

# Analysis of Cost and Time To Complete of Office Project with The Earned Value Method (Case study: Office of Bahtera Elang Perak Indonesia Surabaya)

Linda Nailufar<sup>1\*</sup>, Budi Witjaksana<sup>2</sup>, Esti Wulandari<sup>3</sup>

<sup>1-3</sup>Master of Civil Engineering Study Program, Faculty of Engineering, Universitas 17 Agustus 1945 Surabaya, Indonesia

E-mail: <sup>1)</sup> [nailufar97@gmail.com](mailto:nailufar97@gmail.com), <sup>2)</sup> [budiwitjaksana@umtag-sby.ac.id](mailto:budiwitjaksana@umtag-sby.ac.id), <sup>3)</sup> [wulandariesti@umtag-sby.ac.id](mailto:wulandariesti@umtag-sby.ac.id)

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\*Corresponding author:

Linda Nailufar

[nailufar97@gmail.com](mailto:nailufar97@gmail.com)



## ABSTRACT

The rescheduling of the initial schedule carried out on the Bahtera Elang Perak Indonesia Office Construction project has an impact on increasing the duration of work causing the project completion target to be delayed from the time it should be. Increasing the project completion target can affect the amount of costs incurred. The contract value for this office construction project is Rp. 13,908,226,157 with a work duration of 43 weeks to 54 weeks. The current condition of work progress at week 31 is -0.225% while the total actual cost or that has been incurred during the work is Rp. 3,191,740,254. To overcome this, an analysis is carried out on the value of the estimate at complete (EAC) and time estimate (TE) of the Surabaya BEPI Office Construction Project using the earned value method. This method combines the elements of cost, schedule, and work performance. The earned value method aims to determine the estimated cost and time of project completion. From the results of the analysis conducted in the 41st week, it was obtained that the estimated cost and time to complete the project implementation (EAC) was 14,289,833,105, - and the estimated time (TE) was 499 days, which was 121 days later than the original schedule.

Keywords: Cost Estimate, Time Estimate, Earned Value

## 1. Introduction

As project complexity increases, it is common to experience delays in completing the project and exceed the estimated costs. Usually, the management system separates the accounting system for spending from the construction project scheduling system. The cost accounting system facilitates the production of performance reports and project cost estimates, while the schedule system provides data on the progress of project completion. The project management information obtained from the two systems is mutually supportive, however it can yield divergent insights into the project's current state (Khairunnisa et al., 2020).

The building project for the Bahtera Elang Perak Indonesia office is scheduled to span a duration of 43 weeks, commencing on June 19, 2023 and concluding on April 14, 2024. The project is situated at Jl. Simpang Darmo Permai Selatan I number 38. The project was tendered in March 2023. The project contract for the tender work package involves exclusively the structural work of an 8-story building. The budget allocated for this project is Rp. 13,908,226,157. The building has a total size of 1,081 m<sup>2</sup> and the requirements include reinforced concrete structures and steel structures for the roof truss. During the piling work, many modifications took place in the field. These included the incorporation of pile points as suggested by the planner, alterations in designs, extra pile drilling, and the inclusion and assessment of re-drive work as requested by the planner. These factors resulted in a substantial delay in the project, requiring the rescheduling of the reference timetable that was initially anticipated.

Rescheduling the original project schedule has a direct effect on prolonging the period of work, resulting in a delay in achieving the project completion goal. The project, initially scheduled to be finished in 43 weeks, experienced a delay of 11 weeks, resulting in a revised completion timeline of 54 weeks. The revised deadline for the completion of this project is June 30, 2024. In week 32, the project's progress has reduced by -0.225% compared to week 31, resulting in a realization progress of 24.505%. The entire actual cost incurred during week 31 is Rp. 3,191,740,254,-.

