A Method for Choosing a Project's Planned Value Curve by Integrating Earned Value and Risk Management

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Summary:

The timely and precise feedback is of crucial importance for the success of every project. It allows identifying the problems at an early stage and performing corrective actions that help keeping the initially planned costs and time of the project on schedule. Nowadays Earned Value Management is known as one of the most effective methods for the performance measurement of projects. At the same time it uses the fundamental principle that the models and trends of the past can be used to determine the future status.

As both Earned Value Management (EVM) and Risk Management (RM) are directed towards solving the same problem – measuring a project's performance by providing information that is used for a basis for making informed decisions and taking actions, there is a considerable interest in the possibility of developing a combined approach and creating a synergy between them, given their different point of view - while EVM is based on the past, RM is directed towards the future.

Currently in practice EVM and RM function as parallel processes without systematic integration. Most of the discussions on the relationship between them are rather theoretical and are addressed to the key principles underlying the two techniques. In this regard the aim of this article is to present the opportunity of these two management approaches to be integrated, given their common intent to explore and reveal the driving forces of the project performance. The study will provide a methodology that will assist the selection of one of the key figures in the theory of EVM - the basic project plan. This methodology is based on historical data from completed projects, as well as on simulation methods that generate possible project outcomes.

Key words: Project Management, Earned Value Management, Risk Management, Planned Value

Jel Classification: O22, D81

Introduction

In today's dynamic environment project management is a pretty arduous work as there are more factors that should be taken into consideration and increases the uncertainty of the project (Petit & Hobbs, 2012). The projects have become more complex and even though a few decades ago it was possible to manage each

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project only by using a single management approach, nowadays this will inevitably lead to failure. For example, many possible risks were underestimated during the construction of one of the largest hydroelectric sites in the world - Simplício Hydroelectric Complex near Rio de Janeiro, Brazil (Pereira, 2013). The project with a budget of $2 billion was completed three years behind schedule due to increased costs, lengthy permit approvals as well as a court decision which delayed the Anta Reservoir from being filled with water. Those risks were not foreseen during the planning process and were not managed well afterwards. A set of management approaches was vital for such a huge project in order to keep it in schedule, because the major problem in the common project management is not that the methods are wrong or their logical path is confounded. The environment has changed. It has become more complex which forces us to change our models so that they can reflect correctly the primary objects. Using the fundament of the known methods we should develop them further and integrate them, so that they could correspond to the new, more complex projects.

1. Aims and objectives. Where is the knowledge gap in the integration of the Earned Value and Risk Management?

As the project management is the process and activity of planning, organizing, motivating and controlling resources and procedures in order to achieve specific goals (Project Management Institute (PMI), 2008), our task is to promote and unite those stages to achieve a synergetic effect. One of the techniques used not only for integrating the various processes but also for measuring the performance of the project (PMI, 2000) is Earned Value Management (EVM). As this method is a multi-dimensional project control system, it is one of the most effective methods for performance measurement as well as a feedback tool when dealing with projects (Fleming & Koppelman, 2000).

The current article is focused on the opportunity for integrating EVM and Risk Management (RM) given their common goal to provide information in decision making and taking actions. A way for their integrated use is creating a set of curves that represent the possible baseline plans, known as Planned Value (PV) curves (Hillson, 2004). The PV curve is the base on which all EVM calculations are made, so the process of defining which curve of the possible predefined set will be chosen for a baseline is crucial. Here the pioneer in the integration of EVM & RM - Dr. David Hillson (2004) makes an assumption that the manager is free to make his or hers choice by using the method of the expected values, an 80% confidence level, etc. None of the subsequent studies answers the question which method to use according to the unique characteristics of each project, nor offers a model that can help us in making such a choice. The available software products (Lazić & Mastorakis, 2005, Hayashi & Kataoka, 2008) only help generating a set of possible Planned Value curves, but again leave the manager to make a decision based on their discretion.

