International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Earned Value Management (EVM) Technique in Oil and Gas Construction Project: A Critical Analysis

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A B S T R A C T

Earned Value Management (EVM) is a performance measurement technique that focuses on project physical, financial, and time progress, indicating planned and actual performance, variances, and final project duration and cost projections. Traditional measurement tools like PERT/Cost are taken a step further. Although the Project Management Institute and the Project Management Community actively support EVM, the technique has recently been attacked for its conceptual flaws and operational issues. Through a case study on a construction project that used EVM, this paper tries to delve deeper into this argument.In the hunt for a larger list of topics, four significant issues are examined. The EVM approach fails to enable lean construction applications in four ways. One of them is the failure to address the mobilization of resources phase, as well as the indirect expenses of construction. Finally, the writers came to the conclusion that EVM is simply an extension of the old method of monitoring physical and financial progress through time. As the assessments of the building project under discussion revealed, this narrow approach is insufficient to provide a comprehensive managerial tool.

Keywords:EVM (Earned Value Management), Project Monitoring & Control, Lean Construction, and Project Management are all examples of EVM.

1. INTRODUCTION

Building businesses have used more sophisticated procedures and tools to efficiently plan and control building developments as a result of the uncertainty and complexity typical of construction projects. Due to the importance of cost management in project performance, these strategies are usually associated with it. With the development of CPM and PERT, the theory of planning and control evolved rapidly during the 1950s. Only during the 1990s could organized reasoning be used to support the debate, which coincided with the birth of Lean Construction Theory as a result of foundational research (Koskela, 1992). Old managerial paradigms were broken thanks to Lean Construction Principles, which introduced an innovative proactive management style that led to agility and responsiveness to changes demanded by customers and the market. Customers and the market can now benefit from two different perspectives on how to assess building performance, which are briefly described below.

Earned Value Management Technique (EVM) or Earned Value Analysis (EVA) developed as an alternative. This approach, which was developed by the US Defense Department, is extensively used as a control tool and is recognized by the Project Management Institute (PMI) as a standard instrument for project performance monitoring. From the early efforts with PERT/COST (1962, 1965, and Cost Schedule Planning and Control Specification - C/ SCSC), the PMI gives a historical perspective on the evolution of this approach (1967, 1996). The integration of project planning, control, and definition into a single platform is a significant advancement.

EVM focuses on projecting final costs and project length, which is considered critical in alerting management and enforcing their response in order to avoid delays and cost overruns. The EVM approach does not give management tools that may help get a project back on track, but it is reasonable to assume that they do not go beyond what is typically accessible in a manager's toolbox. This is to suggest that variation assessments and a clear presentation of project goals are critical factors in triggering standard management activities that would naturally lead to suitable decisions and project success.

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2. . LITERATURE REVIEW

2.1. EVM TERMINOLOGY

EVM nomenclature is divided into two categories by PMI (2018): (1) essential EVM parameters such as PV, EV, and AC, and (2) EVM measurements (variances, indices and forecasts).

The specification of key parameters is easy. The Budgeted Cost of Work Scheduled (BCWS), also known as Scheduled Value (PV), is an initial estimate for planned work. It is the standard data seen on Project Budgets and created by estimating departments. It is given by well-established techniques for evaluating anticipated costs, and it has been included by EVM to expand the toolkit available to its practitioners in their consulting work. It is based on a Project Breakdown Structure that does not always correspond to the sequence of operations that would occur on the job site. The quantity of budgeted work will be determined by site planning.

Earned Value (EV), also known as Budgeted Cost of Work Performed (BCWP), is the amount of work that has been completed to date, expressed as the project's initial budget. For the time being, it should be noted that such numbers of Planned and Earned amounts that are referred to as value should at the very least be accurate in terms of estimating techniques. Furthermore, if it is to represent value for the client, it can only be accepted indirectly through microeconomics: if it has been logically recognized as the amount of money to be paid for the project, the entire estimated price and value may be equated according to the customer's views.