The Earned Value approach is a methodology employed to evaluate the progress and effectiveness of a project. This approach integrates the factors of expenses, timeline, and task execution. By quantifying the progress of a task and evaluating it in relation to the allocated budget. This method can be employed to ascertain if the allocation of a portion of the project budget is commensurate with the advancement of its execution. Analyze the notion of Earned Value to find the correlation between physical accomplishments and financial expenditure. Effective time management is crucial for ensuring the project is executed within the designated timeframe (Asnur Pranata M. H., 2020).

Strategic management and oversight Cost and time are integral components of comprehensive building project management. Aside from evaluating the quality, the performance of a project can also be evaluated based on its cost and duration. It is necessary to regularly measure the costs and time spent on finishing a task in order to identify any deviations from the original plan. Poor project management is indicated by the presence of substantial discrepancies in both cost and time. By monitoring the project's cost and time indicators, it is possible to proactively address any issues and ensure that the project is executed as planned (Febriantoro et al., 2022).

Based on the background above, this paper will discuss the analysis of the cost and time of project completion using the earned value method with a case study of the Bahtera Elang Perak Indonesia office building project. The purpose of this study is to calculate the value of the estimate at complete (EAC) and the length of time to complete the work (TE) at the Bahtera Elang Perak Indonesia Surabaya office.

## 2. Literature Review

### 2.1. Earned Value Analysis

Earned value analysis is a commonly used technique for quantitatively analyzing project progress, forecasting completion dates and overall costs, and assessing schedule and budget variances as tasks are completed. Evaluating the actual performance and achieved value in relation to an integrated baseline will offer feedback on the present project state compared to the baseline, as well as provide insight into future performance (Sri Mahapatni et al., 2022). The Earned Value Index is a tool that can be utilized to predict the cost and duration of project completion. It is calculated by analyzing the project's performance up until the time of review and assuming that this performance will persist till the completion of the project or maintain a consistent level (Castollani & Puro, 2020).

Three fundamental factors serve as a benchmark for measuring project performance using the earned value concept:

- a. BCWP = budgeted cost of work performed.
- b. BCWS = budgeted cost of work scheduled.
- c. ACWP = actual cost of work performed

EVM performance analysis involves the computation of various variance measures and performance indices, which aid in assessing and comprehending the project's state, among other:

#### a. Cost Variance

Cost variation refers to the disparity between the actual expenses accrued throughout a project and the value achieved upon the completion of a specific work package.

$$CV = BCWP - ACWP \dots \dots \dots (1)$$

**b. Schedule Variance**

Schedule variance is employed to quantify the discrepancy between Budgeted Cost of Work Scheduled and Budgeted Cost of Work Performed.

$$SV = BCWP - BCWS \dots\dots\dots (2)$$

**c. Cost Performance Index**

The cost efficiency factor can be demonstrated by comparing the earned value of completed work with the actual expenditures incurred during the same period.

$$CPI = BCWP / ACWP \dots\dots\dots (3)$$

**d. Schedule Performance Index**

The performance efficiency factor in completing the task can be demonstrated by comparing the value of the work that has been physically done with the expected cost expenditure incurred based on the work plan.

$$SPI = BCWP / BCWS \dots\dots\dots (4)$$

**2.2. Estimated Time and Cost of Project Completion**

The Earned Value approach can be utilized to determine the precise cost and duration of project completion. Estimates are derived based on project performance patterns at the time of the review, assuming that these trends remain constant throughout the project or regularly follow a certain pattern. This estimate serves as a valuable tool for the contractor, offering a comprehensive summary that enables them to implement the required remedial measures (Putra et al., 2020).

**a. Estimate to Complete (ETC)**

The estimate for the remaining work (ETC) is based on the assumption that the project's performance trend will remain consistent until completion. There are other methods available to conduct the estimation, which are outlined below:

- a) The remaining work will incur the anticipated budget, regardless of the outcome of the review.
- b) The performance remains consistent over the duration of the project. The estimate assumes that the performance observed during the review will persist until the completion of the project.
- c) The mixed or combination strategy involves the integration of both strategies.

