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# Cost and Time Control Analysis with Earned Value Method in the MRT-Hub Building Construction

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**Abstract.** As Indonesia's economy and population continue to grow, the demand for building construction and infrastructure within the community will also increase. Therefore, the successful implementation of projects is crucial to meet the predetermined quality, time, and cost targets. However, obstacles during project performance often cause delays and over-budget situations, resulting in a mismatch between planning time and realization. Therefore, it is necessary to monitor the cost and time carried out in an integrated manner to estimate the total cost and time until the project is completed. This monitoring is used to avoid delays and cost overruns, which can be performed using the Earned Value Analysis Method. This research aims to analyze the time and cost required to implement the MRT-Hub Building Construction Project of Dukuh Atas Intersection and evaluate the losses or delays during the project's completion. Based on the Earned Value Analysis Method, it was found that at week 57th after the addendum, the result of the Schedule Variance (SV) is negative. In contrast, the Cost Variance (CV) is positive (+). The result of the Schedule Performance Index (SPI) is smaller than 1, while the Cost Performance Index (CPI) is greater than 1 (> 1). Thus, it is known that the project performance is running slower than the planned schedule, and the actual cost is smaller than the budget performed. Based on these results, the estimated temporary schedule (ETS) at week 57th is 188.3538 days with a remaining cost (ETC) of IDR 97,526,302,702.70. Meanwhile, the estimated project completion time (EAS) is 584.3538 days with an estimated all-cost (EAC) of IDR 171,868,372,084.14. Thus, it can be concluded that the project is expected to be -0.0606% later than the addendum schedule, with an estimated project profit of 10.0123% of the addendum budget.

**Keywords**: *Construction Management, Project Performance, Earned Value Analysis (EVA).*

## INTRODUCTION

As Indonesia's economy and population continue to grow, the demand for building construction and infrastructure within the community will also increase. Therefore, the successful implementation of projects is crucial to meet the predetermined quality, time, and cost targets. Project management is a series of activities carried out to plan, schedule, and control projects to ensure the results of project implementation are on target in terms of time, quality, and cost[1]. Construction requires resources, such as labor (man), equipment (machine), work methods, materials, money, and time. Time and cost are essential foundations in the construction implementation, and therefore, these two components must be continuously monitored to prevent deviations. However, there is often a mismatch between planning time and

realization due to obstacles during project performance, causing delays and over-budget on the project completion. Therefore, it is necessary to integratedly monitor the cost and time to estimate the total cost and time needed until the project completion. This monitoring is used to avoid delays and cost overruns, and can be done using the Earned Value Analysis Method. Earned Value Method is a method that calculates the actual costs incurred for the work completed, according to the project budget. [2]. **This research is expected to analyze the time and cost required to evaluate losses or delays when the project is completed by foreseeing the construction time and cost using earned value analysis**.

Previous research has used Earned Value Analysis (EVA) to estimate the final cost and the time required to complete the project, as well as determine the index performance of the project. Zakariyya [3] used the EVA method to estimate the time and final cost on the Trenggalek Regency Health Office Building Construction Project. Based on his research, it is known that the project will be completed in 29.707 weeks, with a planned time of 24 weeks. the project was expected to experience a delay of 5.707 weeks, equivalent to 23.780% of the planned schedule, and a profit of IDR 405,885,332.51 with a profit percentage of 10.435% of the project budget.

However, most of the previous analyses have only been conducted for a specific period. his study aims to analyze the MRT-Hub Building Construction Project at the Dukuh Atas Intersection for a period starting from week 25 until week 57, using the EVA method to monitor the project's time and cost performance in an integrated manner to avoid potential delays and cost overruns.

## RESEARCH METHOD

This research was conducted at the MRT-Hub Building Construction Project of Dukuh Atas Intersection, located at Ex. Pasar Blora, Jl. Kendal No. 25 Dukuh Atas, Menteng, DKI Jakarta. This project is part of the Transit Oriented Development (TOD), which aims to facilitate public transportation users such as the MRT, Transjakarta, Jabodetabek LRT, and even online motorcycle taxis, and as an office, retail, and modern market area. Based on the initial contract, the construction of this project began on October 10$^{th}$, 2021, and is planned to be completed on July 24$^{th}$, 2023, with an initial budget of IDR 258,250,000,000.00 and a planned time performance of 638 days. However, after the contract addendum, the project's planned time performance was changed from October 10$^{th}$, 2021, until May 31$^{st}$, 2023, with a budget of IDR 212,000,000,000.00 and a planned time performance of 584 days or equivalent to 84 weeks. This project is planned to be built with 2 basements and 12 floors.