Actual Cost (AC), also known as Actual Cost of Work Performed (ACWP), is a measure of the genuine cost of work completed to date. Planning and control systems should be connected with corporate accounts linkages or other mechanisms to estimate and take notice of real expenses in order to deliver feedback information on actual costs (PMI 2005, Fleming and Koppelman 2010). The timely examination of actual costs may prove to be a significant challenge when using EVM. It can be claimed that only estimates of real costs are accessible during the course of a project, with their inherent probability nature in terms of accuracy.

The second group of terms to be defined, EVM measurements, make use of a mixture of the prior important parameters. The formula for calculating Schedule Variance (SV) is SV=EV – PV. It shows how much ahead (SV>0) or behind (SV0) schedule the project is. SV takes care of time performance because both EV and PV employ cost estimations from the initial budget. Nonetheless, due to inaccuracies in the initial budget, the project may be classified as behind schedule (EVPV). Assume that a large number of out-of-schedule activities were completed, but that the expense of these activities was underestimated, and that overestimated scheduled activities were abandoned.

Due to the overestimated scheduled activities, which will not be offset by the underestimated out of schedule activities that were actually conducted, SV calculations will reveal that a significant amount of expenditures should have already been allocated.

Variation in Cost (CV) CV=EV – AC is the formula for calculating CV. It indicates if the project is under budget (CV > 0) or above budget (CV > 0). (PMI 2005; Fleming and Koppelman 2010). It primarily gauges cost variances, but it is also prone to initial estimate inaccuracies in the context of EV. Because AC should be evaluated with real costs at various phases of construction, the cost control system is under pressure to deliver such data, which may result in AC being calculated using another set of estimations of actual costs.

The Schedule Performance Index (SPI = EV PV) measures the rate of transforming budgeted cost into earned value, or the rhythm of production. It gives you the same information as SV, but this time in relative terms. It fluctuates between 1 and 1. When the SPI is more than one, the time performance is better than projected. The inaccuracy sources for this index are the same as for SV.

The Cost Performance Index (CPI=EV/AC) measures the efficiency with which resources are used. CPI denotes the rate at which AC is converted into EV (PMI 2005, Fleming and Koppelman 2010). A CPI of less than one indicates that the project is on the verge of a cost overrun, as what has been accomplished does not match what was expected for the same set of activities. The sole explanation is that costs are rising faster than expected, or that, like with CV, activities whose costs are put together to form EV were overestimated in the initial budget.

Table 1 - Forecasting Indicators by EVM technique

Indicator	Equation	Interpretation
Budget at Completion (BAC)	-	BAC represents total budget at completion; at completion PV=BAC
Estimate at Completion (EAC)	EAC= (BAC/SPI) / (BAC/Month)糕	The estimated completion time for the project if the work continues at the current rhythm
Estimate To Complete (ETC)	¹ETC = BAC − EV	Cost to complete the project if all packages remain achieving the goals of time and cost, irrespective of what happened to EV
Estimate To Complete (ETC)	²ETC = (BAC – EV) / CPI	Cost to complete the project assuming that current cost performance will remain the same (as occurred up to EV) throughout the rest of the project
Estimate To Complete (ETC)	ETC = (BAC – EV) / (CPI *SPI)	Cost to complete the project assuming that current performance cost and schedule performance will remain the same as occurred up to EV) throughout the rest of the project
Estimate at Completion (EAC)	EAC = AC + BAC -EV	Final cost of the project based in the original budget. The optimistic scenario assumes that all remaining work will be performed just with what remains on the initial budget.
Estimate at Completion (EAC)	EAC = AC + (BAC -EV) / (CPI*SPI)	Final cost of the project if current performance trends to CPI and SPI continue. The pessimistic scenario assumes that all work remaining will performed with the actual CPI and SPI, both in terms of cost and durations.
Estimate at Completion (EAC)	EAC = AC + (BAC-EV) /CPI	Final cost of the project if current performance trends to CPI continue. The realistic scenario assumes that all work remaining will performed with the actual CPI.
Variation at completion (VAC)	VAC = BAC - EAC	Cash balance at completion
To-complete performance index (TCPI)	TCPI = (BAC – EV) / (BAC -AC)	CPI to recover cost variances from the moment EV and AC are evaluated up to project completion

