific aims and targets can be summarized as follows:

- What are the static (before project execution) and dynamic (during project execution) drivers of forecast accuracy? Knowledge about project performance drivers and accurate forecast accuracy measures should allow the project manager to critically analyze EVM performance measures and to accurately predict the final cost and duration of a project. Static and dynamic drivers that have been investigated into detail are:

  o Static drivers:
    ▪ Project network structure: Characteristics of the project can be easily calculated during the construction of the baseline schedule, and affect the accuracy of the performance measurement during project tracking.
    ▪ Activity criticality: The degree of activity criticality affects the project tracking process and the performance accuracy.

  o Dynamic drivers:
    ▪ Time span of control: The time span and the number of review periods during project performance measurement clearly affect the accuracy.
    ▪ Schedule adherence: The project schedule and the adherence to that schedule (in terms of precedence logic, EVM measurement system, etc.) should have an effect on the accuracy of project performance measurement.

- How does the project time sensitivity affect the accuracy of performance measurement?
  o Information obtained during the scheduling step (baseline plan) as well as sensitivity information and risk analysis obtained through a Schedule Risk
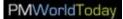
Analysis (SRA) should allow the project manager to improve the project tracking process and the corrective actions decision making process.

- How does the knowledge on forecast accuracy (two previous aims) lead to improved corrective actions decision making during project tracking?

   o Since EVM is a methodology to provide an often quick sanity check of the project health on the cost control account level or even higher Work Breakdown Structure (WBS) levels, it cannot be considered as an alternative of the often time-consuming activity-based Critical Path Method (CPM) scheduling approach. The research aims at detecting when and how the EVM tracking approach offers a full alternative to the detailed CPM project tracking, and in which cases a need to drill down to lower WBS levels is necessary to take corrective actions.

4   Summary

The dynamic uncertain environment of projects is not fully understood by many students and inexperienced managers. Without a good understanding of this environment and the resulting risk, managers tend to assume that project planning is a one time effort and a good plan is a guarantee to project success. Training is the key to exposing students and practitioners to the need for proper tools and techniques and to practice the use of tools like Earned Value in an environment that show the advantages of available tools.

The development of forecasting methods based on the EVM concept can be taught efficiently and effectively by using the Project Team Builder. It can bridge the gap between published research that evaluates different tools and techniques and the current knowledge of the trainee by providing hands on experience in a controlled well managed training environment. Moreover, proper use of various tools and techniques available in most commercial software tools can only be fully understood and integrated in the project planning approach of project managers when the underlying principles are tailored to the wishes and needs of the project under study. ProTrack's assistant serves well to that purpose and offers tips and tricks to software users tailored to his or her needs based on project specific data.

References

Anbari, F. (2003). Earned value project management method and extensions. *Project Management Journal*, 34:12–23

Davidovitch, L., A. Parush and A. Shtub, (2006) Simulation-based Learning in Engineering Education: Performance and Transfer in Learning Project Management", *Journal of Engineering Education,* 289–299.

Davidovitch, L., A. Parush and A. Shtub, (2008) Simulation-based Learning: The Learning-Forgetting-Relearning Process and Impact of Learning History", *Computers & Education,* Vol. 50, No. 3, 866–880.

Davidovitch, L., A. Parush and A. Shtub, (2009) The Impact of Functional Fidelity in Simulator based Learning of Project Management", *International Journal of Engineering Education,* Vol. 25, No. 2, 333–340(8).

Davidovitch, L., A. Parush and A. Shtub, (2010) Simulator-based Team Training to Share Resources in a Matrix Structure Organization". *IEEE Transactions on Engineering Management*, Vol. 57, No. 2, 288-300.

Henderson, K. (2004). Further developments in earned schedule. *The Measurable News*, Spring:15–17, 20–22.

Henderson, K. (2005). Earned schedule in action. *The Measurable News*, Spring:23–28, 30.

Jacob, D. (2003). Forecasting project schedule completion with earned value metrics. *The Measurable News*, March:1, 7–9.

Jacob, D. and Kane, M. (2004). Forecasting schedule completion using earned value metrics revisited. *The Measurable News*, Summer:1, 11–17.