(a) (b)

**FIGURE 1.** (a) The project location is on Kendal Street No.25; (b) Overview of project performance in July 2022

The quantitative descriptive analysis was used in this research. This method involved collecting and analyzing data to produce results and draw conclusions. Meanwhile, descriptive research was used to systematically and accurately describe the problems being studied [4]. *Descriptive quantitative analysis* is an analytical method to describe data processing results with predetermined calculation stages. This method was chosen to monitor the time and cost performed during project implementation. Data collection was carried out by conducting field surveys and interviews with the contractor during the internship. The data obtained were in the form of weekly project reports, cost budget plans (RAB), master schedules, and field documentation. From these data, The independent variables were work

duration, contract value, work performance schedule, and project performance, while dependent variables such as BCWP, BCWS, ACWP, SV, CV, SPI, CPI, ETS, ETC, EAS, and EAC were derived from these independent variables.

*Earned Value Analysis Method* is a quantitative project management method used to evaluate project performance and predict the project performance results by comparing the progress that has been performed (realization) and the costs incurred against the progress plan and budget plan[5]. This method employs a three-dimensional approach consisting of the amount of work completed, the percentage completed, and the earned value[6]. This method makes it possible to find the relationship between the percentage of work performed and the budget spent during project performance, providing information about the estimated cost and time required to complete all work based on the performance index at the reported period and knows how the project has been performing. Thus, corrective measures can be taken if there is a deviation from the predetermined plan. The Earned Value Concept (EVA) can be analyzed by calculating indicators, variances, and the performance index. The results are then used to estimate the remaining time and cost of the project to completion. The analysis phases can be completed in the following method:

1. Indicator Analysis

   The earned value concept has three indicators used in the calculation analysis, such as:

   a. *Actual Cost of Work Performed* (ACWP)

      Actual Cost (AC) or Actual Cost of Work Performed (ACWP) refers to the actual cost incurred for work completed in a specific reporting period[7]. This cost is obtained from the project financial report on the reporting date, including all actual work package expenses or overhead costs and other consts. According to Tolangi[8], the Actual Project Cost is the Performance Budget Plan (RAP), which includes the contractor's profit and general overhead costs of 10%. The profit percentage can be adjusted according to the provisions of each contractor. In other words, actual cost is obtained by deducting the profit set by the contractor from the budget value spent in a certain period.

$$\text{RAB} = \text{RAP} + \text{Profit} \rightarrow \text{RAP} = \text{RAB} - \text{Profit} \quad \text{a)}$$

   b. *Budgeted Cost of Work Performed* (BCWP)

      Budgeted Cost of Work Performed (BCWP) or better known as Earned Value (EV), is a percentage of the total budget required to complete a job in a specific period[7]. This calculation explains the relationship between the work performed and the planned budget.

$$\text{BCWP} = \%\text{realization progress} \times \text{BAC} \quad \text{b)}$$

   c. *Budgeted Cost of Work Scheduled* (BCWS)

      *Budgeted Cost of Work Scheduled* (BCWS) or better known as the Planned Value (PV), is a budget allocated based on the project performance schedule to complete a job within a specific period[7]. This calculation is done to explain the relationship between the budget for a work package and the work performance schedule.

$$\text{BCWS} = \%\text{progress plan} \times \text{BAC} \quad \text{c)}$$

2. Variance Analysis

   After obtaining the value of the three indicators in the earned value concept analysis, the next step is to analyze the variance, namely time and cost. Variance analysis can be done in the following way:

   a. *Schedule Variance* (SV)

      *Schedule Variance* (SV) compares the work performed and the work planned for a certain period[9]. This calculation determines whether there is a deviation between BCWP and BCWS.

$$\text{SV} = \text{BCWP} - \text{BCWS} \quad \text{d)}$$

   b. *Cost Variance* (CV)

      *Cost Variance* (CV) compares the work performed and the actual costs incurred by the project over a specific period[9]. This calculation determines whether there is a deviation between BCWP and ACWP.

$$\text{CV} = \text{BCWP} - \text{ACWP} \quad \text{e)}$$

   After obtaining the two variance values, further analysis is carried out in an integrated manner to determine the relationship between these variances. The analysis can be done by looking at the criteria in Table 1 below[10].

**TABLE 1.** Integrated variance analysis criteria[10]

| Schedule Variance (SV) | Cost Variance (CV) | Descriptions |
|---|---|---|
| (+) | (+) | The work was performed ahead of schedule at a lower cost than the budget. |
| (0) | (+) | The work was carried out on time according to schedule at a lower cost than the budget. |
| (+) | (0) | The work performed ahead of schedule while the cost is within the budget performed. |
| (0) | (0) | The work was performed on time as scheduled and within the planned budget. |
| (–) | (–) | The work was performed later than scheduled at a cost greater than the budget. |
| (0) | (–) | The work was performed on time as scheduled at a cost greater than the budget. |
| (–) | (0) | The work was performed later than scheduled at a cost within the budget. |
| (+) | (–) | The work was completed ahead of schedule at a cost greater than the budget. |

3. Performance Index Analysis

After analyzing the indicators and variances, the next step is to analyze the project performance index. The analysis can be done using the following methods:

a. *Schedule Performance Index* (SPI)

*Schedule Performance Index* (SPI) compares the work's performed value and the planned work's value [11]. This calculation determines the efficiency of the project work implementation time.

$$\text{SPI} = \frac{\text{BCWP}}{\text{BCWS}} \quad \text{f)}$$

The results of the SPI are then analyzed using the criteria in Table 2 below.

