

The Cost Monitoring of Construction Projects Through Earned Value Analysis

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Abstract— In construction industry, the term ‘procurement’ is considered as a project based job where clients and contractors are always keen to observe performance indicators. These indicators represent financial and non-financial efficiency of project activities. Among these, the monitoring of financial indicators is an important function of project management. Therefore, during the construction phase, it is the prime responsibility of project managers to monitor cost and avoid any overruns to maintain the cost baseline. Cost monitoring is an ongoing process and its importance cannot be undermined during the project life cycle. It can be monitored by using traditional approach of direct reporting of actual cost against budget. However, the comparison of budget versus actual spending does not indicate the worth of the work which is completed at any given time. This approach does not portray the true cost performance of the project. Because of these limitations, this paper discusses the applications of Earned Value Analysis (EVA) for cost management of construction projects in Malaysia. Besides traditional approach, EVA is a three-dimensional technique that compares the budgeted value of work scheduled with the earned value of physical work completed and the actual cost of work completed. Therefore, cost management by EVA is an objective measure of actual work performed. This paper uses a case study, an example application of EVA as a cost monitoring tool. This case study reaffirms the benefits of using EVA for project cash flow analysis and forecasting.

Keywords— *cost monitoring; earned value analysis; construction cost management.*

I. INTRODUCTION

The life cycle of construction projects comprises of different phases. This may include preparatory, procurement, contract award and contract management phases. During the preparatory phase, the project team of client develops the initial time and cost estimates for the overall project duration. Based on these estimates and other preliminary information tender are sought from the bidders. After the tenders screening and appraisal process, the contract is awarded based on lowest or best evaluated offer. The contract document which is the binding agreement between the client and the contractor stipulated the project timelines for completing the scope of work with the in the approved cost. During the contract management phase, it has been observed

that certain causes may lead to delays in construction activities. This will result in time and cost overruns in projects. Among them, cost overruns are the unplanned expenditures which avoidably or unavoidably required for mitigating the underlying problems associated with the project activities.

The Malaysians Auditor General 2008 report suggests the cost overruns significantly affect the viability of construction projects in Malaysia. Because of this, the clients and the contractors suffer great financial loss and it causes disputes which turn down the overall project progress. It also causes a significant increase in the construction cost because of the fragmented nature of construction supply chain process. For example, the audit report revealed that delay in project completion of Electrified Double Track Project between Rawang and Ipoh resulted in a cost overrun of RM 1.43 billion [1]. So, a delay in carrying out the project activities causes deviation from the approved time and cost baselines. The delays will affect the current prices of the input due to the inflation factor. Time delay and cost overruns are the underlying factors that in principal affect the value of money to the governments.

Construction projects need significant capital investment and the most of which are used up during the execution stage. All construction projects inherit a large degree of risk and may bear the loss, if the project completion is delayed or the costs are overrun. Therefore, to secure the mutual interest of all the key stakeholders, a systematic monitoring and controlling of a project is a prerequisite. The traditional method of project cost monitoring is based on simple parameters using two data sources that is the budget (or planned) spending and the actual spending. The comparison of budget versus actual spending merely tells what was planned to be spent versus what was actually spent at any given time. Besides, it does not relate any current performance trend to forecast future performance.

Therefore, because of these limitations, this paper aims to highlight the importance of Earned Value Analysis as an effective tool that relates time and cost for monitoring project cash flows.

II. PROJECT COST MONITORING

Most of the project budget is consumed during the construction process. Therefore, it is the prime responsibility

of the project manager to control the costs associated with the work packages. A project cost can be usually classified in to direct, indirect and overhead costs. During the budgeting process, all these costs are sum up to develop a cost baseline. A cost baseline is defined as a cumulative time-phased budget that will be used to measure and monitor the current and future project cost performance [2]. It is graphically represented in the form of S-curve and it is an important cost monitoring tool. It allows the user to see the project cash flows over the period of time and make it possible to forecast the trends of future spending. Neale and Neale (1989) expressed that S-curve is an important tool for managing the cash flows in construction projects [3]. It defines the amount of construction spending according to the budget allocation. S-curve is a convenient tool for cost management. It can produce different cost scenarios that will make possible for the manager to envisage the cost trends [4]. Fig. 1 shows an example of typical S-curve that is based on accumulative values of cost estimates.

