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Application of Earned Value Method for evaluation the Time/Cost Consequences of Variation Orders in a Construction Project

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Abstract. The decision-making process of acceptance of the variations order (VO) for running construction project is always subjected to the risk of consequences, which are difficult to be defined. But, even having all the technical and organizational consequences identified, their impact on the project completion date and final project cost, is not easy to state. The practical methodology of using the Earned Value Method (EVM) as a tool supporting the acceptance decision of the VO being considered during construction works, is presented in the paper. The main strength of the presented concept is a quick prognosis of the final project completion date and the final project cost in case the VO is accepted.

1. Introduction

Variation Orders (Change Orders) are very often the reason of construction project delays and exceeding the project budget. It is the global problem, especially intensive in case of stagnation and recession of local economy. The contractors, however, acting in a difficult economic environment, used to lower their cost offers calculating on future variation orders which would allow the them to generate additional profits. This is frequent tendering practice. The global standard set of procedures recommended for management of changes in projects (*Perform Integrated Change Control*) is well detailed and considering all the main risk factors [1]. But, it would be good to supplement that set of procedures with the managerial tool providing the numbers representing time delays and cost exceeds, as generated by a variation. The phenomenon of risk of VOs is well recognized in technical literature. Problem of reducing the risk of VOs has been analyzed by means of various methods, like functional analysis concept, value analysis, web-based applications, and many others [2, 3, 4]. One of the fundamental problems with variations considered during the construction projects is making the decision about their acceptance or refusal. The impact of the VO on the project time-schedule and on the final project costs is usually the critical argument for the project manager considering acceptance of a VO. Moreover, since complexity of a construction project, each variation does develop next variations with respect to original design and project specifications. So, it is critical to estimate the final project cost and the final project completion date in the case the considered variation is accepted and entered. Quick and not complicated way to predict the final project date and the final cost, can be achieved by easy and practical simulation, with use of Earned Value Method. The method is well known in econometrics and has been used in project management for several years, but its practical use in construction projects is not so popular, yet.

2. Typical use of EVM for construction projects

According to [1], the Earned Value Method is recommended as the global standard for project performance measurement. The method really integrates scope, cost and schedule measures, and could give good picture of current project status at the date of control. Concept of implementation of the EVM into the cost control and even to overall performance measurement of construction projects have been presented by many authors [5, 6, 7]. Application of EVM in the construction site management practice requires systematic register of time and cost data (usually once a week) in order to get the two following values: ACWP which is Actual Cost of Work Performed and BCWP – Budgeted Cost of Work Performed. The third required value, namely BCWS – Budgeted Cost of Work Scheduled can be defined before works start, based of the time schedule of all works and the respective cost plan (Figure1).

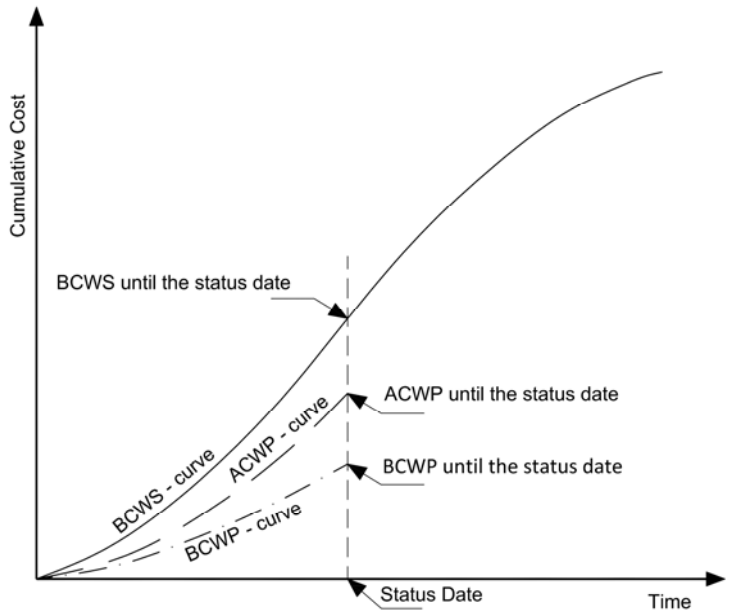

Figure 1. Three basic curves as used in the EVM

Effective managing the construction site with supporting decisions by EVM needs use of some other managerial instruments like the cost plan and the breakdown of lump-sum price which enable for quick and efficient cost/time data identification needed for each date of control. As an effect of systematic use of EVM on site, the site manager can get every week the up-dated prognosis on cost variance at completion and schedule delay at completion (Figure 2).