**TABLE 2.** SPI results from analysis criteria

| Criteria | Descriptions |
|---|---|
| SPI < 1 | Progress late than scheduled |
| SPI = 1 | Progress on time as scheduled |
| SPI >1 | Progress faster than scheduled |

b. *Cost Performance Index* (CPI)

*Cost Performance Inder* (CPI) is a cost efficiency factor issued by comparing the value of the work performed with the actual costs incurred in the same period[11]. This calculation is carried out to determine the cost efficiency of project work performance.

$$\text{CPI} = \frac{\text{BCWP}}{\text{ACWP}} \quad \text{g)}$$

The results of the CPI are then analyzed using the criteria in Table 3 below.

**TABLE 3.** CPI results from analysis criteria

| Criteria | Descriptions |
|---|---|
| CPI < 1 | The cost exceeds the budget |
| CPI = 1 | The cost is within budget |
| CPI >1 | The cost is less than budget |

4. Time and Cost Estimate Analysis

After analyzing indicators, variances, and the performance index, the last step is to estimate the remaining time and cost of the project. This estimation can be done using the following methods:

a. *Estimate Temporary Schedule* (ETS) and *Estimate Temporary Cost* (ETC)

*Estimate Temporary Schedule* (ETS) estimates the time to complete the remaining work of the project until completion[7]. Meanwhile, *Estimate Temporary Cost* (ETC) estimates the costs to complete the remaining work of the project until completion[7].

$$\text{ETS} = \frac{\text{Time Performance Schedule} - \text{Time Spent}}{\text{SPI}} = \frac{\text{Remaining Time}}{\text{SPI}} \quad \text{h)}$$

ETC has two equations, where its use is based on the cumulative percentage at the reporting time.

- For cumulative progress greater than 50%

$$\text{ETC} = \frac{\text{BAC} - \text{BCWP}}{\text{CPI}} \quad \text{i)}$$

- For cumulative progress less than 50%

$$\text{ETC} = \text{BAC} - \text{BCWP} \quad \text{j)}$$

b. *Estimate All Schedule* (EAS) and *Estimate All Cost* (EAC)

*Estimate All Schedule* (EAS) estimates the total time required to complete the project[7]. Meanwhile, *Estimate All Cost* (EAC) is the total cost required to complete the project[7].

$$\text{EAS} = \text{Time Spent} + \text{ETS} \quad \text{k)}$$

Thus, finding the estimated remaining time after project completion can be done with the following equation:

$$\text{Remaining Time} = \text{Time Performance Schedule} - \text{EAS} \quad \text{l)}$$

Meanwhile, finding the EAC can be done with the following equation:

$$\text{EAC} = \frac{\text{BAC}}{\text{CPI}} = \text{ACWP} + \text{ETC} \quad \text{m)}$$

Thus, finding the estimated remaining budget after the project is completed can be done with the following equation:

$$\text{Remaining Budget} = \text{BAC} - \text{EAC} \quad \text{n)}$$

Descriptions:
BAC: Project contract value (NK)
SPI: The schedule performance index value in the reporting week
CPI: The cost performance index value in the reporting week
ACWP: The value of the actual cost of work performed
BCWP: The value of the budgeted cost of work performed
BCWS: The value of the budgeted cost of work scheduled
ETS: The result of the estimated temporary schedule in the reporting week
ETC: The result of the temporary cost estimate in the reporting week
EAS: The result of the estimate of all schedules in the reporting week
EAC: The result of estimating all costs in the reporting week

## RESULT AND DISCUSSION

This research discusses the process of collecting data, analyzing data, and the process of processing the data, including indicator and tabulation calculations for variance identification analysis and the concept of earned value. The entire process of data calculation and processing was aided by Microsoft Excel software. The study covers weeks 25 to 57 of the MRT-Hub Building Construction Project at Dukuh Atas Intersection. The results of the earned value analysis are presented below:

***Actual Cost of Work Performed*** **(ACWP)**

Due to the unavailability of the actual cost data on the project's weekly financial report, the ACWP can be calculated using Equation a) and a recapitulation of the pay item. Based on the RAB data and interviews that have been conducted, it is known that the profit percentage set for this project is 13%. Then the ACWP value in the week 57th is as follows:

$$\text{RAB} = \text{RAP} + \text{Profit} \rightarrow \text{RAP} = \text{RAB} - \text{Profit}$$
$$\text{ACWP}_{57} = \text{Recapitulated value}_{57} - \text{Profit}_{57}$$
$$\text{ACWP}_{57} = 1{,}680{,}477{,}325.16 - 451{,}566{,}955.71$$
$$\text{ACWP}_{57} = \text{IDR } 1{,}228{,}910{,}369.45$$
$$\text{ACWP Cumulative}_{57} = 73{,}113{,}159{,}011.98 + 1{,}228{,}910{,}369.45 = \text{IDR } 74{,}342{,}069{,}381.44$$

