CONSTRUCTION PROJECT CONTROL ANALYSIS USING EARNED VALUE MANAGEMENT, EARNED SCHEDULE MANAGEMENT, EARNED DURATION MANAGEMENT (Case Study: Highrise Building Project in Jakarta)

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ABSTRACT

Appropriate control methods are needed to anticipate potential problems and make construction projects better managed to improve efficiency, productivity, and quality of work. Earned Value Management (EVM) experienced problems in predicting duration because it used two scopes, namely cost and schedule. Then there is Earned Schedule Management (ESM) which monitors project performance through project schedules, but in its application ESM still uses variable costs for its indicators. To make up for the shortcomings of EVM and ESM, another method was developed by Khamooshi and Golafshani, namely Earned Duration Management (EDM) a method for measuring or estimating duration by separating the dimensions of schedule and cost. The purpose of this study is to determine the inaccuracies of the control methods of EVM and ESM in estimating EAC (Estimated At Completion) so that it requires EDM to estimate it. In this research, data collection was carried out in weeks 32 to 59. The data collected in the field was actual project work progress data, actual project financial data, and master plan data. The analysis of Schedule Varian (SV) and Schedule Varian time SV(t) variants shows negative values that result in an estimate of the final duration of the project that is late from the plan inversely proportional to dv which is positive value, meaning that the project is in accordance with the plan. Then the Schedule Performance Index (SPI) and Schedule Performance Index time SPI(t) show a value that is less than one which indicates the project is slower than scheduled, in contrast to the DPI it produces a value equal to one which means the project is in accordance with the plan. The EDM method generates an accurate trend in providing an assessment of the performance of project execution time compared to EVM and ESM. The contribution from research results comparing 3 methods shows that the EVM method produces anomalies in schedule control analysis, so that these deficiencies can be directed towards using the ESM method. while the EDM method, which is less familiar, is more appropriate for use in certain construction cases such as analysis of determining the amount of a claim.

Keywords*: Project Control, Earned Value Mangement, Earned Schedule Management, Earned Duration Management*

INTRODUCTION

A construction project can be said to be successful if it can be completed within the stipulated time and budget, accompanied by other criteria such as meeting quality, safety, sustainability and others. In the implementation of construction projects, uncertainty and risk often lead to budget overruns, delays in the duration of construction, and quality that is not in accordance with the contract. Other problems that also often arise such as limited resources in the form of labor, materials, tools, and others (Sarjos, 2021).

Project supervision and control is an important aspect of project activities aimed at addressing these challenges. Evaluating project performance by comparing what happened in the field with the initial plan is very necessary because if there are deviations it can be resolved as early as possible and to ensure the project is completed on time with a predetermined budget and good quality. Appropriate control methods are needed to anticipate potential problems and make construction projects better managed to increase efficiency, productivity and quality of work (C. Miglaccio and Holm, 2018).

The s-curve control method is too common for most local contractors, the information provided by the s-curve contains data based on the tasks completed, and only tells the boundary relationship between actual costs, plan costs and shows what the project has done, from here found whether the project is delayed or not. Because it is not detailed and only limited to assessing the progress of the project. Furthermore, it is necessary to try another control method, namely Earned Value Management (EVM) which focuses on performance by showing whether the project is implemented ahead of schedule, on schedule, or behind schedule. However, because it uses two scopes, namely cost and schedule, EVM experiences problems in predicting duration. Then there is Earned Schedule Management (ESM) which monitors project performance through the project schedule, but in practice ESM still uses cost variables for its indicators. To cover the shortcomings of EVM and ESM another method was developed by Khamooshi and Golafshani, namely Earned Duration Management (EDM), which is a method for measuring or estimating duration by separating the dimensions of schedule and cost. The case study (object research) reviewed in this research is the Highrise Building Project in Jakarta. This project has been going on for 14 months, but the Project has experienced a time delay. The problem of this research is the difference between the project master plan and the progress of work implementation in the field which is caused by a decrease in worker productivity and internal problems in the project organizational structure. This is compounded by the non-implementation of project control methods. This research will analyze the estimated time and cost of the Pegadaian Tower Development Project, so that this research can help related parties in deciding what steps to take so that the project can be completed on time with the planned costs. This research aims to compare the control methods of Earned Value Management, Earned Schedule Management, and Earned Duration Management in estimating EAC (Estimated At Completion).Earned Value Management (EVM) is a widely used managerial tool that enables project teams to evaluate project cost and schedule status at the reporting date and estimate that status at project completion. While its use for project costs is reported to have reasonable accuracy, its use for schedule performance evaluation is inadequate and requires further refinement (Arabpour and Moselhi, 2020).