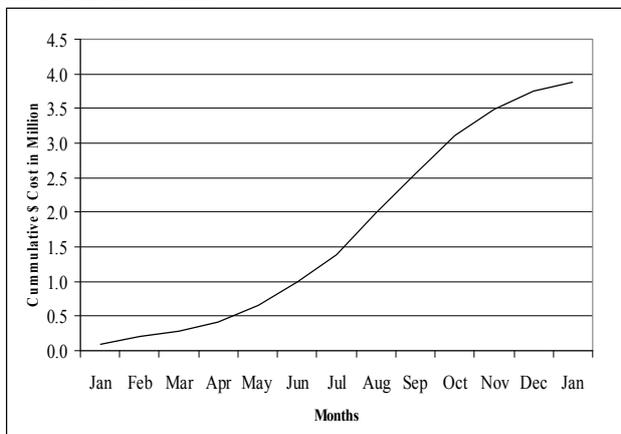


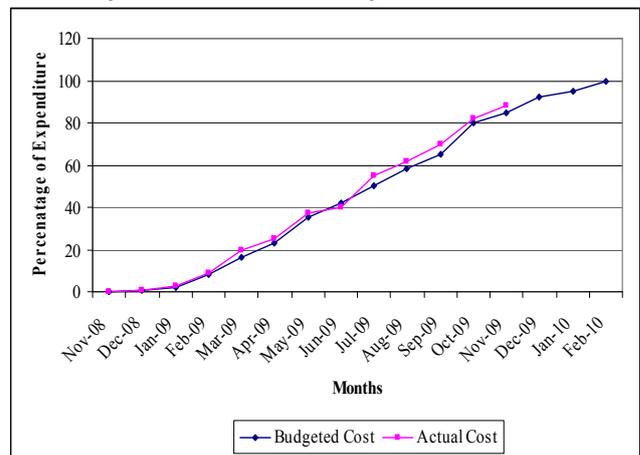
Figure 1. An Example of Initial Project S-curve

In these customary approaches, usually separate and direct monitoring is used for time and cost analysis. Kenley (2003) described the direct monitoring techniques for time and cost management in construction projects. In direct monitoring, there is split up between the time and cost performance indicators. Both of them are measured and reported in isolation with each other by comparing their planned and actual values at stipulated time frames. The direct monitoring does not point out anything about what has actually been produced for the amount of money spent nor whether it is being produced at the rate, or according to the schedule, originally planned. In other words, it does not relate the time versus cost performance of the project [5].

An effective project performance control cannot be achieved only by monitoring the actual physical progress with the planned progress and actual spending with the budgeted values [6]. This approach may be deceptive as it does not take into consideration the worth of the work which is completed during a particular period. The cost performance graph as shown in Fig. 2 suggests the actual cost against budget. It does not point out any information that how much has been produced against the spent money.

This aspect may limit the scope of traditional cost monitoring as it does not address the complete depiction of project current and as well as future progress trends in a true manner.

Figure 2. An Illustration of Budgeted vs. Actual Costs



III. EARNED VALUE ANALYSIS

Earned Value Analysis (EVA) is a project control technique which integrates cost, schedule and technical performance. It proves the earn value of a completed work and compares it with actual cost and planned cost to determine the project performance and forecast its future trends. EVA is also described as an integrated, indirect or remote monitoring technique for the complex interaction of time and cost parameters to provide the performance measurement of a whole project [5]. It is an effective and useful project tool that helps the client and as well as contractor to assess the project performance. As discuss in the previous section, the traditional approach of project performance measurement usually separates the time and cost parameters during the progress reporting. Nevertheless, EVA integrates time and cost functions and allows the project manager to see a clear insight of project performance with an open eye.