***Budgeted Cost of Work Performed* (BCWP)**

BCWP analysis was carried out by calculating the work realization in one week against the budget. This realization value was obtained from the weekly project report in the progress recapitulation section.

$$\text{BCWP}_{\text{Add}} = \%\text{cumulative realization progress} \times \text{BAC}$$
$$\text{BCWP}_{57-\text{Add}} = 48.9367\% \times 190{,}990{,}990{,}990.99$$
$$\text{BCWP}_{57-\text{Add}} = \text{IDR } 93{,}464{,}688{,}288.29$$

***Budgeted Cost of Work Scheduled* (BCWS)**

BCWS analysis was performed by calculating the work plan progress in one week against the budget. The work plan progress is obtained from the weekly project report in the progress recapitulation section.

$$\text{BCWS}_{\text{Add}} = \%\text{cumulative plan progress} \times \text{BAC}$$
$$\text{BCWS}_{57-\text{Add}} = 49.0288\% \times 190{,}990{,}990{,}990.99$$
$$\text{BCWS}_{57-\text{Add}} = \text{IDR } 93{,}640{,}590{,}990.99$$

***Schedule Variance* (SV)**

The SV calculation was done by subtracting the BCWP calculation results from the BCWS results using equation (d) as follows:

$$\text{SV}_{\text{Add}} = \text{BCWP}_{57-\text{Add}} - \text{BCWS}_{57-\text{Add}}$$
$$\text{SV}_{\text{Add}} = 93{,}464{,}688{,}288.29 - 93{,}640{,}590{,}990.99$$
$$\text{SV}_{\text{Add}} = -\text{IDR } 175{,}902{,}702.70$$

***Cost Variance* (CV)**

CV calculation was done by subtracting the results of the BCWP calculation from the ACWP results using equation (e) as follows:

$$\text{CV}_{57-\text{Add}} = \text{BCWP Kumulatif}_{57-\text{Add}} - \text{ACWP Kumulatif}_{57}$$
$$\text{CV}_{57-\text{Add}} = 93{,}464{,}688{,}288.29 - 74{,}342{,}069{,}381.44$$
$$\text{CV}_{57-\text{Add}} = \text{IDR } 19{,}122{,}618{,}906.85$$

***Schedule Performance Index (SPI)***

The SPI calculation was done by comparing the results of the BCWP calculation with the BCWS results using equation (f) as follows:

$$\text{SPI}_{57-\text{Add}} = \frac{\text{BCWP}_{57-\text{Add}}}{\text{BCWS}_{57-\text{Add}}}$$
$$\text{SPI}_{57-\text{Add}} = \frac{93{,}464{,}688{,}288.29}{93{,}640{,}590{,}990.99} = 0.9981$$

***Cost Performance Index (CPI)***

The CPI calculation was done by comparing the results of the BCWP calculation with the ACWP results using equation (g) as follows:

$$\text{CPI}_{57-\text{Add}} = \frac{\text{BCWP}_{57-Add}}{\text{ACWP}_{57}}$$
$$\text{CPI}_{57-\text{Add}} = \frac{93{,}464{,}688{,}288.29}{74{,}342{,}069{,}381.44} = 1.2572$$

***Estimate Temporary Schedule* (ETS)**

The ETS calculation was done by comparing the remaining time to the SPI results using equation (h) as follows:

$$\text{ETS}_{57-\text{Add}} = \frac{\text{Time Performance Schedule} - \text{Time Spent}}{\text{SPI}_{57-\text{Add}}}$$
$$\text{ETS}_{57-\text{Add}} = \frac{584 - 396}{0.9981} = 188.3538 \text{ hari}$$

***Estimate Temporary Cost* (ETC)**

Because in week 57$^{th}$, the cumulative progress of project implementation is still less than 50%, the ETC calculation was carried out by subtracting the budget from the BCWP result using equation (j) as follows:

$$\text{ETC}_{57-\text{Add}} = \text{BAC} - \text{BCWP}_{57-\text{Add}}$$
$$\text{ETC}_{57-\text{Add}} = 190{,}990{,}990{,}990.99 - 93{,}464{,}688{,}288.29$$
$$\text{ETC}_{57-\text{Add}} = \text{IDR } 97{,}526{,}302{,}702.70$$

***Estimate All Schedule*** **(EAS)**

The EAS calculation was done by summing up the time spent at the time of reporting and the ETS results using equation (k) as follows:

$$\text{EAS}_{57-\text{Add}} = \text{Time Spent} + \text{ETS}_{57-\text{Add}}$$
$$\text{EAS}_{57-\text{Add}} = 396 + 188.3538 = 584.3538 \text{ days}$$