The impact of this research is that the contractor receives input from the research results regarding the implementation of project control methods that are most appropriate to the case study location. Apart from that, this research also has an impact on adding insight into the implementation of project control methods, especially in the implementation of ESM and EDM methods which are still unfamiliar. the solutions and concepts resulting from this research are the real implementation of ESM and EDM methods in controlling project construction schedules.

The Earned Value Management method was developed by the United States Department of Defense in the 1960s, as an integral part of the cost or schedule control system criteria. Currently EVM is a popular method for controlling the time and cost performance of a project. The EVM method can be seen as a top-down project tracking approach it is an early warning signal system, which allows to detect problems and opportunities in an easy and efficient way (Mareels and Martens, 2021).

Earned value applies to any industry, not only the construction industry. The benefit of EVM is controlling the cost and schedule risks associated with the project business. EVM is a measurement of the work done in the project against the project plan. Earned Value Management uses a management approach from the scope of work, work schedule and project budget.

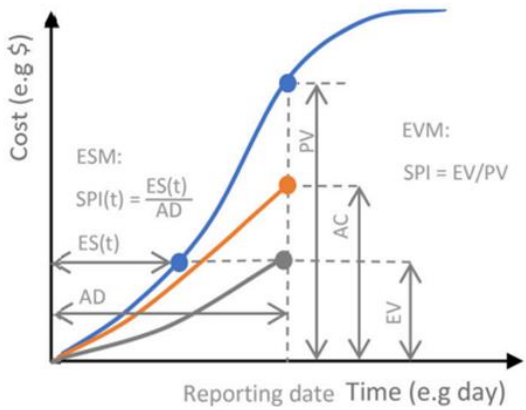


Figure 1. EVM and ESM Diagram

The following are the indicators contained in the S curve of the EVM method:

1. Planned Value (PV)

   Approved budget to complete the project. This is the value that can be obtained when the work

package is completed on time (Budgeted Cost of Work Scheduled – BCWS).

2. Actual Cost (CV)
   The cumulative cost of completing an activity or project at a given time. Also called Actual Cost of Work Performance – ACWP.
3. Earned Value (EV)
   Accumulated value obtained from work completed at a certain time (Budgeted Cost of Work Performed – BCWP).
   %Complete × BAC
4. Budget At Completion (BAC)
   Total budget for the project. This is the maximum value of the PV, occurring at the end of the project.
5. Schedule Variance (SV)
   Schedule Variance (SV) compares Earned Value (EV) and Planned Value (PV). Schedule Variance basically measures the budget fit of actual progress.
   SV = EV – PV
6. Cost Variance (CV)
   Cost Variance (CV) compares Earned Value (EV) and Actual Cost (AC). Cost Variance basically measures the suitability of the budget from actual costs.
   CV = EV – AC
7. Schedule Perfromance Index (SPI)
   The Schedule Performance Index (SPI) shows the efficiency of a project's schedule and measures time performance as a percentage of the expected baseline schedule. Index is the ratio between Earned Value (EV) and Planned Value (PV) at a point of measurement.
   SPI = EV/PV
   SPI < 1 : Project is behind schedule
   SPI = 1 : Project is according to schedule
   SPI > 1 : Project is ahead schedule
8. Cost Perfromance Index (CPI)
   The Cost Performance Index (CPI) measures the cost efficiency of a project. Index is the ratio between Earned Value (EV) and Actual Cost (AC) at the point of measurement.
   CPI = EV/AC
   CPI < 1 : Project cost is over budget
   CPI = 1 : Project cost according to budget
   CPI > 1 : Project cost is under budget
9. Estimated cost At Completion (EAC)
   Estimate cost At Completion is calculated to perform cost forecasting with the EVM matrix. This formula is used to predict the final cost of the project.
   EAC = AC + (BAC – EV)
10. Variance At Complete (VAC)
    Variance At Complete is calculated to find out the results of the difference from the project cost plan with the estimated final project cost.
    VAC = BAC – EAC
11. Estimated To Schedule (ETS)
    Is the estimated time required to complete the remaining work. ETS is analyzed when the implementation of the work is not in accordance with the planned schedule.
    ETS = (AT – PD)/SPI
12. Estimated time At Completion (EAC(t))
    Estimated time At Completion is calculated to perform time forecasting by utilizing the EVM matrix. This formula is used to predict the total project duration.
    EAC(t) = AT + ETS

Earned Schedule (ES) technique was put forward by Walter Lipke in 2003. In this method, instead of using costs to measure schedule and time performance. Since all key EVM metrics are cost based, ES has been developed as an extension of EVM to monitor schedule progress in units of time (de Andrade, Martens, and Vanhoucke 2019).