In this regard, we can see that there is a lack of a model useful in common situations when choosing a baseline spend plan. The manager should have the option to choose the PV curve based not only on his assessment, but also on quantitative methods and simulations. The aim of the study is to provide a methodology that will assist the selection of one of the key figures in the theory of EVM – the Baseline Spend Plan (i.e. Planned Value Curve). To this effect, the operational objectives of this paper are:

1. To present the existing theoretical framework regarding the integration of the EVM and RM, as well as some studies on their improvement.

2. To provide a methodology based on historical data from completed projects, as well as on simulation methods that generate possible project outcomes.

3. To offer a model that will not leave the choice of a Planned Value curve to random factors or the manager›s judgment, but on a method of detailed calculations.

Those objectives will help in a future study, based on the approbation of the model. It will answer the following research questions:

Q1: Is the expected value method the most appropriate one for determining the basic of the Earned Value Management - the Baseline Spend Plan?

Q2: Under what circumstances (limitations on projects› scope, budget and duration) will it be more suitable to use a confidence level method rather than the expected value method when choosing a Baseline Spend Plan?

The research objects of the future study shall be projects with a predefined scope of activities, duration, budget, and other distinguishing characteristics will be used as. This however is a matter of a follow-up research.

2. What has been done so far for the integration of EVM and RM according to the existing literature?

The roots of the EVM can be traced back to the industrial engineers on the factory shop in the late 1800s (Fleming & Koppelman, 2000; Kim, 2000) as the concept of the earned value was first presented to American companies that have contracts with the defense sector (Fleming & Koppelman, 2000, Anbari, 2003). Through the years the method and its variations have been used under several names - earned value project management, earned value method, earned value analysis, and cost/schedule summary report (Fleming & Koppelman, 2003, 2010; Kim, 2000, Kim et al., 2003). In 2000 the Project Management Institute (PMI) issued A Guide to the Project Management Body of Knowledge (PMBOK Guide) where more simplified EVM formulas and terminology was presented (Anbary, 2003). The essence of the method was also clarified so that it could be easily implemented into practice.

EVM is a quantitative technique that involves variance analysis and performance indexes in order to identify any deviation and its effects on cost and schedule at completion (Jarnagan, 2009; Kim et al., 2003; Lukas, 2008; PMI, 2008). Nevertheless currently the method is considered to be one of the most common techniques to predict the outcomes at completion of different projects (Chen & Zhang, 2012; Kim, Wells & Duffy, 2003), the weakness of the EVM can be seen in the lack of a quality control as the EVM only covers cost and schedules (Schulze, 2010), the veracity of the predictions made by simple extrapolation and the assumption that the future performance will be the same as the past one (Stratton, 2006), etc. The current research is targeted at the last one of the above mentioned limitations.

In 2000 Howes states that the estimated cost to completion is based on past performance and this may not always be a correct estimation, as the future of the project could be unrelated to past performance, and therefore it will be wrong to assume that the future performance will be the same as the past. Several approaches for solving this problem were offered. One of them was preparing a new forecasting method based on the Kalman

filter and the Earned Value Method (Kim & Kenneth, 2010). The concept is called Kalman Filter Forecasting Method and provides a probabilistic prediction for project's duration at completion. It can be used from the beginning of a project without causing concerns over a significant loss of accuracy, because the filter not only finds the optimum averaging factor for each consequent state, but also manages to "remember" a little about the past states (Welch & Bishop, 2001). The shortcoming of this method is that it is focused only on the schedule aspect of the EVM and does not take into consideration the costs. That is why a new trend is established in order to eliminate this disadvantage. It offers the integration of the EVM and the Risk Management (RM) in order to create a synergy between these two areas, given their different points of view – while EVM is based on the past, RM is oriented towards the future. Thus it is possible to use the strengths of the second method to eliminate the weaknesses of the first one, because in their essence they both are directed towards the same problem – providing information about the cost, scope and schedule.