Thus, the estimate of the remaining project completion time after the addendum can be done using equation (l) as follows:

$$\text{Remaining Time} = \text{Time Performance Schedule} - \text{EAS}$$
$$\text{Remaining Time} = 584 - 584.3538 \text{ days} = -0.3538 \text{ days}$$

***Estimate All Cost*** **(EAC)**

The EAC calculation was done by summing up the cumulative ACWP results in the reporting week and the ETC results using equation (m) as follows:

$$\text{EAC}_{57-\text{Add}} = \text{ACWP cumulative}_{57} + \text{ETC}_{57-\text{Add}}$$
$$\text{EAC}_{57-\text{Add}} = 74{,}342{,}069{,}381.44 + 97{,}526{,}302{,}702.70$$
$$\text{EAC}_{57-\text{Add}} = \text{IDR } 171{,}868{,}372{,}084.14$$

Thus, the estimate of the remaining project completion budget after the addendum can be done using equation (n) as follows:

$$\text{Remaining budget} = \text{BAC} - \text{EAC}_{57-\text{Add}}$$
$$\text{Remaining budget} = 190{,}990{,}990{,}990.99 - 171{,}868{,}372{,}084.14$$
$$\text{Remaining budget} = \text{IDR } 19{,}122{,}618{,}906.85$$

Based on the calculations above, the recapitulation of the earned value analysis results in week 57th is shown in TABLE 4 as follows:

**TABLE 4.** Earned value analysis results at week 25th and 57th

| | **Week 25th** | **Week 57th** | **Week 57th (Addendum)** |
|---|---|---|---|
| **BAC** | IDR 234,772,727,272.72 | IDR 234,772,727,272.72 | IDR 190,990,990,990.99 |
| **Plan Progress (%)** | 15.8398% | 37.6267% | 49.0288% |
| **Realization Progress (%)** | 10.3753% | 48.9367% | 48.9367% |
| **ACWP Cumulative** | IDR 19,675,955,515.71 | IDR 74,342,069,381.44 | IDR 74,342,069,381.44 |
| **BCWP Cumulative** | IDR 24,358,374,772.73 | IDR 114.890.025.227,27 | IDR 93,464,688,288.29 |
| **BCWS Cumulative** | IDR 37,187,530,454.54 | IDR 88,337,229,772.73 | IDR 93,640,590,990.99 |
| **Schedule Variance (SV)** | IDR –12,829,155,681.82 | IDR 26,552,795,454.55 | IDR –175,902,702.70 |
| **Cost Variance (CV)** | IDR 4,682,419,257.02 | IDR 40,547,955,845.83 | IDR 19,122,618,906.85 |
| **Schedule Performance Index (SPI)** | 0.6550 | 1.3006 | 0.9981 |
| **Cost Performance Index (CPI)** | 1.2380 | 1.5454 | 1.2572 |
| **Estimate Temporary Schedule (ETS)** | 706.8545 days | 186.0702 days | 188.3538 days |
| **Estimate Temporary Cost (ETC)** | IDR 210,414,352,500.00 | IDR 119,882,702,045.45 | IDR 97,526,302,702.70 |
| **Estimate All Schedule (EAS)** | 881.8545 days | 582.0702 days | 584.3538 days |
| **Remaining Time** | –243.8545 days | 55.9298 days | –0.3538 days |
| **Estimate All Cost (EAC)** | IDR 230,090,308,015.71 | IDR 194,224,771,426.89 | IDR 171,868,372,084.14 |
| **Remaining Cost** | IDR 4,682,419,257.02 | IDR 40,547,955,845.83 | IDR 19,122,618,906.85 |

Based on the table above (Table 4), on week 25th, the BCWP25 value (IDR 24,358,374,772.73) is smaller than the BCWS57 value (IDR 37,187,530,454.54), so it can be concluded that the progress of project performance is running slower than planned schedule. It can be proven by the negative SV value, which is IDR -12,829,155,681.82. In the cost aspect, it can be seen in the graph that the BCWP25 value (IDR 24,358,374,772.73) is greater than the ACWP25 value (IDR 19,675,955,515.71), but the ACWP25 value is still smaller than the BCWS25. So, the actual costs incurred are less than the budget plan, and the cost performed. It can be proven by the positive CV value, which is IDR 4,682,419,257.02.