The ETC formula for physical progress < 50% is:

$$ETC = BAC - BCWP \dots\dots\dots (5)$$

BAC (Budget at Completion) = the budgeted total project cost.

**b. Estimate at Completion (EAC)**

The Estimate at Completion (EAC) is calculated by adding the Actual Cost of Work Performed (ACWP) to the Estimate to Complete (ETC), providing a projection of the total cost at the end of the project. There are other methods to calculate the EAC formula, including:

- a) The total cost of the project, including the current expenses and the expected cost of the remaining work, assuming that the project's performance will remain consistent until completion.

$$EAC = AC + ETC \dots\dots\dots (6)$$

- b) The quotient of the Budget at Completion (BAC) and the project cost performance factor (CPI). Utilize the formula if the Budget at Completion (BAC) remains constant.

$$EAC = BAC / CPI \dots\dots\dots (7)$$

**c. Time Estimate (TE)**

The projected project completion (TE) date is determined based on the premise that the project performance will remain consistent with the findings from the on-site evaluation.

$$TE = ATE + OD - (ATE \times SPI) \dots \dots \dots (8)$$

SPI

### 2.3. Previous Research

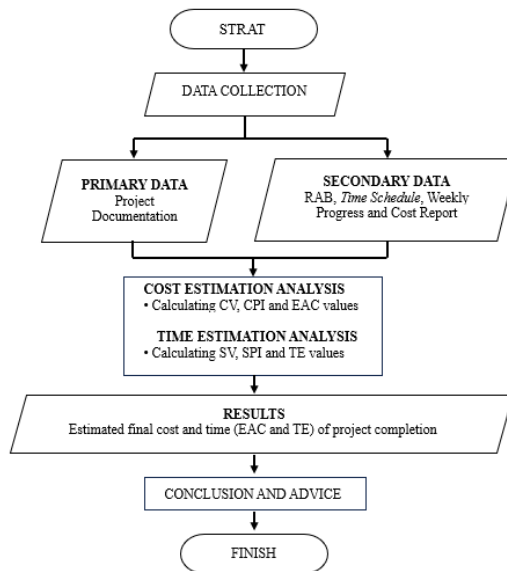
A prior study conducted by Proboretno et al (2024) focused on utilizing the Earned Value technique to regulate Afv Earthwork in Kedungpeluk Sidoarjo. The cumulative duration (ETS) by the conclusion of the eighth week evaluation was 91 days. The project is expected to be completed within 140 days (EAS). The project completion time experienced a 0.16 percent increase. In order to guarantee the successful completion of Plengsengan AFV. Kedungpeluk Sidoarjo, it is imperative that construction service providers employ efficient execution techniques and maintain continuous oversight during every phase of the project.

The research was conducted by (Asmoro et al, 2024). Utilizing this analytical methodology will facilitate comprehension of project advancement and enable the identification of areas necessitating modifications to mitigate delays. According to the Earned Value Method study conducted for the construction project of the Open University Urban Education Center Phase 2, the projected total cost till the completion of the project is Rp 73,908,443,223.09. This estimation will provide stakeholders with a clear understanding of the required financial resources to successfully finalize this project. Furthermore, the anticipated timeline for completion is 53 weeks, a crucial aspect of project planning and administration.

A study conducted by Pramadha et al (2024) investigated the earned value technique. The Kediri Airport Access Road Phase 1 between Kediri and Nganjuk has yielded outcomes. The acquired data encompasses cost and time analysis, planning, and earned value analysis. The project's BCWP value is Rp 35,700,446,881.00, while the ACWP value is Rp 16,482,905,558.96 up to week 8. The projected budget for completion amounts to Rp 17,470,510,292.77, while the anticipated total final cost is Rp 32,509,153,464.05. The projected duration of the project is 84 days, and an SV value of 0 indicates that there is a delay. The TE number, also known as the projected time required to finish the project, is 89 days, indicating a delay of 5 days from the original timetable.