Lipke, W. (2003). Schedule is different. *The Measurable News*, Summer:31–34.

Sandboxmodel (2010) http://www.sandboxmodel.com/

Shtub, A. (1992) Evaluation of two schedule control techniques for the development and implementation of new technologies: a simulation study. R@D *R&D Management,* Volume 22 Issue 1, Pages 81 – 88

Shtub, A. (2010) Project Management Simulation with PTB Project Team Builder, Springer, forthcoming.

Vandevoorde, S. and Vanhoucke, M. (2006). A comparison of different project duration forecasting methods using earned value metrics. *International Journal of Project Management*, 24:289–302.

Vanhoucke, M. and Vandevoorde, S. (2007a). A simulation and evaluation of earned value metrics to forecast the project duration. *Journal of the Operational Research Society*, 58:1361–1374.

Vanhoucke, M. and Vandevoorde, S. (2007b). Measuring the accuracy of earned value/earned schedule forecasting predictors. *The Measurable News*, Winter:26–30.

Vanhoucke, M. (2010). Measuring Time: Improving Project Performance using Earned Value Management, *International Series in Operations Research and Management Science.* Springer, vol. 136.
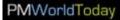
About the Authors

Mario Vanhoucke, PhD

Co-Author

Prof. Dr. Mario Vanhoucke is a professor at the Ghent University, the Vlerick Leuven Gent Management School (Belgium) and University College of London (UK). He teaches Project Management, Business Statistics and Applied Operations Research. He is the program director of the Commercial Engineers and the advanced Master in Operations and Technology Management. He is partner of the company OR-AS (www.or-as.be) and is co-developer of ProTrack (www.protrack.be), a novel project scheduling software tool that integrates baseline scheduling, risk management and project control using earned value/schedule. His main research interest lies in simulation and optimization models in project scheduling and scheduling in the health-care sector. He is advisor of various PhD projects, in collaboration with different university hospitals. He has articles published in international journals, such as Annals of Operations Research, Management Science, Operations Research, The Account- ing Review, International Journal of Production Research, Journal of the Operational Research Society, Journal of Scheduling, International Journal of Project Management, Project Management Journal, European Journal of Operational Research and Lecture Notes on Computer Science. He is author of the award winning book "Measuring Time: Improving Project Performance Using Earned Value Management". Professor Vanhoucke can be contacted at mario.vanhoucke@UGent.be.

Avraham Shtub

Co-Author

Avraham Shtub is the Stephen and Sharon Seiden Professor of Project Management in the Industrial Engineering and Management Department at Technion Israel Institute of Technology in Haifa, Israel. He has a B.Sc in Electrical Engineering from the Technion - Israel Institute of Technology (1974), an MBA from Tel Aviv University (1978) and a Ph.D in Management Science and Industrial Engineering from the University of Washington (1982). He is a certified Project Management Professional (PMP) and a member of the Project Management Institute (PMI-USA). He is a senior member of the Institute of Industrial Engineering (USA), and the recipient of the Institute of Industrial Engineering 1995 "Book of the Year Award" for his Book "Project Management: Engineering, Technology and Implementation" (co-authored with Jonathan Bard and Shlomo Globerson), Prentice Hall, 1994. He is the recipient of the Production Operations Management Society 2000 Wick Skinner Teaching Innovation Achievements Award for his book: "Enterprise Resource Planning (ERP): The Dynamics of Operations Management". Professor Shtub is the recipient of the 2008 Project Management Institute Professional Development Product of the Year Award for the training simulator "Project Team Builder – PTB". His books on Project Management were published in English, Hebrew, Greek and Chinese.

Prof. Shtub was a Department Editor for IIE Transactions, he was on the Editorial Boards of the Project Management Journal, The International Journal of Project Management, IIE Transactions and the International Journal of Production Research. He was a faculty member of the department of Industrial Engineering at Tel Aviv University from 1984 to 1998 were he also served as a chairman of the department (1993-1996). He joined the Technion in 1998 and was the Associate Dean and head of the MBA program. He has been a consultant to industry in the areas of project management, training by simulators and the design of production - operation systems. He was invited to speak at special seminars on Project Management and Operations in Europe, the Far East, North America, South America, New Zealand and Australia.