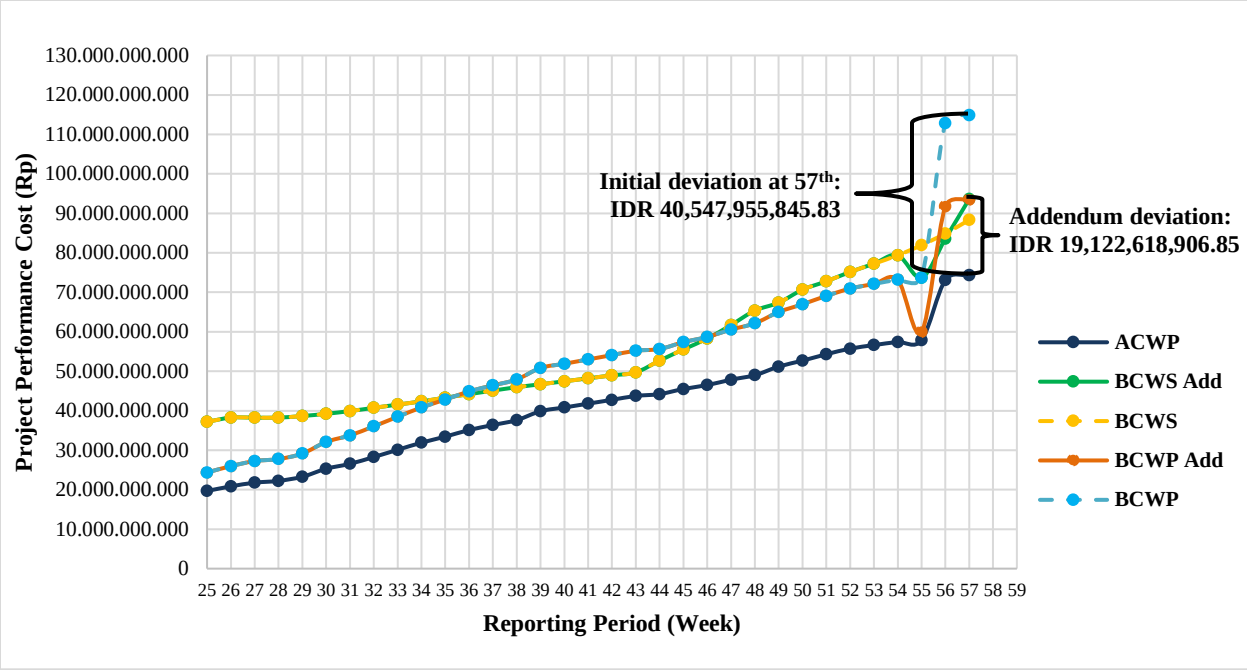


**FIGURE 2.** The indicator graph of the earned value analysis results (EVA)

According to Figure 3, before the addendum was implemented, in the week 57$^{th}$, the $BCWP_{57}$ value (IDR 114,890,025,227.27) is greater than the $BCWS_{57}$ value (IDR 88,337,229,772.73), so it can be concluded that the progress of project performance is running faster than planned. This is further supported by the positive SV value, which is IDR 26,552,795,454.55. In terms of cost, the graph shows that the $BCWP_{57}$ value (IDR 114,890,025,227.27) is greater than the $ACWP_{57}$ value (IDR 74,342,069,381.44). So, the actual costs incurred are less than the cost performed. It can be proven by the positive CV value, which is IDR 40,547,955,845.83.

In the week 57$^{th}$, after the addendum was carried out, t can be observed from Figure 3 that the $BCWP_{57}$ value (IDR 93,464,688,288.29) is smaller than the $BCWS_{57}$ value (IDR 93,640,590,990.99), indicating that the project's performance progress is slower than planned. The negative SV value of IDR -175,902,702.70 can prove this conclusion. In the cost aspect, it can be seen in the graph that the $BCWP_{57}$ value (IDR 93,464,688,288.29) is greater than the $ACWP_{57}$ value (IDR 74,342,069,381.44, indicating that the actual costs incurred are less than the cost performed. This conclusion can be supported by positive CV value of IDR 19,122,618,906.85.

So, it can be concluded that at the beginning of the research in week 25$^{th}$, progress was slower than the planned schedule, but the actual cost was less than the plan and the cost incurred. Then in week 57$^{th}$, when the addendum has not been carried out, the project is predicted to be completed faster than the initial plan schedule at a cost less than the initial contract budget. Meanwhile, when the addendum has been carried out, the project is predicted to experience delays, but the cost is still less than the budget, so the contractor will still benefit.

Based on the graph below (Figure 3), on week 25$^{th}$, the $SPI_{25}$ value (0.6550) is less than one, and the $CPI_{25}$ value (1.2380) is greater than one (> 1). So, it is known that on week 25$^{th}$, the time performance is not running well because of the delay in work performance. Then, at week 57$^{th}$ before the addendum was carried out, the $SPI_{57}$ value (1.3006) and the $CPI_{57}$ value (1.5454) were both greater than one (> 1). But after the addendum was carried out, the $SPI_{57}$ value (0.9981) became less than one, and the $CPI_{57}$ value (1.2572) was greater than one (> 1). So, it can be concluded that before the addendum was made, the time and cost performance of the project performance was going well. However, when the addendum was made, the time performance of the project performance decreased while the cost performance continued to run well. In the 55$^{th}$ week, there was a very significant decrease in the SPI and CPI values. The contract addendum caused this event, resulting in BCWP and BCWS value changes.