### 3. Methodology

The steps used in this study can be seen in Figure 1 below :



Source: Author's Processed Data (2024)

**Figure 1. Research Flowchart**

Based on figure 1 illustrates the steps or sequence of activities that have been specifically created in accordance with the flow to accomplish the objectives of this study. Gathering data for the computation of budgeted cost of work scheduled, budgeted cost of work performed, and actual cost of work performed. Once the necessary data has been gathered, the subsequent task involves conducting performance analysis to determine budgeted cost of work performed, CV (cost variance), CPI (cost performance index), and SPI

(schedule performance index). This is followed by activities to calculate the estimated cost of the remaining work (ETC) and estimate the final cost of the project (EAC). Additionally, the estimated time of project completion (TE) is also calculated. The final step is deriving findings and recommendations based on the interpretation of the collected data.

### 3.1. Data Analysis Method

The analysis techniques carried out on Earned Value include:

- a. Cost variance analysis  
The variance is the disparity between the actual expenses accrued during the project and the value acquired upon completion of the work package.
- b. Schedule variance analysis  
employed for determining the discrepancy between budgeted cost of work scheduled and budgeted cost of work performed.
- c. Cost Performance Index analysis  
The CPI value represents the ratio of the value gained (in relation to the total project value) to the expenditures expended.
- d. Schedule Performance Index analysis  
The SPI value quantifies the extent to which work has been accomplished (in relation to the entire project) compared to the intended workload.
- e. Estimate at Completion analysis  
The total cost projection at the end of the project is calculated by adding the actual cost to the estimated to complete (ETC).
- f. Time Estimate analysis  
The projected duration for project completion. The estimation of the completion time is based on the premise that the project's performance trend would remain consistent, as observed during the on-site inspection.

## 4. Results and Discussion

In this Earned Value research, the original data of the Surabaya Bahtera Elang Perak Indonesia Office project planning is required. This primary and secondary data is used as a reference so that the estimated cost calculation and project completion time can achieve the desired results. The study was carried out throughout Weeks 38-41, namely from March 04 to March 31, 2024.

### 4.1. Analysis of Work with Earned Value Method

The method used in controlling costs and time in the field is the use of a time schedule where the percentage of the project plan and the percentage of realization are depicted in an S-curve graph.

#### a. Budgeted Cost of Work Schedule (BCWS)

The calculation of the budgeted cost of work schedule week 41 is calculated using the following formula:

$$\begin{aligned} \text{BCWS} &= \text{weekly plan weight} \times \text{BAC} \\ &= 3.957 \% \times \text{Rp. } 13.908.226.157,- \\ &= \text{Rp. } 550.338.505,- \end{aligned}$$

The computation for the cumulative budgeted cost of work schedule week 41 is as follows:

$$\begin{aligned} \text{BCWS} &= \text{cumulative plan weight} \times \text{BAC} \\ &= 61.834 \% \times \text{Rp. } 13.908.226.157,- \\ &= \text{Rp. } 8.599.947.213,- \end{aligned}$$

#### b. Budgeted Cost for Work Performed (BCWP)

The budgeted cost for work in the 41st week. The computation is performed using the following formula:

$$\text{BCWP} = \text{weight weekly realization} \times \text{BAC}$$

$$= 2.650 \% \times \text{Rp. } 13.908.226.157,-$$

$$= \text{Rp. } 368.567.993,-$$

The computation for the cumulative budgeted cost for work performed week 41 is as follows:

$$\text{BCWP} = \text{cumulative realization weight} \times \text{BAC}$$

$$= 46.860 \% \times \text{Rp. } 13.908.226.157,-$$

$$= \text{Rp } 6.517.422.468,-$$

**c. Actual Cost for Work Performed (ACWP)**

The Actual Cost for task Performed refers to the precise budget allocated for the completed task in the current volume of activity. The ACWP estimate is derived from the computation of both direct and indirect costs in the construction project of the Bahtera Elang Perak Indonesia Surabaya office. The actual project expenses are presented in table 1.