The concept of Earned Value was evolved in 1967 by US Department of Defense and subsequently developed a 35 criterion-based approach which is the then called Cost/Schedule Control Systems Criteria (C/SCSC). Initially, it was considered that C/SCSC is a financial control tool which confined its use in project and program management. However, in 1989, Undersecretary of US Department for Acquisition adopted this criterion for program management and procurement. In 1996, it was revised by the US industry and renamed it as Earned Value Analysis (EVA). Since then, it has been used as a widely accepted tool by many US government agencies like United States Department of Energy, NASA and US Defense Acquisition Department etc. Besides United Sates, EVA has also attracted many other governments and public departments including industrial

sectors like engineering, construction, oil and gas, infrastructure, information technology etc.

In the construction industry, EVA is being used as a time and cost control tool. It has an ability to bring together planning and management functions. During the last decade, many developed countries have imposed EVA technique in their public and private funded construction projects and achieved remarkable improvements in their practices. South Korean Congress in July 2000 passed a bill named ‘The Effective Plan of the Public Construction Industry Bill’ which mandated the construction firms to adopt Earned Value Management System (EVMS) in their project having worth more than USD 50 million [7].

EVA is a three-dimensional approach and is based on following data sources:

- Planned Value (PV) describes portion of the project budget planned to be spent at any given point in time.
- Earned Value (EV) is a description of work progress at a given point in time and reflects the amount of work that has actually been accomplished at any particular time frame.
- Actual Costs (AC) is the amount of spending that is utilized for the completion of the work package activity.

EVA takes these three data sources and is able to compare the budgeted value of work scheduled (PV) with the Earned Value (EV) of physical work completed and the Actual Value (AV) of work completed. So, performance data achieved by using EVA is an objective measure of actual work performed. Fig. 3 shows a graphical example of EVA approach.

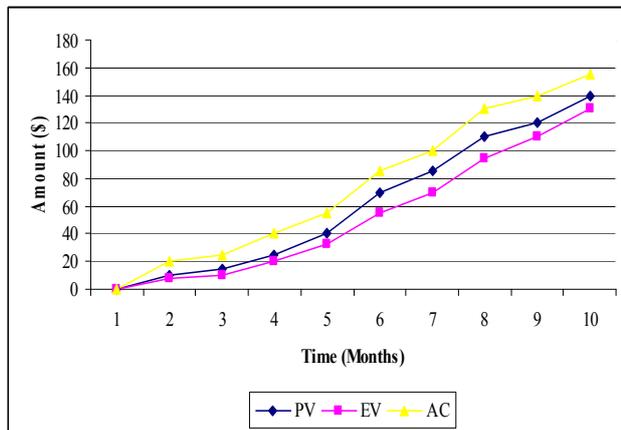


Figure 3. An Illustration of EV, PV and AC

After the terms PV, EV and AC are defined; the assessment of current and future cost performance can be done which will provide important information on the project progress.

A. Cost Analysis and Forecasting

Project cost analysis and forecasting is an important concern of management and it needs for the cost wise

evaluation of project performance. PMI PMBOK[®] provides a list of Earned Value cost performance variance and indicators [3]. Some of the key parameters are discussed below;

- Cost Variance (CV): It is the difference between the worth of the work that has been carried out and to the amount of money that was spent to do it. Mathematically it is represented as;

$$CV = EV - AC \quad (1)$$

A positive value of CV shows the project is spending less than the planned budget whereas the negative value shows that actual cost is exceeded than the budgeted amount. Whenever the later condition happens, it signals an unfavorable scenario to the management and needs necessary corrective measures to control the negative variance with in the approved limits.

- Cost Performance Index (CPI): It indicates the efficiency of resource use and measures the worth of the work that is achieved by spending every single unit dollar. Mathematically it is expressed as;

$$CPI = EV \div AC \quad (2)$$

A ratio less than 1.0 is an unfavorable and suggests the value of the work that has been accomplished is less than the amount of money spent. Similarly, conversely is the case for CPI ratio greater than 1.0.

