Project Performance Measurement in John Arne Construction Company Using Earned Value Management

Delfa G. Castilla[1], Rapunzel V. Marabi[2], Jetche C. Montecalvo[3], Raymond C. Nuñez[4], Michelle C. Pepito[5], Chariss Petiluna[6], Niña Marie Pilapil[7]

[1](*Professor, College of Engineering, Cebu Technological University – Danao Campus, Cebu, Philippines*)
[2,3,4,5,6,7](*Students, College of Engineering, Cebu Technological University – Danao Campus, Cebu, Philippines*)

Abstract: Construction projects are developing and becoming more complex over time, necessitating particular requirements throughout the project. Project time and cost are crucial factors in the construction business since they are over-run or under-run. One of the responsibilities of the engineering department is to monitor and control expenses during implementation in order to determine the actual cost associated with carrying out the task. As a result, cost control is a continual and essential activity that evaluates the effectiveness and performance of management. Earned Value Management (EVM) is a method that integrates scope, schedule, and resource measurements to assess project performance and improvement; it involves integrating the three critical components of a project covering schedule, work score, and cost. This research aims to evaluate the cost and schedule analysis in John Arne Construction project using earned value management. The results revealed that the project was behind schedule at the status date of October 31, 2022 and the project was completed on schedule at the status date of November 30, 2022. Project only needs 29% efficiency rate to finish the project. In terms of cost, the results showed that the project spent was smaller than the budget or the project was under budget.

Keywords: Actual cost, Construction, Earned value, Earned value management, Planned value, Project management.

1. INTRODUCTION

The Earned Value Management (EVM) method is one of the top management techniques approved by the Project Management Institute (PMI). It offers a strategy for gauging the success of projects based on the selection of cost and schedule performance indicators, which provide projections and early warnings of issues with economic and physical development so that appropriate corrective decisions and complete a successful project. Earned Value Management is one of the most often used methodologies in construction projects since it can objectively monitor project performance and progress by measuring scope, time, and cost in a single integrated system [1]. Due to its considerable impact on project planning and control, it is also renowned for its capacity to produce precise forecasts of performance issues. Similarly, utilizing the approach enhances scope definition and total project performance analysis. In order to signal project performances at a specific time or any chosen time to determine the time and cost performance of the project within the defined scope, earned value management methodologies integrate the project scope, schedule, and cost. In addition to estimating the project's total cost and completion date, it aims to gauge its progress. It may use inadvertently to reduce project risks, such as failure by going over budget or taking longer than expected to complete [2].

The construction industry has grown increasingly competitive in recent years as more and more contractors compete to stand out and complete their projects. Overrunning project budgets and schedules is a persistent issue that can prove fatal in developing nations [3]. It is relatively usual for scheduling delays and cost losses in complex projects [4]. Projects in the construction sector have frequently experienced delays and cost increases [5]. The complexity of the projects and the excessive fragmentation throughout the process are two of the many reasons for such issues [6]. In order to take preventive actions to reduce the adverse effects of confounding factors, it is crucial to continuously check the job's progress and rigorously examine any deviation in work schedules and project costs compared to the value initially planned. The conventional cost estimate method takes project costs that were anticipated and incurred [7]. However, with earned value management, the third

variable and earned value are considered, making it easier to evaluate expenditures and allocate time more accurately. In [8], the execution phase productivity failures, planning phase productivity underestimations, design flaws, omissions, and poor communication among the numerous process stakeholders were the leading causes of delays or negative time deviation.

In [8], research shows that Earned Value Management has many advantages for project managers. It enables timely schedule recognition, cost overrun prediction, project and schedule variances analysis, and cost and schedule outcomes forecasting [9]. By promptly alerting project customers to any potential problems relating to the project's development and attempting to take corrective action, the strategy helps project managers with their jobs to mitigate risks related to the scope, schedule, and cost. However, research conducted in Qazvin, Iran, by [10] shows that by evaluating the project's development in monetary terms, the gained value also helps to evaluate and control the dangers that the project may encounter. In reality, earned value offers essential data, including cost-time performance indices, estimates of cost and time for completion, and project performance and progress about the budget value and actual costs associated with their corresponding earned values.