The first ideas for integrating the EVM with Risk Management (RM) were brought to light in 2004. One of the pioneers in this trend - Dr. David Hillson (2004) proposed in front of the PMI 2004 Global Congress Proceedings – Anaheim, California, USA, three areas for accomplishing a synergy between EVM and RM.

1) Creating a baseline spend plan (Planned value (PV))

2) Predicting future outcomes (Estimate at completion (EAC))

3) Evaluating risk process effectiveness

The first area for creating a profile of the Planed Value is done by clarifying the process of uncertainty and risk consideration. This is achieved by a full risk assessment of the project's plan regarding the uncertainties in both time and cost before the start of the project. A commonly used method here is a Monte Carlo simulation for time and cost as it is one of the most popular quantitative risk analysis techniques. The model should take into consideration threats and opportunities, as well as the planned responses to risks, developed during the risk process. After all possible project outcomes are generated– including the best (with minimum costs and time for execution) and the worst one (with maximum cost and time for performance) – Hillson offers the selection of a cumulative curve that represents the expected values cumulative profile from a quantitative time-cost analysis as a baseline spend plan. The author points out that it is acceptable to choose another curve by using, for example, 80% confidence level.

The second area for integrating EVM and RM is closely linked to the first one. For predicting the future outcomes it is assumed that a certain period of time has passed and it is possible to record the progress of the project and the Actual Cost, as well as to calculate Earned Value. The integrated risk model for time and cost is used again for the incomplete part of the project, but this time it takes into account the revised estimates and new risks updated by the assessment and quantification of the risk and the newly generated responses. A Monte Carlo simulation is run again for the remaining portion of the project. A new risk-based profile for the Planned Value (PV) from the present moment to the completion of the project is determined so that EAC can be calculated. Here is also stated that the PV curve is selected thanks to the method of the expected values or some confidence level.

The third area for accomplishing a synergy between EVM and RM aims to evaluate the risk using the EVM performance indicators (i.e. Cost Performance Index (CPI) as well as

Schedule Performance Index (SPI), which is not the focus of this paper.

The idea for integrating EVM and RM is comparatively new for software engineers, although they have done numerous products for each of the two management techniques separately (Hayashi & Kataoka, 2008). One of the first people who decided to put their efforts toward providing a software product, based on Hillson's theory were Lazić and Mastorakis. While discussing the use of modeling and simulation-based analysis and optimization of software testing (Lazić & Mastorakis, 2005), they point out that RM predict a range of possible futures by analyzing the combined effect of known risks and unknown uncertainty on the remainder of the project in conformity with the second area of integrating EVM and RM proposed by Hillson (2004). The two engineers generate a set of possible curves, divide them into groups according to the date that the project is expected to finish, and point the possibility for each day. In the study it is pointed out which is the most likely completion date, the average completion date as well as the one with an 80% likelihood of success. But again the decision for choosing the PV curve is left to the manager. The gap between knowledge and the necessity for providing such software facilitation is evident.

3. A methodology for choosing a Planned Value Curve by integrating Earned Value and Risk Management

Based on the researches of Lazić & Mastorakis (2003, 2004, 2005) about the use of modeling and simulation-based analysis and optimization of software testing mostly done in Oracle software, we can create a program in the software product Simulink, part of MathWorks. This program assists the selection of one of the key figures in the theory of EVM – the baseline spend plan, by upgrading the model of Lazić & Mastorakis as they only offer software for simulating a variety of possible PV curves.