Figure 1 depicts the above-mentioned EVM terminology graphically. Three important calendar dates are shown: the current instant (when PV, EV, and AC are calculated for the first time), the completion scheduled date, and the predicted schedule date.

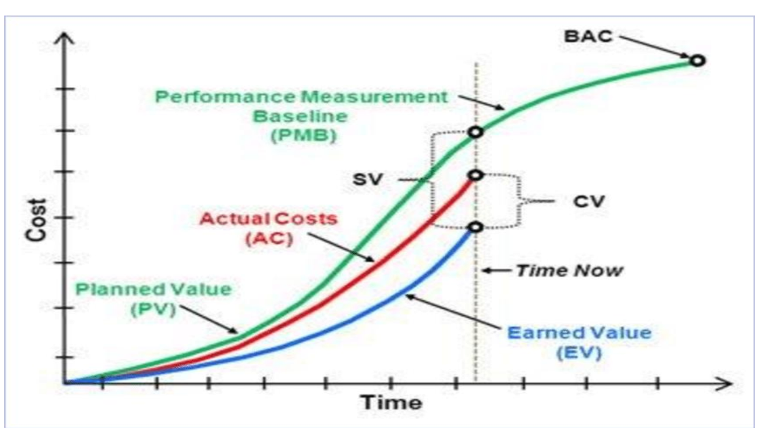

Figure 1: EVM main variables, variances and forecasting simulations

3. OBJECTIVE AND METHODOLOGY

3.1. METHODOLOGY

The case study approach was used in this study. According to Yin (2010), a case study is an empirical research that allows for the analysis of a current event in its natural setting. This work is classified as exploratory research with quantitative data in terms of research goals.
Generalizations were made from specific situations to theory in this study, and they are designated as fundamental since their use can aid in a better understanding of how to apply EVM in a lean construction setting (Collis and Hussey 2005).

3.2. RESULTS AND DISCUSSION

According to Casarotto (1996), three major project stages (construction periods) were taken into account in order to appropriately measure development on site: 1) Resource mobilization: In the early stages of a project, resources must be mobilized and site layout facilities must be established. Physical progress is slow at this point, but human effort and money expended are rather substantial. This mobilization phase lasted 30 percent of the project's overall lifetime; 2) Stabilized workflow: At this point, the consumption of resources and the rate of production have reached a state of equilibrium. This time span encompassed project operations that lasted from 30% to 80% of the total time allotted; 3) Resource demobilization: After this stage, resource use begins to decline progressively, leading to ultimate resource demobilization at project conclusion. This third stage lasted from 80% of the project's scheduled duration to the finish.

3.3. ACTUAL S CURVE AND EVM ANALYSIS OF PROJECT PERFORMANCE

An s-curve is a mathematical graph in project management that plots relevant cumulative data for a project, such as cost or man-hours, versus time. In today's fast-paced corporate environment, keeping a project on track and within budget is critical to its success. The graph's shape usually forms a sloppy, shallow "S," which is why it's termed an s-curve. (Other forms are possible, but the shape depends on the sort of project.) In project management, an s-curve is commonly used to track the development of a project. In today's fast-paced corporate environment, keeping a project on track and within budget is critical to its success.

