A Brief Analysis of The Defects and Countermeasures of EVM in Project Management

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Abstract. Through calculation and induction, demonstration by example, comparative analysis and other methods, this paper draws the following conclusion: the control of project progress and cost by EVM should be evaluated with a single project as the goal, and on the premise of the timely accuracy of phase cost statistics; In the evaluation of comprehensive project progress, it should be carried out in different levels, with the evaluation of key line work as the main and non-key line work as the auxiliary; The influence of safety, quality, environment and other factors on the cost should be fully considered when evaluating the project cost.

Keywords: EVM, Defects, Countermeasures, Project Management

Introduction
As a common method in the field of engineering construction management, Earned value management (EVM) solves the problem of controlling both schedule and cost in the process of engineering management to a certain extent[4]. However, each approach has its limitations, as does EVM. It is of great significance to correctly and effectively understand the defects of this method, consciously adopt reasonable ways to avoid the occurrence of defects or correct and perfect existing problems, to improve the level of project management and the efficiency of resource utilization.

1. Method description
We know that EVM controls project schedule and cost through three basic parameters (Budgeted Cost Of Work Performed, BCWP; Budgeted Cost Of Work Scheduled, BCWS; Actual Cost Of Work performed, ACWP)and four evaluation indexes[3] (Cost Variance, CV; Schedule Variance, SV; Cost Performance Index, CPI; Schedule Performance Index, SPI).

EVM has positive significance in improving the level of project management[3], which will not be repeated here. This paper focuses on the analysis of the defects and shortcomings of this method in the practical application process, which can be roughly divided into two categories: one is reflected in the determination of project schedule, the other is reflected in the cost evaluation.

2. Defect analysis

2.1. Schedule determination aspect
2.1.1. Primary and secondary work are easily confused

In order to achieve comparability, EVM quantifies the work actually completed and planned completed at the same unit price level through the medium of currency. However, for most engineering projects, critical work and non-critical work are often constructed simultaneously. In the process of using EVN project progress control, often due to failure to complete key line work, actual non-critical lines for how many, work in non-critical work done, and the key work is done under the condition of less, you might bring to the project managers the wrong information[6], allowing managers for project period or even in advance. However, the project schedule is likely not to be advanced, and may even be delayed. Let's illustrate this with a simple project network plan diagram:

![Project Network Plan Diagram](2-1)

**Figure 2-1. Schematic diagram of a project network plan**

It is not difficult to know from the figure above that the key work route of the project is C→F→H(construction period: 80d). There are two non-critical work routes B→E→G(duration: 60d) and A→D(duration: 65d). Assume that the budget cost of job A, B and C is 420k, 150k and 300k respectively. If by the 14th day of commencement, work A has completed 3/7, work B has completed all, and work C has only completed 2/5, the two basic parameters of EVM can be estimated as follows: BCWP=420×3/7+150×1+300×2/5=450 (k), BCWS=420×14/42+150×14/15+300×14/30=420 (k). Two evaluation indexes can be obtained as follows: SV=450-420=30(k)>0, SPI=450/420=1.07 >1. Both indicators show progress ahead.

But this is not the case. In terms of the overall progress of the project, by the 14th day of commencement, the key work C is 14-2/5×30=2 (d) later than the planned progress, which means that the overall progress of the project will be 2 days later than the plan if the subsequent progress remains unchanged, which is obviously different from the conclusion calculated by using EVM. In other words, at this time, the EVM evaluation index appears to be significantly inconsistent with the facts. Therefore, to a certain extent, we can draw the following conclusions:EVM is only applicable to the evaluation of a single project progress to a certain extent, and is not suitable for the one-time comprehensive evaluation of the overall progress of complex projects.

2.1.2. Lack of overall consciousness

To give play to the overall function of an engineering construction project, it is necessary to complete all the sub-projects of the project on schedule and in good quality. A small job often affects the overall function of the whole project. As a large engineering construction project, even if a small number of key lines are not completed, they cannot be put into use, although the cost of this small work may be a small part of the total cost of the project. Just as the backfill of a bridge is not completed, the whole bridge is not ready for traffic. The screens of a studio are not installed, and even if the main part of the studio is completed, it cannot be put into use. As shown in Figure 2-1, this is the case for H work on the critical line. Although the planned period is only 10 days, if there are insurmountable technical obstacles or other practical difficulties in the process of implementing the work, the whole project will also be faced with the possibility of not being completed on schedule[5]. Thus, EVM can be used to predict the progress of engineering projects, which must be based on the premise that all the work, especially the work on key lines, is economically affordable and technically barrier-free.
2.2. Cost evaluation

2.2.1. Engineering quality, safety, environmental impact
In the process of project management, the lag in the detection, assessment and loss assessment of quality, safety and environmental problems often makes the statistics of project construction costs not timely and accurate[6]. At this time, if EVM is used for engineering project cost evaluation, the evaluation effect will be affected due to the incomplete consideration of cost factors. Here is an example to illustrate the point.