- Cost Estimate at Completion (EAC_c): It is a forecasting indicator and calculates the finishing cost of the project by assuming the current cost performance efficiency. It is calculated as;

$$EAC_c = BAC \div CPI \quad (3)$$

- Estimate to Complete (ETC): It indicates the estimated remaining worth of the project work. It is calculated as;

$$ETC = (BAC - EV) \div CPI \quad (4)$$

IV. CASE STUDY

This case study illustrates the applications of EVA in real situation and demonstrates that how this approach can be useful in cost monitoring of construction projects and helps the project organization to monitor their performance in an objective manner rather than the traditional approach. It is applied on infrastructure projects in Iskandar Malaysia under the Ninth Malaysian Plan. This is a government funded project of total cumulative budget RM 61 million that was awarded in 2008. The scope of work includes up-gradation of an existing highway. The planned completion timeline for this project is March 2011. Table I depicts PV, AC and EV which are calculated on quarterly basis. The data shows that

during the first six reporting periods, the EV has remained higher than the PV suggesting the project is progressing well and the work packages are being delivered with the schedule and budget.

TABLE I. PV, AC AND EV ANALYSIS (AMOUNT IN RM)

S. No.	Duration	PV	AC	EV
1	Quarter 1	839,184	821,000	952,280
2	Quarter 2	6,789,683	6,771,000	7,391,301
3	Quarter 3	14,268,639	13,951,000	14,870,257
4	Quarter 4	21,528,478	19,220,074	22,142,755
5	Quarter 5	29,102,452	27,159,074	29,716,702
6	Quarter 6	37,867,842	34,990,074	38,587,439

This tabular data is then used for establishing EV graph which is shown in Fig. 4.

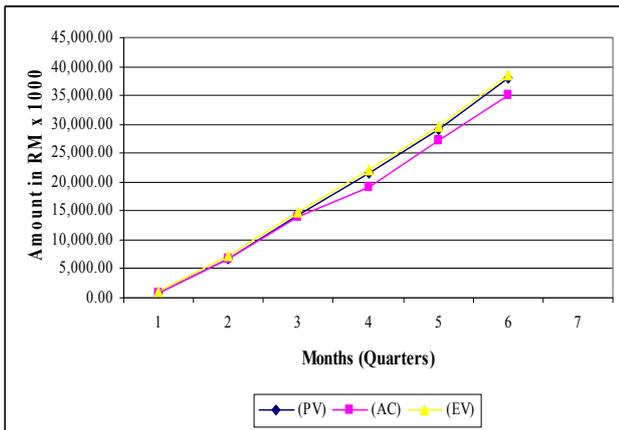


Figure 4. EV Graphical Analysis

A. Cost Analysis

The success of a construction project depends on the ability of a project team to control the causes of cost overruns which threatens its completion with in the approved budgets. This aim can be achieved by a periodical EV Cost Analysis. Table II shows the variance and performance index relating to cost for this project.

TABLE II. EV COST ANALYSIS

S. No.	Duration	EV Cost Analysis		
		$CV = (EV-AC) RM$	$CV\% = (CV/EV) \times 100$	$CPI = (EV/AC)$
1	Quarter 1	131,280.94	13.79	1.16

2	Quarter 2	620,301.40	8.39	1.09
3	Quarter 3	919,257.98	6.18	1.07
4	Quarter 4	2,922,681.36	13.20	1.15
5	Quarter 5	2,557,628.79	8.61	1.09
6	Quarter 6	3,597,365.88	9.32	1.1

The findings of the Table II can be summarized as follows;

- This project has a positive value of CV as the Earned Value is greater than the Actual Cost spending. Therefore, the project progress is favorable cost-wise.
- Fig. 5 depicts a trend of CV% for the entire reporting period. It suggests the project is 9.32% under budget at the end of 6th reporting period that is March 2010.