Earned Value Management method is relevant in most project management. It offers a massive advantage to the construction companies such as John Arne Construction. However, the company prefers traditional or manual monitoring and evaluating the project rather than using Project Management software. The company did not use any project management software or method to evaluate and track the progress, one of the reasons it experienced delays and cost overruns in its past project. Thus, the project eventually led to losses and failure to meet the project deadline.

Per the company's record, research on project evaluation has yet to be conducted. Thus, this research aims to evaluate the cost and schedule analysis of the project by using earned value management. The researchers will then make some proposal for John Arne Construction so that the company can make a better decision to overcome the critical conditions of the project.

2. MATERIALS AND METHODS

2.1 Research Environment

This research took place in John Arne Construction Company, and therefore basically can be seen as a research study. The researchers chose John Arne Construction Company because they are the best candidate for achieving the purpose of this research. John Arne Construction is a small private company that creates products and services for public sector organizations. They produce building supplies such as hollow blocks, cement, and lumber as their products and provide services by hiring contractors to complete government projects like roads, covered courts, and building structures. They have an office in Danao City, and their main office is in Ibo, Lapu-Lapu City, Cebu.

2.2 Research Method

This research utilized a descriptive research design. This study also employed the Earned Value Management method in gauging the performance of a particular project in John Arne Construction Company. This research aims to know the performance measurement of schedule and cost analysis while utilizing earned value management. The data collected for this project was plan, cost, and schedule data. To verify and validate the information, the researchers also conducted an unstructured interview, document review, and observation and collected quantifiable information for statistical analysis. Measure the project's performance; it can be done either manually or using Microsoft Project to analyze and calculate the basic values and indices, which are used to evaluate the process and measure the project's performance. However, a manual calculation is a vast process, and some errors may occur, but using the software can be done effectively and reliably.

2.3 Research Environment

This research took place in John Arne Construction Company, and therefore basically can be seen as a research study. The researchers chose John Arne Construction Company because they are the best candidate for achieving the purpose of this research. John Arne Construction is a small private company that creates products and services for public sector organizations. They produce building supplies such as hollow blocks, cement, and lumber as their products and provide services by hiring contractors to complete government projects like roads, covered courts, and building structures. They have an office in Danao City, and their main office is in Ibo, Lapu-Lapu City, Cebu

2.4 Research Instrument

This study used sources of data, including unstructured interviews and document reviews. The researchers gathered an existing document of the project that helped the researchers in evaluating the project. The data gathered and reviewed are the task of the project, budget estimates, estimated schedule, planned value, project cost, and the project's actual cost. These data were evaluated using the Earned Value Management Key Parameters as project performance measures. In addition, the researchers used Microsoft Project, project management software, to analyze and present project schedules, costs, project plans, and time tracking. The work Breakdown Structure (WBS) tool was also used in the study to break the project down into manageable work elements, allowing these elements to be used throughout the project for planning, scheduling, budgeting, performance evaluation, and earned value analysis.

2.5 Treatment of Data

The data collection for review and evaluation were collected. The data were used to measure and analyze the projects performance including earned value, schedule variance, cost variance, schedule performance index, cost performance index, estimated at completion, variance at completion, variance at completion percent, estimate to complete and to-complete performance index formula in the table below:

Table I. Summary of Earned Value Performance Measure Calculations

Earned Value Parameters	Formula
Earned Value (EV)	= Task Budget (BAC) X % Work Completed
Schedule Variance (SV)	= Earned Value (EV) – Planned Value (PV)
Cost Variance (CV)	= Earned Value (EV) – Actual Costs (AC)
Schedule Performance Index (SPI)	= Earned Value (EV) / Planned Value (PV)
Cost Performance Index (CPI)	= Earned Value (EV) / Actual Cost (AC)
Estimate at Completion (EAC)	= Budget at Completion (BAC) / Cost Performance Index (CPI)
Variance at Completion (VAC)	= Budget at Completion (BAC) – (EAC)
Variance at Completion Percent (VAC%)	= Variance at Completion (VAC) / Budget at Completion (BAC)
Estimate to Complete (ETC)	= Estimate to Complete (ETC) / Actual Cost (AC)
To-Complete Performance Index (TCPI)	= (BAC – EV) / (BAC – AC)
Time Variance at Completion (TVAC)	= Time Estimate at Completion – Duration in Days
Time Estimate at Completion (TEAC)	= Duration in Days / SPI