The current research is based on the Three Steps to a Successful Schedule Risk Analysis, proposed by Lazić & Mastorakis (2005), as it represents the classic approach for system modeling. It includes:

Step 1: A Critical Path Method (CPM) Schedule

Step 2: The Activity Duration Ranges

Step 3: Simulate the Project Schedule

The above-mentioned method is developed further by suggesting a model for choosing a PV curve based on a historical data. The basic idea is to perform a Monte Carlo simulation that generates a number of possible outcomes of the project with the corresponding cost and time for each one of the baseline spend plans. Then, by applying different methods for defining the most likely outcome (including the expected values method, an 80% confidence level, etc.), a set of S-shaped curves is generated and they are compared to the actual performance of the project. The body of the study is shown on *Figure 1*. It should be noted that the study does not explore the CPM Schedule, because it is assumed that we are already aware of the critical path as the CPM is not an object of this study. It should also be stated that the project risks will be identified and evaluated by a Delphi simulator for generating possible risks.

As mentioned before, the first step in the methodology is to define a precise set of the objectives, i.e. defining the base indicators (field, budget, time, etc.) that every project should meet so that it can be enlisted in the group of case studies. After the basic risks and the activity duration ranges are determined on the second stage of the program, a Monte Carlo simulation regarding the projects duration and costs can be performed.