At the beginning of the research in the week 25$^{th}$ (Table 4), the estimated remaining time required to complete the remaining work (ETS) was 706.8545 days, and the estimated project completion time (EAS) was 881.8545 days. Meanwhile, the estimated remaining project completion cost (ETC) is IDR 210,414,352,500.00, and the estimated project performance cost required to complete the project (EAC) is IDR 230,090,308,015.71. So, when the research

was conducted at the beginning, the project was expected to be completed in -243.8545 days or -38.2217% later than the planned schedule (638 days), but still expected to gain a profit of IDR 4,682,419,257.02 or 1.9944% of the initial project budget (IDR 234,772,727,272.72).

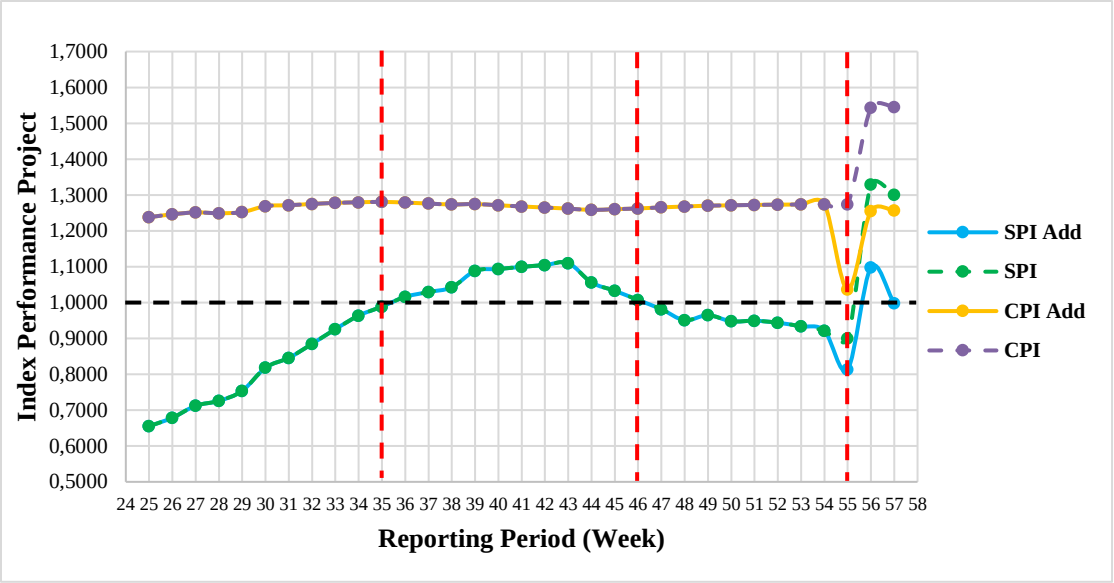


**FIGURE 3.** The performance index graph of the earned value analysis results (EVA)

At the end of the research in the week 57th (TABLE 4), the estimated remaining time required to complete the remaining work (ETS) before the addendum was 186.0702 days, and the final project completion time (EAS) was 582.0702 days. Thus, the project is expected to be completed in 55.9298 days or 8.7664% faster than the original schedule (638 days). Meanwhile, when the addendum has been carried out, the remaining time required to complete the remaining work (ETS) becomes 188.3538 days, and the final project completion time (EAS) is 584.3538 days. Thus, the project is expected to be completed -0.3538 days or -0.0606% later than the addendum schedule (584 days). Thus, before the addendum, the project was predicted to be completed faster. However, when the addendum was carried out, the project was predicted to be behind schedule.

At week 57th (Table 4), the estimated remaining project completion cost (ETC) before the addendum is IDR 119,882,702,045.45, with the estimated cost required to complete the project (EAC) being IDR 194,224,771,426.89. Thus, before the addendum is carried out, the project is expected to get a profit of IDR 40,547,955,845.83 or 17.2712% of the initial project budget (IDR 234,772,727,272.72). Meanwhile, when the addendum is carried out, the estimated remaining project completion cost (ETC) will be IDR 97,526,302,702.70, with the estimated cost required to complete the project (EAC) being IDR 171,868,372,084.14. Thus, the project is expected to earn a profit of IDR 19,122,618,906.85 or 10.0123% of the project addendum budget (IDR 190,990,990,990.99). Thus, before and after the addendum, the project is expected to gain profits. It is just that the percentage decreases from 17.2712% to 10.0123%.

Based on the data at the beginning of the research in week 25th, the project is predicted to be completed later than the planned schedule, with the estimated cost being less than the budget planned. Therefore, the contractor is still predicted to gain a profit. However, based on the data at the end of the study, before the addendum was carried out, the project was predicted to run faster than the project schedule, while the cost was predicted to be less than the budget. In contrast, after the addendum, the project was predicted to experience delays, but the contractor could still earn a profit. In contrast, after the addendum, the project was predicted to experience delays, but the contractor could still earn a profit. In addition, from week 25th to week 57th, the EAS and EAC values continued to decrease in each period. Especially for the EAC value, because the value decreases every period, the remaining project cost becomes greater, so the contractor's profit will also be greater.