The earned schedule technique replaced earned value because SPI and SV were no longer applied because both were widely recognized for failing to present project status when continuing execution past the planned end date. For late projects, SPI and SV meet and conclude at values of 1.00 and 0.00 respectively at the end of project calculations. This was due to the fact that at that time the EV always equaled the PV, which meant that the project was always on schedule. However, the earned schedule also experiences deficiencies when applied, such as the main matrix is still expressed in unit costs and the use of cost data in its calculations causes the information obtained to be unreliable (Khamooshi and Abdi 2016).

The following are the indicators contained in the S-curve of the ESM method:

1. Earned Schedule (ES)
   The schedule obtained by the project tells how the project is progressing in terms of the schedule. It projects the cumulative current acquisition value onto the planned value curve and determines the time when the current acquisition value is supposed to be earned.
   ES = C + I
   C = The amount of time increments by which EV is exceeded
   $$I = \frac{PV_{(EV-PV_C)}}{(PV_{C+1}-PV_C)}$$
2. Actual Time (AT)
   Actual Time (AT) is the elapsed time that has been issued since the start of the project. In the period is usually equal to 1.
3. Schedule Variance time (SV(t))
   Shows how much additional time was spent on the work completed compared to the time allotted for it.
   SV(t) = ES – AT
   SV(t) = 0: Progress according to plan
   SV(t) > 0: Progress is faster than planned
   SV(t) < 0: Late progress from plan
4. Schedule Performance Index time (SPI(t))
   The Schedule Performance Index shows the project progress rate based on the planned period for each actual time period.
   SPI(t) = ES/AT
   SPI(t) = 1 : Project is according to schedule

SPI(t) > 1 : Project is ahead schedule
SPI(t) < 1 : Project is behind schedule

5. Independent Estimate at Completion time (IEAC(t))
   Independent Estimate at Completion (time) is calculated to perform time forecasting. This formula is used to predict the total project duration.
   IEAC (t) = PD / SPI(t)

Earned Duration Management (EDM) was put forward by Khamooshi, whose function is to measure or predict project duration by separating between schedule and cost. Earned Duration (ED) was introduced to cover the drawback of the Panned Value Method (PVM) and Earned Schedule Method (ESM) which can play the same role as the Earned Value Method (EVM) does to costs. Earned Duration Management (EDM) as a method for predicting the duration of project completion that can compare predetermined plan times. Unlike EVM and ESM which are fixated on the reporting date, EDM uses the duration obtained. This unique EDM capability removes the dependency of schedule performance evaluation on project cost data further leading to a more accurate and reliable evaluation of project schedule performance even in cases where timely non-critical activities have high costs and critical pending activities have low costs. (Arabpour and Moselhi 2020). In figure 2, where costs are replaced by project duration (expressed in units of time) on the vertical axis, the EV curve is replaced by the total earned duration (TED) curve, and the PV curve is replaced by the total planned duration (TPD) curve. Similar to ES, the duration obtained on the actual date (ED) is the date by which the current TED is to be reached (Votto, Ho, and Berssaneti, 2020).

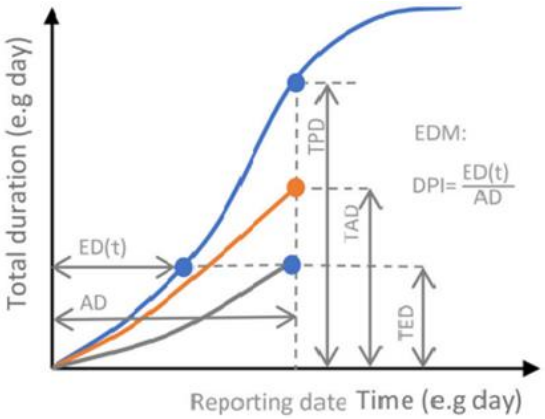


Figure 2. EDM Diagram

The following are the indicators contained in the S-curve of the EDM method:

1. Actual Duration (AD)
   AD is the control milestone we like to use to monitor the project. This is equivalent to the actual time in EVM/ES
2. Total Planned Duration (TPD)
   TPD is the cumulative number of planned work periods over the course of the project.
   TPD = $\sum_{i=1}^{n} PD_i$
3. Total Earned Duration (TED)
   TED is the number of work periods derived by actual duration i.e., the value of work done expressed as a proportion of planned work.
   TED = $\sum_{i=1}^{n} ED_i$
4. Total Actual Duration (TAD)
   The TAD consists of all work periods spent before and up to the actual duration (AD).
   TAD = $\sum_{i=1}^{n} AD_i$
5. Earned Duration at Time (ED(t))
   EDt is time based on work carried out over a certain period of time and divided by planning time. EDt calculation can measure the length of implementation time.

   $$ED = AD + \frac{TED - TPDt}{(TPDt + 1) - TPDt}$$

6. Duration variance (DV)
   DV is the deviation between the value of the work carried out and the value of the work planned.
   DV = ED – AD
   DV > 1 : faster project completion
   DV < 1 : late project completion
   DV = 1 : timely project completion
7. Duration Performance Index (DPI)
   The Duration Performance Index (DPI) at each point in time, represents the overall schedule progress performance towards project completion. In other words, it shows how well the project is performing in reaching the target completion date.
   DPI = EDt/AD
   DPI > 1 : faster project completion
   DPI < 1 : late project completion
   DPI = 1 : timely project completion
8. Earned Duration Index (EDI)
   Duration Earned Index (EDI) is a measure of the duration of work obtained or completed, compared to work planned up to that point.
   EDI = TED /TPD
9. Estimated Duration Time at Completion (EDAC(t))
   Estimated final project duration on earned duration using DPI which is based on EDM data based on units of time.

   $$EDAC(t) = AD + \left(\frac{PD + ED_t}{DPI}\right)$$

METHODS

This research approach used quantitative research approach. The tower pawn shop design building is the location of this research which is located in the Central Jakarta area. This project is adjacent to the office area to the north, the Ciliwung River to the west, while to the south it is bordered by the lurah office, and PBNU, and to the east it is directly adjacent to the Acacia Hotel. This project is an advanced design work from the first tower which is located right in front of this development project.

The stages of conducting the research start from understanding the problems in the field, then proceed to

searching the literature, especially for the Earned Schedule and Earned Duration Management methods. After that, it was continued with designing a research methodology in the form of identifying data needs, identifying data collection methods and identifying research respondents. Next is the data processing and analysis stage starting from monitoring analysis and evaluating project cost performance using EVM and monitoring analysis and evaluating the performance of project implementation schedules using ESM and EDM. The final stage is a comparative analysis of the 3 methods and conclusion of the research implementation.

Primary data is direct observation data in the field by means of interviews with related parties in the field and field observations. The secondary data used in this study is to retrieve data on the project to be reviewed in the form of an implementation time schedule in the form of an s curve, and daily, weekly and monthly reports on project work, Draft Budget, and Project Financial Data. Meanwhile, the primary data needed are factors causing project delays, especially in weeks 46 to 59. The process of collecting primary and secondary data is carried out by conducting field visits and meeting with the project team as respondents to this research. The following is a flowchart of the research implementation:

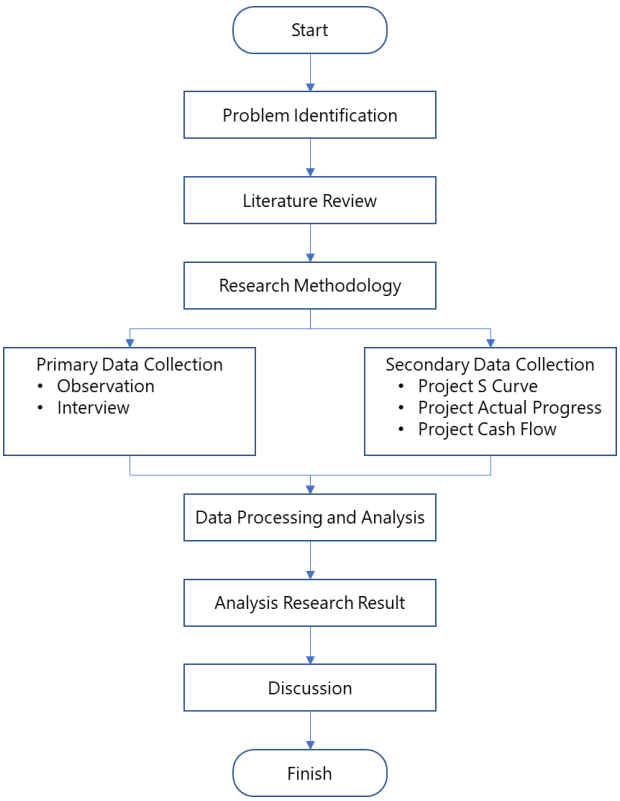


Figure 3. Research Stages

Analysis of project performance that has been obtained from the results of previous data processing is carried out by reviewing the indicators of scheduling accuracy, namely SV, SPI and estimating the final project duration with EAC(t) on EVM. Meanwhile, ESM reviews the indicators of scheduling accuracy, namely SV(t), SPI(t) and estimates the final duration of the project using IEAC(t). Then for EDM it is done by reviewing the indicators of scheduling accuracy, namely DV, DPI and estimating the final project duration with the EDAC(t) indicator. Cost accuracy indicators are CV, CPI and estimate the final cost of the project using the EAC formula.

RESULTS AND DISCUSSION

The project data which is the case study of the implementation of this research is as follows:

Project duration : 730 days
Project budget : IDR. 594.545.454.545, -

The following is the S-curve of the work implementation plan, also shown the work control period, where the performance of the work will be assessed for that month. The work control period is planned from week 32 to 59. This control period was taken because at the time the research was taking place the progress of the project had entered week 32 to 59. or for 8 months. The work progress in week 32 has reached 9.8%.

Each work control period, the performance of work implementation will be assessed using the EVM, ESM, and EDM methods. It should also be noted that the SV value uses cost units, while SV(t) and DV use week units, and the ESM and EDM analysis does not include CV and CPI calculations. The stages of analysis in this study are as follows:

- Stage 1 – identification of project delays on the ground
- Stage 2 – Processing of baseline S-curve data, actual project progress data in the field, and project financial data
- Stage 3 – Development of the S curve for the basic analysis of the EVM, ESM and EDM methods
- Stage 4 – Analysis of Variance and Performance Index for EVM, ESM and EDM methods. For cost variants only use the EVM method, while for schedule variants use the EVM, ESM and EDM methods
- Stage 5 – Analysis of estimated costs and final project duration using the EVM, ESM and EDM methods
- Stage 6 – Comparative analysis of 3 methods
- Stage 7 – Drawing conclusions

Identification of Project Delays

In order to obtain this information, interviews were conducted involving the project team including the owner. The results of the interviews were then summarized and information was obtained that during the initial planning at the project site there were no government-owned utility pipes identified. Prior to any utility pipe removal, the project team requires a utility pipe removal permit. Then these pipes are relocated in a place that does not interfere with project activities.

The following section will explain the development of the S-curve for the 3 methods and the results of the analysis.