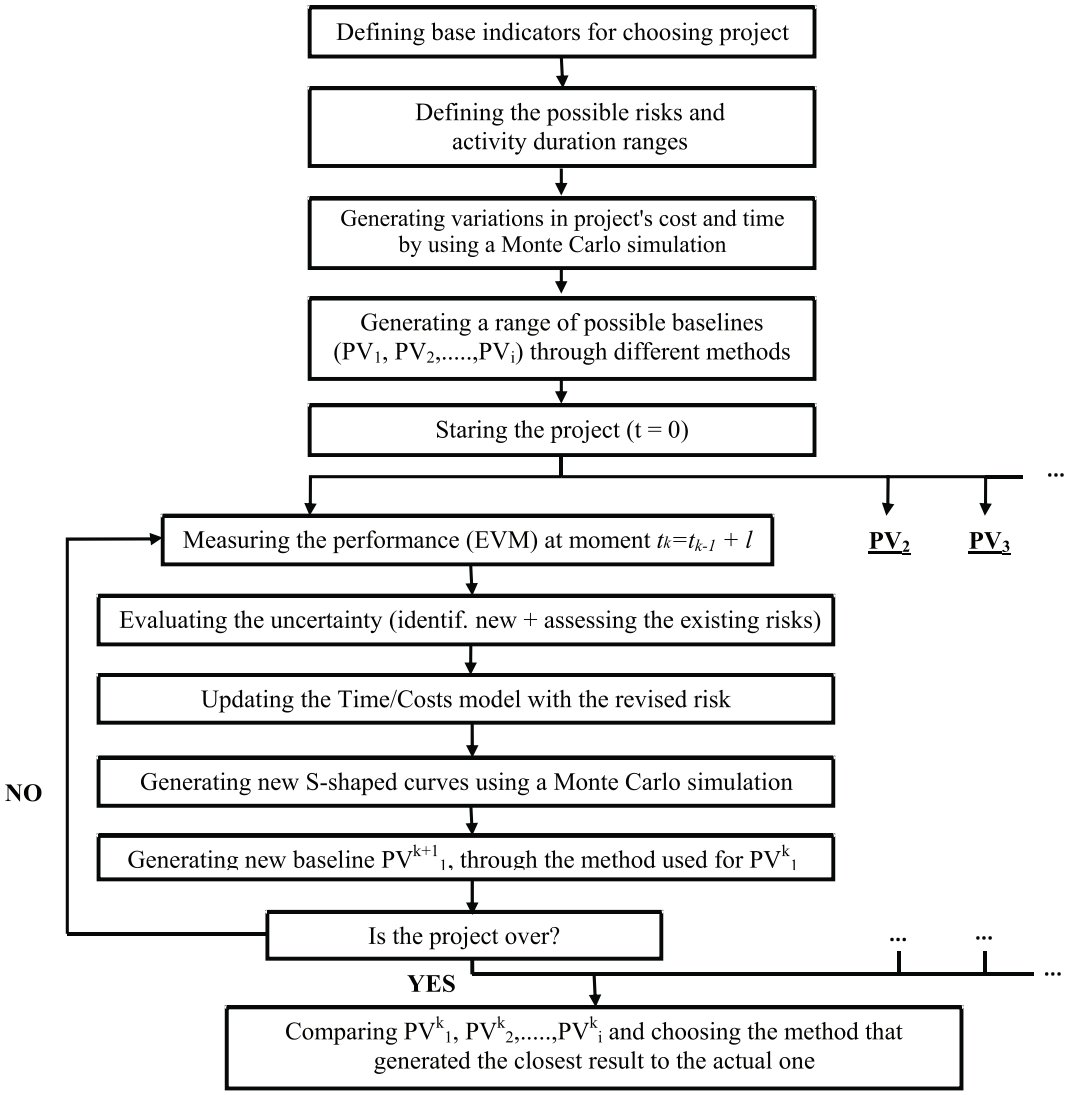

Fig. 1. Stages of the model for selecting a baseline spend plan

Based on pre-selected methods for determining the most likely outcome (expected value method, some confidence level, weighted average method, etc.) a set of possible baselines is generated - PV_1, PV_2, … , PV_i. The Monte Carlo simulation and the generation of PV curves are similar to the ones presented by Lazić & Mastorakis (2005). The difference here comes afterwards with the idea for comparing the different outcomes with the real path. In this regard after a period t_1 (1, 3 or 6 months depending on the duration and scope of the project) an intercurrent comparison is performed aiming to show how far the project has come and to determine which one of the previously generated basic plans is closest to reality. This assessment will be carried out by the indexes of the EVM. It is also pointed out which of the risks have been

realized and with what intensity. Then the program generates the future development of the new baselines PV'_1, PV'_2, ..., PV'_i (for integer *i* and *i>1*) as for each one of them is taken into consideration the risks that have occurred and is used the same selection method through which the corresponding curve of lower order has been determined.

The process is iterative and is repeated through periods t_2, t_3, ...,t_k (where $t_m - t_{m-1} = l$ for integer *m* and so that *l* is constant) until the project ends and the outcomes of the final curves PV^k_1, PV^k_2, ..., PV^k_i are compared to the real outcome of the project.

As the current article aims to present only the model and its stages, a future study shall proceed with the approbation of the model with sufficient number of comparable projects with predefined constraints related to the field of performance, budget, timeline, etc. After the outcomes are summarized and analyzed, it will be possible to point out the most accurate method for selecting a Baseline Spend Plan (PV Curve).

Conclusion

It is clear that both Earned Value and Risk Management are trying to improve the process of decision making by providing a rational framework based on project's implementation. While EVM considers clearly defined quantitative indicators based on past results and uses them to predict the outcome of the project, RM looks forward to identifying and assessing the uncertainty with its corresponding probability and impact on the project to propose prompt actions to each risk.

These two approaches are not in conflict or mutual exclusion. Their similarities suggest a powerful synergy that can combine their strengths so that by using the data from the EVM we can provide more information to the RM techniques. The practical application suggested above shows that together Earned Value and Risk Management offer a powerful management approach, assessing not only past performance, but also the uncertainty of the future for making informed decisions. The method is suitable for complex projects with multiple activities and high risk indicators as it is based on a simulation technique that enables us to generate different results, to assess them and to manage the project successfully. A must is a historical data for common projects, that is, the projects of companies that have already performed similar activities. For example those can be companies that are specialized in constructing water facilities, silos for storing grain, oil or fuel, warehouses, conveyor lines, different types of resistors, or performing scheduled repair of specialized machines and equipment as in each one of the aforementioned businesses we can see a strict sequence of the performed actions and the necessary experience in the respective field. Based on that historical data the manager can use the quantitative methods and simulations proposed in the current methodology in order to come up with a rational decision when choosing a Planed Value Curve.

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