3. Time / cost consequences of VO analyzed by EVM

The normal use of EVM should be a little modified in order to get quick feedback presenting the time/cost prognosis, with considered VO taken into account. The status date should be the day of simulated entering the considered variation. The initial extra cost of VO will be represented by local increase of the cumulated project budget value, i.e. BCWS curve (Figure3). The Cost Variance (CV=BCWP-ACWP) and Schedule Variance (SV=BCWP-BCWS) should be calculated at the given status time for the new, increased level of BCWS. Thus, new prognosis measures BAC' and EAC' including impact of the considered variation, can be easily calculated according to normal EVM methodology.

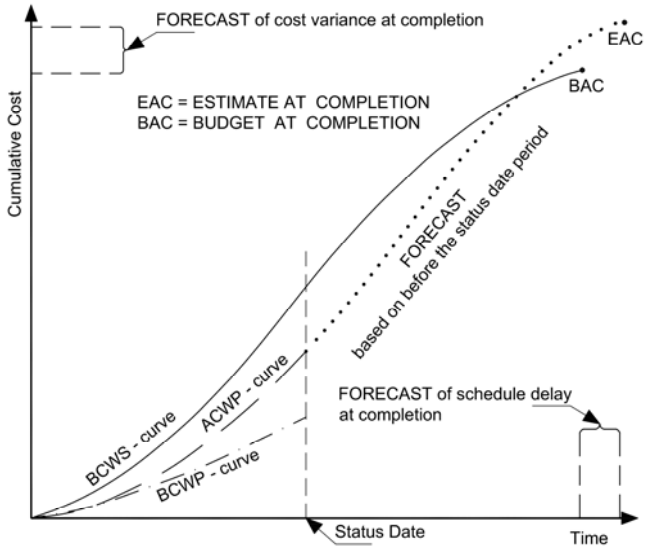

Figure 2. Forecast values provided by EVM

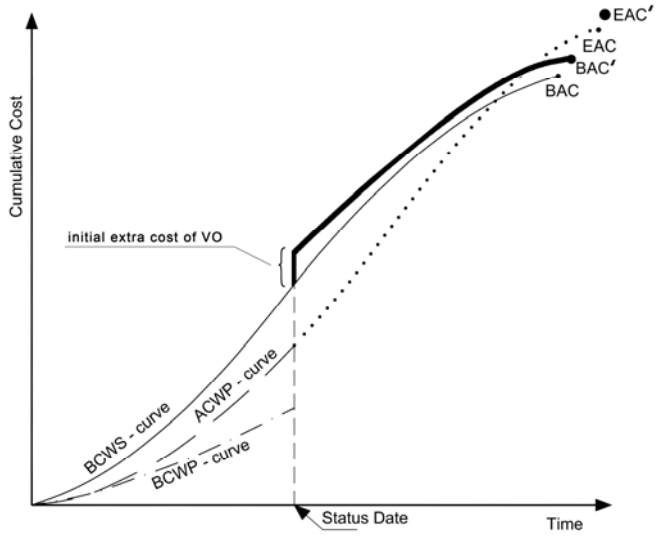

Figure 3. EVM method with VO modifying the BCWS curve.

Heaving the new completion date (EAC') of the project affected by the VO as well as the final project budget (BAC') in case a variation is initiated, the project manager is armed in very concrete arguments supporting the site disputes and the eventual acceptance decision. The proposed method is effective, provided the Earned Value Method is used for the given construction project in systematic way, as a permanent managerial tool for time/cost control of the project during the whole period of construction works performance. Otherwise, especially for large projects, it would be very difficult to make the EVM simulation for the date of VO consideration, with no earlier analysis of earned value available. So, in other words, the proposed method make practical sense only for those construction sites for which the EVM is permanently applied in project monitoring practice.

The presented concept was used for supporting the managerial decision making process during recently completed construction of medium size production plant in Poland (about 9000 sq. m footprint). The project duration was 16 months. It was known from the beginning that many details

would have be designed during the construction time, so considerable number of variation orders were forecasted. On the other hand, the delay of project completion was not acceptable because of the purchase contracts signed for new products. Preliminary all VO applications have been considered before any formal analysis was completed. Preliminary decisions were made based on initial extra cost of the variation and without considering the impact of a variation on the final date and budget. All in all, as the effect of EVM analysis, about 22% of all variations preliminary accepted have been finally rejected and not initiated into action on site. There was rejection, because of too big impact of the considered variations on the final completion date and on the final total project cost. The big impact was not possible to forecast by experienced project managers without disciplinarian, formalized numerical analysis which have been executed by means of EVM, following the concept proposed in this paper.

4. Conclusions

The proposed way of using standard EVM methodology allows forecast the final budget and the completion date of a construction project, considering design, executional and organizational variations. Although the resultant measures BAC' and EAC' may not take into account all the factors influencing their exact values, but even with a certain tolerance of accuracy, the two measures are very strong and concrete supporting data for making a decision about acceptance of a Variation Order. Presented methodology is a simply and practically oriented tool for management of variations on the construction site.

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