S-Curve Development for EVM, ESM, and EDM

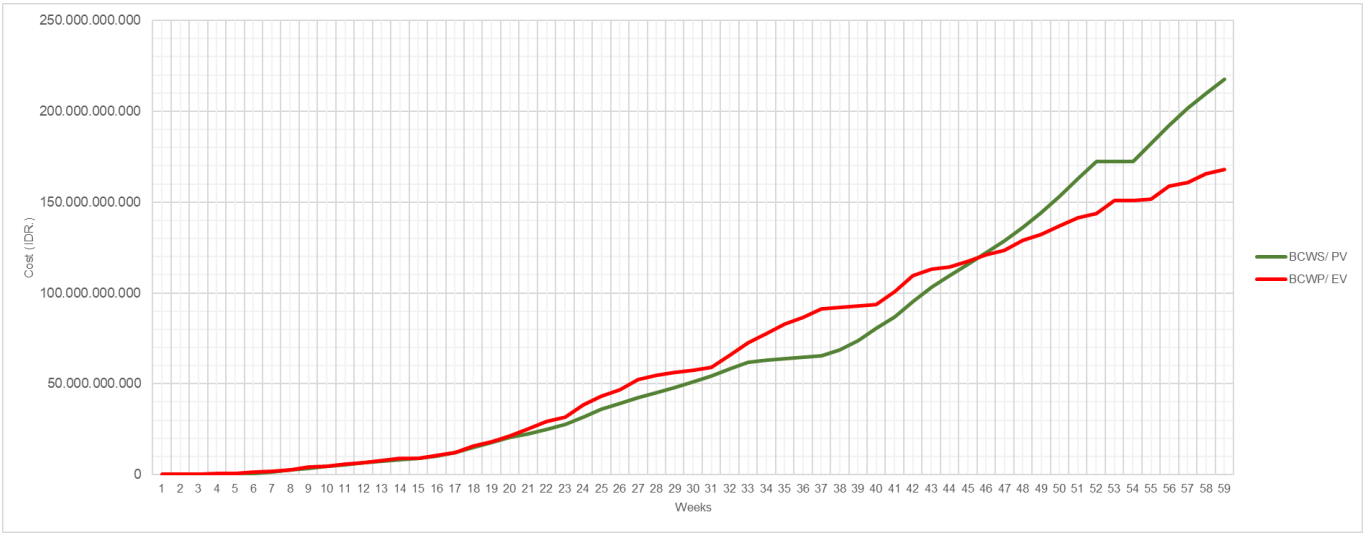


Figure 3. Project BCWS and BCWP S Curves through Week 59

The performance of work implementation up to work control in the 58th week with the EVM method is as follows:

- SV : - IDR. 43,965,955,532, -
- CV : - IDR. 4,014,520,689, -
- SPI : 0.790
- CPI : 0.976

The performance of work implementation up to work control in the 58th week with the ESM method is as follows:

- AT : week 58
- C : week 51
- EV : IDR. 165,630,256,364, -
- PV_C : IDR. 162,798,440,003, -
- PV_{C+1} : IDR. 172,209,457,606, -
- ES : week 51.301
- SV(t) : - 6.699
- SPI(t) : 0.885

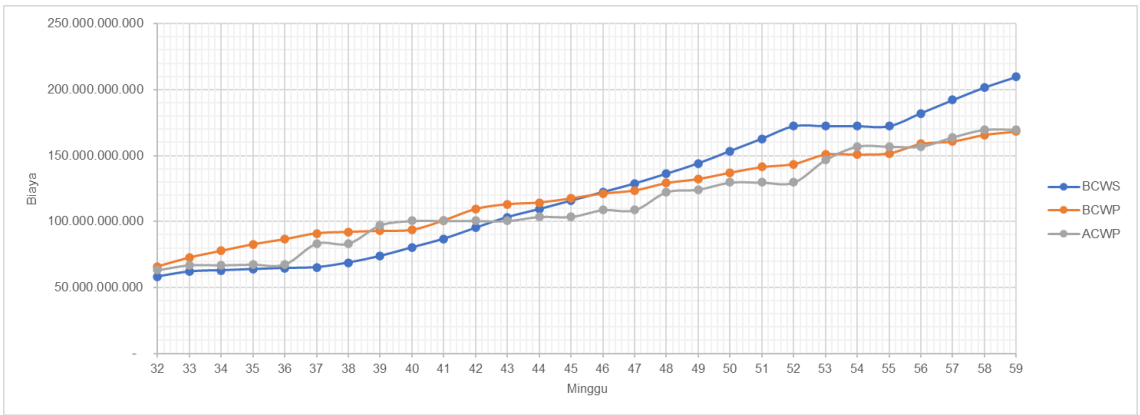


Figure 5. EVM and ESM Curve Control Period week 32 – 58

The performance of work implementation up to work control in the 58th week with the EDM method is as follows:

- AD : 406 days
- TED : 398 days
- TPD_C : 329 days
- TPD_{C+1} : 343 days
- ED : 411 days
- DV : 5
- DPI : 1.012