3. Results and Discussion

Table II. Planned Schedule and Cost of the Selected Project

EVM Parameter	First Tracking	Second Tracking
Status Date	31-Oct-22	30-Nov-22
Planned % Complete	75%	93%
Performance % Complete	71%	93%
Project Duration	122 Days	122 Days
Elapsed Days	91 Days	113 Days
Actual Duration	87 Days	114 Days
Remaining Duration	35 Days	8 Days
Budget at Completion	₱ 4,000,000	₱ 4,000,000

Analysis of Table II revealed that the total planned value or the budget at completion of the project was ₱4,000,000. The planned schedule represents the baseline for the project, which starts on June 27, 2022, and ends on December 13, 2022, with a planned total duration of 122 days. The date from the start of the project until the first tracking has 91 elapsed days out of 122 days of project duration. This signifies that the planned percentage

complete of the project was 75%, and the performance percentage completed on the status date of October 31, 2022, was 71% which means that the project was 4% behind its planned schedule. Therefore, the project leader should plan for risk mitigation to make better decisions to meet the project deadline and to avoid the additional risk that might occur.

Moreover, on the second tracking of the project, the days elapsed was 113 days from the start of the project until status date of November 30, 2022, and there is an actual duration of 114 days with a remaining total duration of 8 days from the date of evaluation until the date of completion. This indicates that the project was precisely from its planned schedule and that the project was doing well against its schedule. In [8], the application of earned value management requires an initial effort in planning work to be done, particularly concerning the definition of the activities to consider, the estimate of their duration, and the costs inherent in each.

Table III. Earned Value Performance Measure Calculations

EVM Parameters	First Tracking	Second Tracking
Status Date	31-Oct-22	30-Nov-22
Planned Value (PV)	₱ 3,026,000	₱ 3,932,500
Earned Value (EV)	₱ 2,853,000	₱ 3,932,500
Actual Cost (AC)	₱ 2,718,152.09	₱ 3,763,654.40

Shown in Table III are the analysis results of Earned Value (EV) indicators such Planned Value (PV), Actual cost (AC), and Earned Value (EV) until the first and second evaluation date of the project. These indices served as the basis for assessing and evaluating the project's performance. Analysis revealed that the sum of the budget for all scheduled work (PV) to be accomplished within October 31, 2022 was Php 3,026,000 and Php 3,932,500 on November 30, 2022. This means that the budget or planned value of the work needed for the project from the start until the date of evaluation was Php 3,026,000 and Php 3,932,500 respectively. Furthermore, the sum of the approved budget for the activities (EV) accomplished by October 31, 2022 was Php 2,853,000 and Php 3,932,500 budget for the work actually completed on November 30, 2022.

This indicates that on the first tracking the work done was Php 2,853,000 which is lesser than its planned value and it has an actual cost of Php 2,718,152.09 activities performed until the status date of October 31, 2022. In the second tracking, it reveals that the cost actually incurred for the work completed was 3,763,654.40 and Php 3,932,500 work was done which is greater than its planned value which means that more work was done than planned. As stated by authors Oliveira (2019), Earned Value Management indicators can be used for monitoring the performance of the schedule and cost of the work when evaluating the values of the actual costs (AC) spent on execution and related to the planned values (PV) and earned values (EV).

Moreover, with the use of PV, EV, and AC, a manager can evaluate or analyze the performance of the works and make estimates defining trends in schedule and cost until its completion [8]. In addition, the manager should track every progress of the project so that the cost spent will not go beyond the budget and the project achieves its objective.