**Table 1. Recapitulation of Actual Cost for task Performed Value**

Week to	Weekly Realization Weight	ACWP	
		Week (Rp)	Cumulative (Rp)
32	1.256	299,174,025	3,490,914,279
33	1.043	180,854,216	3,671,768,495
34	1.524	292,789,214	3,964,557,709
35	2.965	422,016,756	4,386,574,465
36	1.890	308,172,055	4,694,746,520
37	3.742	627,273,311	5,322,019,831
38	2.902	414,327,834	5,736,347,665
39	2.503	366,400,572	6,102,748,237
40	3.135	470,238,125	6,572,986,362
41	2.650	326,043,055	6,899,029,417

Source : Analysis Result, 2024

Table 1 clearly demonstrates a consistent weekly increase in the Actual Cost for task Performed column. Indicating that the expenses for each week of the project have risen.

**d. Cost Variance (CV)**

The Cost Variance for the 41st week can be calculated using equation (1) as follows:

$$\text{CV} = \text{BCWP} - \text{ACWP}$$

$$= \text{Rp } 6.517.422.468 - \text{Rp } 6.899.029.417$$

$$= \text{Rp. } -381.606.949,-$$

**e. Schedule Variance (SV)**

Based on the calculations above, the values of BCWS and BCWP are determined. This allows us to compute the schedule variant in week 41 using equation (2) :

$$\text{SV} = \text{BCWP} - \text{BCWS}$$

$$= \text{Rp } 6,517,422,468 - \text{Rp } 8,599,947,213$$

$$= \text{Rp } - 2.082.524.745,-$$

**f. Cost Performance Index (CPI)**

The 41st week Cost Performance Index (CPI) can be calculated using equation (3) with the BCWP and ACWP values obtained from the above computations :

$$\text{CPI} = \text{BCWP} / \text{ACWP}$$

$$= \text{Rp } 6.517.422.468 / \text{Rp } 6.899.029.417$$

$$= 0,945$$

**g. Schedule Performance Index (SPI)**

The Schedule Performance Index (SPI) for week 43 is calculated using equation (4) as follows:

$$\begin{aligned} \text{SPI} &= \text{EV} / \text{PV} \\ &= \text{Rp } 6.517.422.468 / \text{Rp } 8.599.947.213 \\ &= 0,758 \end{aligned}$$

**4.2. Analysis of Cost Estimation and Project Completion Time**

In the implementation of the Surabaya Bahtera Elang Perak Indonesia Office Construction Project, As mentioned in the previous explanation, the project's performance in the field has experienced a delay, with a deviation of -14.973% from the planned value of 61.834%. Hence, it is imperative to assess the duration and expenses of the project in order to foresee any budget overruns.

**a. Estimate at Complete (EAC)**

In determining the estimated cost value of completing the project or EAC (Estimate at Completion), the first thing to do is to calculate the ETC (Estimate to Complete) value is determined by considering the Budget at Completion and the Budgeted Cost for Work Performed. Work progress in week 41 amounted to 46.860%. The following is the calculation of the ETC value with work progress less than 50%:

$$\begin{aligned} \text{ETC} &= \text{BAC} - \text{BCWP} \\ &= \text{Rp } 13.908.226.157 - \text{Rp } 6.517.422.468 \\ &= \text{Rp } 7.390.803.688,- \end{aligned}$$

Based on the results of the Estimate to Complete (ETC) computation, it can be inferred that the projected cost needed to finish the project amounts to Rp. 7.390.803.688. While the prediction of the total cost at the end of the project is calculated according to the formula below:

$$\begin{aligned} \text{EAC} &= \text{ACWP} + \text{ETC} \\ &= \text{Rp } 6.889.029.417 + \text{Rp } 7.390.803.688 \\ &= \text{Rp } 14.289.833.105,- \end{aligned}$$