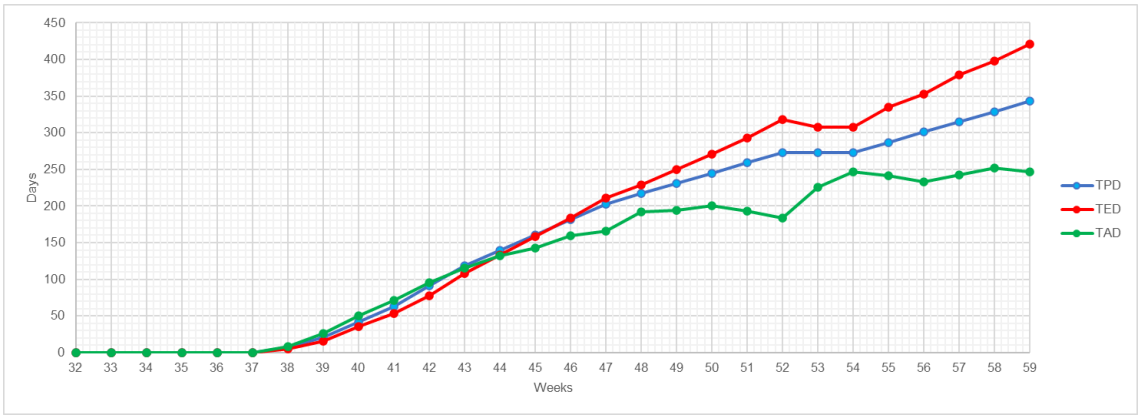
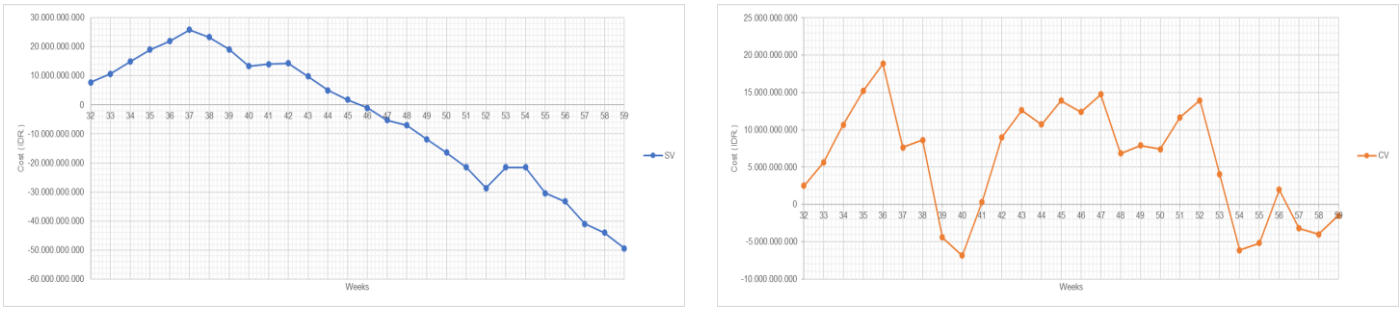


Figure 6. Control Period EDM Curve week 32 - 58

Earn Value Management analysis

Analysis of Schedule variance (SV) and Cost Variance (CV)

Trend Schedule Variance (SV) to analyze time performance. The SV trend decreases every week, indicating that the project is experiencing a delay from the planned schedule. Trend Cost Variance (CV) to analyze cost performance. This unstable Trend Cost Variance in week 58 reaches a minus value, which means there is a deviation in cost issues.

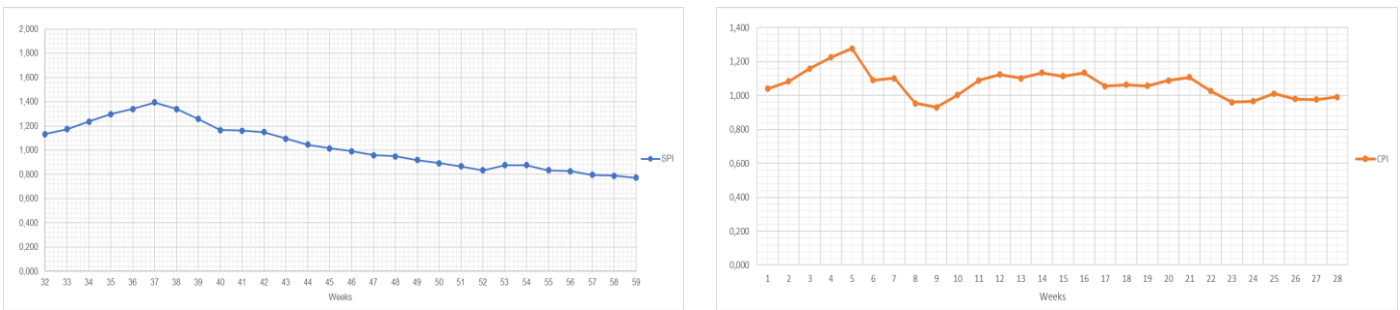


SV Schedule Varians CV Cost Varians

Figure 7. Project Varians Diagram

Analysis of Schedule Performance Index (SPI) and Cost Performance Index (CPI)