Table IV. SPI & CPI Earned Value Progress Measure Calculations

Planned Parameter	First Tracking	Second Tracking
Status Date	31-Oct-22	30-Nov-22
Cost Variance	₱ 134,847.91	₱ 168,845.60
Schedule Variance	(- ₱ 173,000)	₱0.00
Schedule Performance Index (SPI)	0.94	1.00
Cost Performance Index (CPI)	1.05	1.04

Table IV revealed the analysis results of the project performance in terms of executing the project. The analysis reveals that the project's cost variance of the project until the date of evaluation was Php 134,847.91 and Php 198,845.60 on the status date of November 30, 2022 means that the cost spent for the project completed in the first and second tracking was less than the original planned budget and it has a variance of Php 134,847.91 in the first tracking and Php 198,845.60 in the second tracking. Furthermore, the schedule variance which represents

the status of the schedule was negative value on the first tracking which indicates unfavourable schedule performance since the amount of work performed is lesser than what was scheduled and the project was behind schedule.

On the other hand, the schedule variance on the second tracking was equals to zero means that the schedule performance of the project is great and the project was on schedule. Moreover, the performance indices of values reinforce previous indications. Therefore, the Cost performance Index (CPI) value at the evaluation date of October 31, 2022 was 1.05 and 1.04 on November 30, 2022, which is greater than 1.0, signifies that the cost spent was under budget and the project was performing well against the budget. Concerning the execution behind, the value of Schedule Performance Index (SPI) was 0.94 on the date of evaluation October 31, 2022, which is lesser than 1.0, indicates that the project was behind its planned schedule and 6% more of the planned work needed to be accomplish.

Furthermore, the Schedule Performance Index (SPI) value at the status date of November 31, 2022 was 1.0 signifies that the project was on schedule and the project was performing great against planned schedule. The interpretations of the CPI and SPI performance indicators state that although the ideal situation is for these indicators to be around 1.0, there are proposed tolerance limitations. Values between 0.8 and 1.0, or between 1.0 and 1.2, signify that project is well controlled and executed, and its efficiency is excellent; if, on the contrary, they are below 0.8 or above 1.2, this is a signal to take corrective measures. Values below 0.5 or above 1.5 imply that there is a critical situation. However, values below 0.2 or above 2.0 indicate a problem in the conception of the baseline measurement, from which unrealistic situations are inferred, such as a very poor and unrealistic estimation of the execution of the project, activities that can be carried out in less time than specified, or expenses that are much lower or higher than planned, all of which can lead to the wrong interpretation of the execution [11].

Table V. Earned Value Progress Measure Calculations

Planned Parameter	First Tracking	Second Tracking
Status Date	31-Oct-22	30-Nov-22
Estimate to Complete (ETC)	₱1,092,786.70	₱64,601.82
Estimate at Completion (EAC)	₱ 3,810,938.79	₱ 3,828,256.22
Variance at Completion (VAC)	₱ 189,061.21	₱ 171,743.78
Time Estimation at Completion (TEAC)	129 Days	122 Days
Time Variance at Completion (TVAC)	7 Days	0 Day
To-Complete Performance Index (TCPI)	0.89	0.29

Table V showed the forecast indicators, which indicate estimates of time and cost at the end of the works. In keeping with project performance, the forecast indicators allow researchers to estimate that the probable final cost of the work will be Php 3,810,786.70 (EAC), with a variation of Php 189,061.21 (VAC) from the original planned, with a lower cost than the estimated at the status date of October 31, 2022. Furthermore, the remaining cost will be spent in order to complete the project is Php 1,092,786.70 (ETC). Moreover, the To-Complete Performance Index (TCPI) value is equal to 0.89, which is less than 1.0, indicating future efficiency can be less than planned to achieve the financial goal. The project needs only a 89% efficiency rate to finish as planned. In addition, on the same status date, predicted at completion (PAC) is 122 days, and the estimation of time at which the project will be completed, considering the unintended changes produced to the initial plan (TEAC) are 129 days. While maintaining the verified performance, the researchers conclude that the time estimate at completion will be 129 days, which is 7 days more than planned signifies that the project was behind schedule.