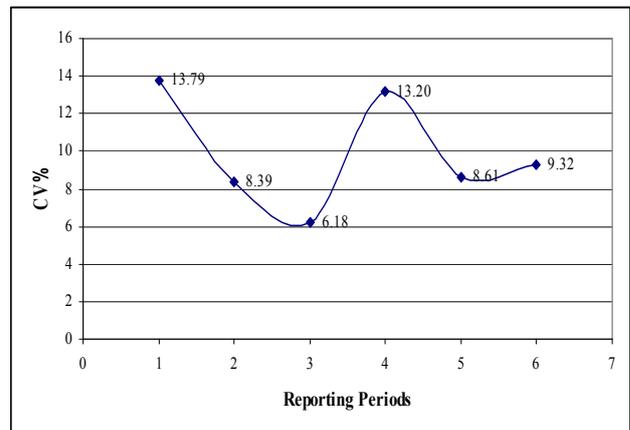
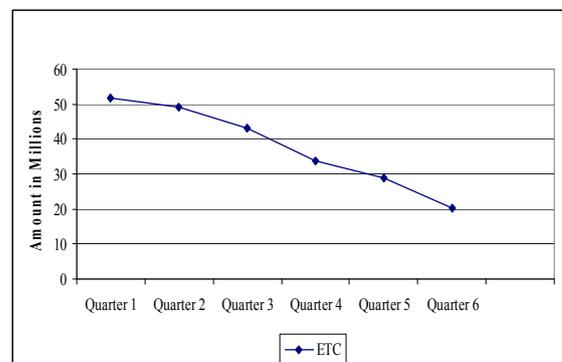


Figure 5. Graph of CV

- Fig. 6 shows a graph of CPI. As the values are greater than 1.00 which shows that value of the work that has been carried out is higher than the amount of money spent. So, the efficiency of using project resources is favorable.

Figure 6. CPI Graphical Analysis



V. CONCLUSIONS

Cost monitoring through EVA is an effective approach for finance management of construction projects. The calculation of EV performance variances and indices from the case study make it possible to examine the current and future cost performances of projects in many ways. With EVA, it is possible to monitor and forecast the cash flows and points out cost overruns which may happen during the project cycle. Therefore, this approach provides early warning signs for any cost divergence from the project baseline and helps the project team to carry out any contingency strategies to ensure the successful completion of project.

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B. Cost Forecasting

To forecast the future performance trends, cost forecasting is made by calculating the following performance measures;

- i. Fig. 7 shows the quarterly estimates of the future project cost i.e. Estimate at Completion (EAC_c). The reporting data is plotted by dividing total cumulative budget of the project with its corresponding performance index value (i.e. CPI) for each quarter. From the EAC_c graphical curve, it is clear that efficiency of project team resource use mainly affect the final estimated cost of the project. For example, at the end of quarter 3, the CPI is 1.07 and its corresponding EAC_c is about at RM 57 million. However, it remains at the minimum during 1st and 4th quarters when the CPI values are 1.16 and 1.15 respectively.

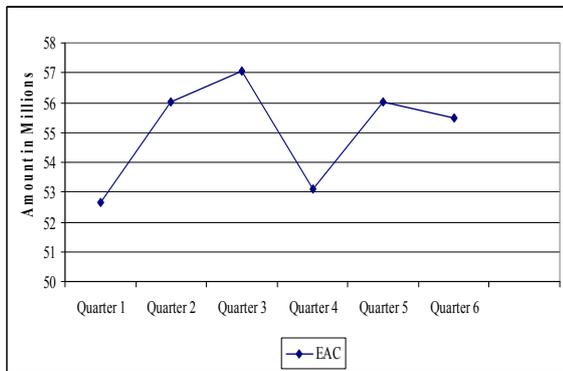


Figure 7. Trend of EAC

- ii. The remaining cost of the project is determined by Estimate to Complete (ETC) factor. Fig. 8 shows the decreasing trend of ETC. For calculating the value of ETC in this graph, the efficiency of resource utilization by the project team i.e. CPI for the first six quarter is also taken in to consideration.

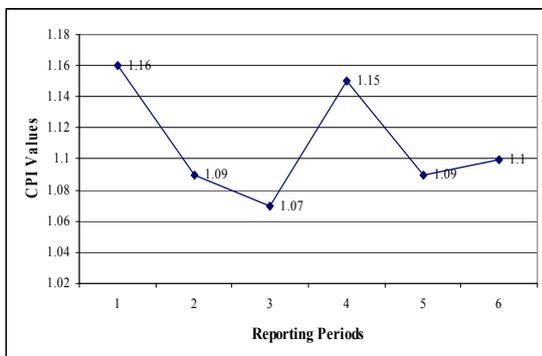


Figure 8. Trend of ETC