Now assume that the EVM parameters of an engineering project by September 2019 without considering the impact of quality, safety and environment are as follows: BCWP=13013.6 (k)、BCWS=12474.9 (k)、ACWP=12672.3 (k). Then the following indexes can be further obtained: CV=BCWP-ACWP=341.3 (k)、CPI= BCWP/ACWP=13013.6/12672.3=1.03 > 1, This illustrates cost savings, as shown in Figure 2-2a.

If a hole of cast-in-place cover plate completed on September 22 of this project is found by subsequent tests to not meet the quality requirements, it needs to be removed and repoured. The demolition cost will be 20,000 yuan, and the estimated pouring cost will be 215,000 yuan. During the operation of cutting, a worker forgot to fasten his seat belt, which caused him to fall from a high altitude and fractured his leg. The cost of medical treatment, recuperation and related expenses is 90,000 yuan, and the project management organization shall bear 40,000 yuan after deducting insurance. At the same time, due to poor awareness of environmental protection, workers illegally dumped concrete slag into the river below the bridge, and the river is a source of drinking water. After the environmental protection department found it, it was required to clean up and fined, with a total cost of 120,000 yuan. In view of the above situation, we should revise BCWP and ACWP. As the cast-in-place girder is not qualified, it cannot be deemed to have been completed, so the BCWPx=13013.6-21.5=1279.86(10k); For ACWP, on the basis of the original calculation value, the demolition cost of 20,000 yuan, the safety accident cost of 40,000 yuan, and the environmental protection cost of 120,000 yuan should be added, that is, the ACWPX=1267.23+2+4+12=1285.23(10k). Now we calculate EVM cost evaluation index again, and get: CVx=BCWPx-ACWPx=-5.37 (10k)、CPIx= BCWPx/ACWPx=1279.86/1285.23=0.996 < 1, This indicates cost overruns, as shown in Figure 2-2b.
There are obvious differences in the conclusions drawn from the above two calculation diameters. It can be seen that whether quality, safety, environment and other factors can be timely and accurately considered on the impact of cost has a great impact on the calculation results of EVM evaluation index.

2.2.2. **Statistical impact of data**

In engineering project management, EVM controls costs by summarizing, calculating, comparing and analyzing a series of data, which requires project planning and financial management personnel to have good business quality and data processing ability. In addition, to ensure the accuracy of analysis results, it is necessary to ensure the timeliness and accuracy of basic data sources. Therefore, comprehensive, timely and accurate collection of on-site basic data is the key to determining the accuracy of EVM parameters. However, in project management practice, these basic data is often by project management department, through its various business units from the hand of the specific personnel or front-line workers collected. Through layer upon layer and data transfer, plus the line workers lack of statistical knowledge, the comprehensiveness, timeliness and accuracy of the data is difficult to guarantee. Which can make the accuracy of EVM calculation and analysis results be affected.

3. **Correction method**

3.1. **Correction of schedule impact**

In view of the defect that "primary and secondary work is easy to be confused", we need to conduct multi-level analysis when using EVM to control the engineering cost and schedule of a comprehensive project. Special attention should be paid to the analysis and evaluation of critical line work and non-critical line work respectively, and the key line situation should be paid special attention to, and then comprehensive evaluation should be conducted. In this way, incorrect information can be prevented and the project management organization can effectively control the overall schedule and cost of the project.
For the defect of "insufficient overall consciousness", before using EVM method, the evaluation tool should be used to evaluate the technical and economic feasibility of the whole project, one by one, in order to identify possible risks. If a certain partial and partial project is not qualified for implementation, and the partial and partial project is located on the key line, the problem of whether to continue the project should be solved first, instead of simply using EVM index to predict the overall progress of the project.

3.2. Revision of cost impact
In ACWP statistics, the increase of environmental damage, safety incidents and quality accidents should be fully considered. For the quality problems of the construction project itself and the continuous damage caused by the construction to the environment, the overall loss should be assessed once and for all. According to the division of the project units and the schedule of the project, the damage should be taken as the cost in each evaluation stage in time to increase the accuracy of the actual cost statistics. In addition, EVM cost and schedule control should be carried out on the premise of qualified project quality. If the project is reworked or maintained, the project cannot be considered completed. At this time, the reworked project cost should be included into the total cost, and the reworked project can only be counted as the progress once.

No matter at that stage of project management, comprehensiveness, timeliness and accuracy of data statistics are the key to give full play to EVM control. Therefore, in the process of project cost control by using EVM, the costs incurred must be collected into the account in time, so that the actual costs in the construction process can be truly and effectively reflected. To do this, you need ensure plan, financial management personnel professional quality at the same time, to strengthen the training of basic data statisticians, unify financial management system, clear statistical rules, form a perfect data statistical analysis management system to ensure that the artificial, machinery, materials, management, finance, inspection, evaluation of the cost of comprehensive, timeliness, accuracy.

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