The projected cost incurred or the overall cost upon project completion is Rp. 14.289.833.105. The disparity between the expense of the project completion plan and the projected cost of finishing the project is as follows:

$$\begin{aligned} \text{VAC} &= \text{BAC} - \text{EAC} \\ &= \text{Rp. } 13.908.226.157 - \text{Rp. } 14.289.833.105 \\ &= \text{Rp. } -381.606.949,- \end{aligned}$$

From the above calculations, it is known that the result for the difference between the cost of the project completion plan (BAC) and the estimated cost of completing the project (EAC) is Rp. -381.606.949. The recapitulation of the calculation of the EAC and VAC values in the previous month can be seen in table 2 below:

**Table 2. Rekapitulasi Nilai ETC, EAC dan VAC**

Week to	Index		
	ETC	EAC	VAC
32	10,499,951,608	13,990,865,887	-82,639,730
33	10,354,873,389	14,026,641,884	-118,415,727
34	10,142,910,283	14,107,467,992	-199,241,835
35	9,730,551,707	14,117,126,172	-208,900,015
36	9,467,634,995	14,162,381,514	-254,155,358
37	8,947,120,838	14,269,140,669	-360,914,512
38	8,543,525,249	14,279,872,914	-371,646,758

Week to	Index		
	ETC	EAC	VAC
39	8,195,397,175	14,298,145,412	-389,919,255
40	7,759,371,682	14,332,358,044	-424,131,887
41	7,390,803,688	14,289,833,105	-381,606,949

Source : Analysis Result, 2024

Based on the calculations in table 1 above, the estimated cost of completing the project is Rp. 7.390.803.688, so that it can be seen that the difference between the cost of the project completion plan (BAC) and the estimated cost of completing the project (EAC) is Rp. 14.289.833.105, with a large cost difference value of Rp. -381.606.949.

#### b. Time Estimate (TE)

The formula for calculating the projected project completion time (Time Estimate) is as follows:

Duration (ATE) : 287 hari

Scheduled time (OD) : 378 hari

Index Value (SPI) : 0,758

$$TE = \frac{ATE + OD - (ATE \times SPI)}{SPI}$$

$$= \frac{287 + 378 - (287 \times 0,758)}{0,758}$$

$$= 498.783 = 499 \text{ day}$$

The following is a recapitulation of the estimated completion time (TE) of the Bahtera Elang Perak Indonesia Surabaya office construction project in the previous week listed in table 3:

**Table 3. Time Estimate (TE)**

Week to	OD	ATE	SPI	TE	Difference	Description
32	378	224	0.991	381.466	-3.466	later than planned
33	378	231	0.935	404.360	-26.360	later than planned
34	378	238	0.877	431.205	-53.205	later than planned
35	378	245	0.873	433.038	-55.038	later than planned
36	378	252	0.819	461.795	-83.795	later than planned
37	378	259	0.818	462.230	-84.230	later than planned
38	378	266	0.787	480.304	-102.304	later than planned
39	378	273	0.774	488.681	-110.681	later than planned
40	378	280	0.764	494.849	-116.849	later than planned
41	378	287	0.758	498.783	-120.783	later than planned

Source : Analysis Result, 2024

Based on the computation of the projected completion time, it can be inferred that the project is delayed by 121 days compared to the anticipated duration of 378 days. Work item implementation delays can be attributed to several factors, such as design drawing modifications, limited material warehouse space due to a narrow location, and hindered casting work due to heavy rainfall. Effective management is necessary to mitigate these factors and minimize project delays for future work.



## 5. Conclusion

Based on the results of the analysis and discussion that has been carried out, the estimated completion time or Time Estimate (TE) for the implementing contractor is 499 calendar days, which is 121 calendar days slower than the initial plan of 378 calendar days. The estimated cost of completing the remaining work (ETC) is Rp. 7,390,803,688, - and the total cost to complete the work (EAC) is Rp. 14,289,833,105

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