Because project growth is typically gradual in the early phases, the s-curve commonly takes shape. The wheels are just starting to revolve; team members are either researching the industry or just getting started with the first phase of execution, which can be delayed as the kinks are worked out. The growth accelerates as more progress is achieved, forming the upward slope that forms the middle half of the "s." The point of inflection is the maximum point of growth. During this time, project team members devote a significant amount of time to the project, and many of the key costs are incurred. The growth continues to plateau after the point of inflection, generating the upper part of the "s" known as the upper asymptote—and the project's "mature" phase. This is because the project is nearly complete and is winding down at this stage; normally, only finishing touches and final approvals are remaining at this point.

3.4. VALUE-ADD IN LEAN CONSTRUCTION X EARNED VALUE IN EVM

Earned Value (EV), according to EVM, is the budgeted cost for work completed, i.e., how much work completed so far would cost based on the starting budget (PMI 2005, PMI 2008, Fleming and Koppelman 2010, Mattos 2010). It's a monetary value that has nothing to do with Lean Construction's value notion. If microeconomics is introduced into the conversation, as previously stated, it may have an indirect relationship.

If clients are ready to pay for a project with such a low initial budget (and for each step of work to be priced accordingly), it suggests they value it at that price. If the contractor was able to do the task for this price, it is reasonable to assume that the client will benefit. It's always worth debating what the value of simply pieces, completed stages of work, vs the benefits of having the entire facility ready to go is for a client.

The terminology used in Lean Construction is not the same as that used in EVM. Lean Construction is concerned with physical progress in terms of man-hours or quantity of service, labor productivity, and completion of specific project elements, among other things. It avoids using money as a universal metric. EVM, on the other hand, focuses on monetary measures of performance. For example, EV represents how much work was completed, but the indicator is expressed in terms of the cost of such work as expressed in the initial budget, rather than any physical measure of what was accomplished, such as the amount of concrete poured or the number of hours spent handling materials.

3.5. INSUFFICIENCY OF PROCESS INDICATORS AND QUALITY OF CONSTRUCTION

Leading indications from the EVM do not include indicators for construction quality or process quality. They only report on conversion performance, that is, how much of what was intended was completed and how much remains to be completed till the project is completed. Lean Construction, on the other hand, is concerned with the quality of products and processes in as much as external and internal clients place a value on them.

3.6. INCOMPATIBILITY FOR EARLY STAGES OF WORK PROGRESS FORECASTS

During the early stages of building, there was a lot of variation in terms of eventual costs and timelines. EVM should grasp that now is not the time to make predictions, as it is well known that physical progress is not equal to money spent on the job site. Cooke (1980), for example, estimated that a 10% initial physical progress on site would result in a 16 percent consumption of overall project length. Because cost is employed as a criterion for progress measures in the EVM technique, there is an obvious distortion of true progress at the start of the project (Narbaev and DeMarco 2013).

4. CONCLUSIONS

According to observations on a construction site, the use of EVM as a performance monitoring technique was shown to be inadequate for a normal construction site. Limitations were mentioned in a variety of areas, ranging from a lack of vocabulary (such as the usage of word value) to conceptual problems (disregard for the special low progress in the early stages of work).

Forecasting variability was quite high, making EVM unsuitable for use as a management tool to aid decision-making. Prediction variability was largest in the beginning of the project, both in terms of overall project cost and time. Doubtful information could put a strain on managers' schedules as they try to rearrange work based on ominous projections.

The use of expenses as a metric for measuring success was a major concern. When contrasted to physical progress measured in man-hours, this resulted in unacceptable levels of distortion of up to 87 percent. Finally, an error was discovered in the process of adding indirect costs to monthly progress reports. This resulted in a 20% increase in actual man-hour progress, which is difficult to justify in terms of EV (Earned Value) for the client.

In short, EVM is limited to the financial evaluation of construction progress, with all of the flaws that money produces as a universal measure of all things. Measurement techniques should be based on physical and qualitative characteristics of manufacturing progress in order to be useful. This is a problem that Lean Construction presents to project managers: The best elements of both management philosophies could be combined in future performance measuring research.

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