## CONCLUSION

Based on the results of the time and cost analysis, as well as the discussion using the earned value analysis method, for the performance of the MRT-Hub Building Construction Project at Dukuh Atas Intersections, the following conclusions can be drawn:

1. At the end of the research, in week 57$^{th}$, before the addendum, both the SV and CV were positive (+). However, when the addendum was carried out, the SV changed to negative (-), while the CV remained positive (+). So, before the addendum, the project was carried out ahead of schedule with less cost. but experienced delays after the addendum while still maintaining costs below the budget. The changes in the project's progress due to the addendum resulted in the Schedule Variance (SV) value being affected.
2. At the end of the study, in week 57$^{th}$ before the addendum was carried out, it was found that SPI and CPI were greater than one (> 1). However, after the addendum was carried out, the SPI changed to less than one (< 1), while the CPI remained greater than one (> 1). Therefore, it can be concluded that prior to the addendum, the project's time and cost performance was already satisfactory. However, after the addendum was implemented, the project's time performance declined, while the cost performance continued to be satisfactory.
3. At the end of the study, in week 57$^{th}$ before the addendum, the estimated time required to complete the project (EAS) was 582.0702 days with an estimated cost required to complete the project (EAC) of IDR 194,224,771,426.89, so the project was predicted to be completed 8.7664% faster than the original plan with a profit of 17.2712% (IDR 40,547,955,845.83). However, after the addendum was carried out, the estimated time required to complete the project (EAS) becomes 584.3538 days with an estimated performance cost (EAC) of IDR 171,868,372,084.14, so the project is predicted to be -0.0606% later than the addendum schedule with a profit of 10.0123% (IDR 19,122,618,906.85).

## REFERENCES


[1] W. I. Ervianto, *Manajemen Proyek Konstruksi*, Edisi Revi. Yogyakarta: Penerbit ANDI, 2005.

[2] I. Soeharto, *Manajemen Proyek : Dari Konseptual sampai Operasional Jilid 2*, Edisi Kedu. Jakarta: Penerbit Erlangga, 2001.

[3] B. Zakariyya, A. Ridwan, and S. Suwarno, "Analisis Biaya Dan Jadwal Proyek Pembangunan Gedung Dinas Kesehatan Kabupaten Trenggalek Dengan Metode Earned Value," *J. Manaj. Teknol. Tek. Sipil*, vol. 3, no. 2, pp. 362–376, 2020, doi: 10.30737/jurmateks.v3i2.1197.

[4] Hardani, N. H. Auliya, H. Andriani, R. A. Fardani, J. Ustiawaty, E. F. Utami, D. J. Sukmana,and R. R. Istiqomah, *Buku Metode Penelitian Kualitatif & Kuantitatif*. Yogyakarta: CV Pustaka Ilmu, 2020.

[5] J. A. Lukas, "Earned Value Analysis – Why it Doesn't Work," *AACE Int. Trans.*, vol. EVM.01, pp. 1–10, 2008, [Online]. Available: http://www.icoste.org/LukasPaper.pdf.

[6] Q. W. Fleming and J. M. Koppelman, "The Essence of Evolution of Earned Value," *Cost Eng.*, vol. 36, no. 11, pp. 21–27, 1994, [Online]. Available: https://www.proquest.com/scholarly-journals/using-earned-value-management/docview/220438070/se-2?accountid=173659.

[7] I. Widiasanti and Lenggogeni, *Manajemen Konstruksi*. Bandung: PT REMAJA ROSDAKARYA, 2013.

[8] M. F. Tolangi, J. P. Rantung, J. E. C. Langi, and M. Sibi, "Analisis Cash Flow Optimal Pada Kontraktor Proyek Pembangunan Perumahan," *J. Sipil Statik*, vol. 1, no. 1, pp. 60–64, 2012, [Online]. Available: https://ejournal.unsrat.ac.id/index.php/jss/article/view/633.

[9] S. Suresh and G. N. Ramasamy, "Analysis of Project Performance Using Earned Value Analysis," *Int. J. Sci. Eng. Technol. Res.*, vol. 4, no. 4, pp. 1080–1085, 2015, [Online]. Available: https://doi.org/10.25077/jrs.15.1.12-20.2019.

[10] F. Hamzah, D. A. R. Wulandari, and J. Tistogondo, "The Application of Earned Value Analysis of The Progress of Construction Work in The Development of The Porch or Vestibule of The Basement Building Area Youth Surabaya," *ADRI Int. J. Civ. Eng.*, vol. 5, no. 2, pp. 9–22, 2022, doi: 10.29138/aijce.v5i2.8.

[11] R. Setiawan and A. Handayani, "Analysis of Ramp on Off Costs And Time Using the Earned Value Analysis (EVA) Method," *ADRI Int. J. Civ. Eng.*, vol. 7, no. 1, pp. 144–150, 2022, doi: 10.29138/aijce.v7i1.74.