On the other hand, at the status date of November 30, 2022 the forecasted cost of the project at completion is Php 3,828,256.22, with a variation of Php 171,743.78 (VAC) at completion, with a less cost than predicted. Moreover, in order to complete the project the remaining cost to be spent is Php 64,601.82. The To-Complete Performance Index (TCPI) value is less than 1.0, meaning future efficiency can be lesser than planned in order to achieve the financial goal and the project only needs 29% efficiency rate to finish the project. In addition, on the status date of November 30, 2022, schedule at completion (SAC) was 122 days, and the time estimation at which the project will be completed, given the unintentional changes produced to the original plan

(TEAC)is 122 days. Based on the unstructured interview with the project leader, he said they did not utilize any project management software tools to evaluate and monitor the project. There is no monthly forecast made by the management and no clear process on how to monitor the project. The project leader should make a site visit every day or every week to monitor the progress of the project and to control the existing problem.

4. CONCLUSION

The researchers concluded that the project at the status date of October 31, 2022, was behind schedule, and the cost was under budget. It means that the project took longer than planned and the project spent less cost than had been planned. Thus, project needs 89% efficiency rate to finish as planned. Moreover, the schedule and cost performance index values signified that the project execution time was behind schedule an d the cost was under the estimated budget. On the other hand, the project's status at the status date of November 30, 202 2, revealed that the project was on schedule and the cost spent was less than planned. Furthermore, in order to achieve the financial goal, the project only needs 29% efficiency rate to finish the project. The researchers concluded that earned value management in project management assists managers in making decisions about the project scope, resources, and cost supported by the facts during overall project oversight. It is also an efficient methodology for cost and schedule control, and it monitors the progress of the work on various tasks and records deviation from the project's work schedule or budget through the calculation of time deviation and cost deviation.

REFERENCES

[1] Dalibi, S. D., Kumo, H. A., &Abubakar, A. M. (2016). *The Fundamentals of Earned Value Management in Construction Projects: Applications and Simulations. Nigerian Institute of Quantity Surveyors*. Retrieved October 12, 2022, from https://www.academia.edu/28102789

[2] Mahdi, I. Abd-Elrashed, A. S. Essawy, and L. Raed, (2018*). "Difficulties of Implementing Earned Value Management in Construction Sector in Egypt."* Retrieved October 12, 2022, from https://www.researchgate.net/publication/323855260

[3] Susanti, R. (2020), *"Cost Overrun and Time Delay of Construction Project in Indonesia". Journal of Physics: Conference Series, vol.1444.* Retrieved October 15, 2022 from https://doi.org/10.1088/1742-6596/1444/1/012050

[4] Miranda, L. J, H., Bezerra, N.R.A., Bezerra, M.J.S. et al. (2017). *"The internet of things sensors technologies and their applications for complex engineering projects: A digital construction site framework."*Brazilian Journal of Operations & Production Management, Vol. 14, No. 4, pp. 567-76.

[5] Olivieri, H., Granja, A.D. and Picchi, F.A. (2016). *"Planejamentotradicional, Location-Based Management System e Last Planner System: um modelointegrado",*AmbienteConstruído, Vol. 16, No. 1, pp.265-83.

[6] Besser Freitag, A.E., Anholon, R., Oliveira, V.M. et al. (2017*). "Integration of conceptsabout lean construction, sustainability and life cycle of buildings: a literature review",* Brazilian Journal of Operations. Retrieved October 13, 2022, from https://bjopm.org.br/bjopm/article/view/384

[7] M. Durga Sruthi and A. Aravindan, (2020). *Performance measurement of schedule and cost analysisby using earned value management for a residential building, Materials Today: Proceedings.* Retrieved October 31, 2022 fromhttps://doi.org/10.1016/j.matpr.2020.05.210

[8] Oliveira, R., (2019). *"Monitoring and Control of Schedule and Cost performance in Façade Conservation.".* Retrieved from https://creative commons.org/licenses/by-nc-nd/4.0/

[9] Ziyash A., *"Earned Value Management and its Applications : A Case of an Oil,"* vol. VII, no. V, pp. 1–23, 2018.

[10] N. Moradi, S. M. Mousavi, and B. Vahdani, (2017). *"Anearned value model with risk analysis for project management under uncertain conditions."* J. Intell. Fuzzy Syst., vol. 32, no. 1, pp. 97– 113.

[11] Kim, B.-C.; Pinto, J.K., (2019). What CPI = 0.85 *ReallyMeans: A Probabilistic Extension of the Estimate at Completion.* J. Manag. Eng. 2019, 35, 04018059-18.