Trend Schedule Performance Index (SPI) to analyze time performance. The downward trend of SPI can be seen in week 58 which reached a value of 0.790 which indicates that the project is running behind schedule. Trend Schedule Performance Index (SPI) to analyze time performance. The downward trend of SPI can be seen in week 58 which reached a value of 0.790 which indicates that the project is running behind schedule. This is in accordance with the results of discussions with the project team and owner regarding the causes of project delays in the field. Cost Performance Index (CPI) trends to analyze cost performance. On the chart CPI trend is stable but in week 58 the chart value is at a value of 0.976 which indicates the cost of implementing the project is more than the budget. This is in accordance with the results of the analysis of variance.

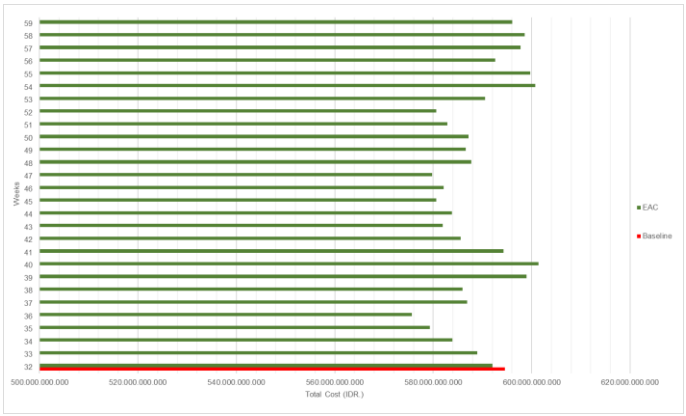


SPI Schedule Performance Index CPI Cost Performance Index

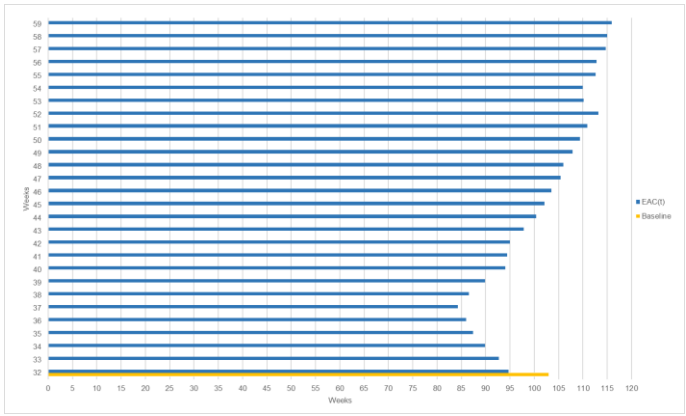
Figure 4. Project Performance Index

Estimated Cost at Completion (EAC) Analysis Based on Budgeted at Completion (BAC)

In the graphic image of the EAC analysis with BAC, the result is that in the 58th week of controlling the project, the estimated cost at the end of project implementation is IDR. 598,559,975,234, - which is based on the planned contract value of IDR. 594,545,454,545, -.



EAC against BAC



EAC(t) against Project Planned Duration

Figure 9. Graph of Estimation at Completion (budget and duration)

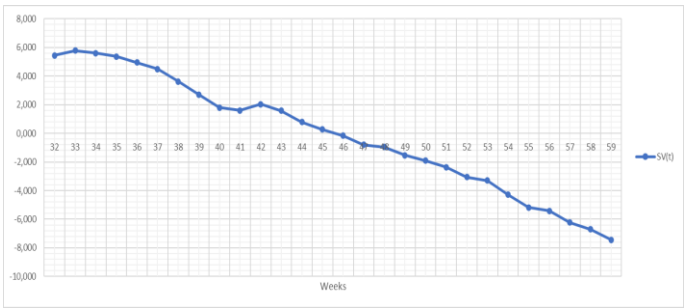
Based on the figure, the project above can already be estimated for the duration of project implementation based on deviation data that occurred during implementation, on the 45th week control duration the estimated duration of work is 102 weeks, while on the 58th control duration the estimated duration of work is 115 weeks when compared to the duration planned for the project, namely 103 weeks, the project experienced delays. This is also in accordance with the results of the analysis of variance and the performance index that has been carried out.

Earn Schedule Management Analysis
Analysis of Schedule Variance time (SV(t))

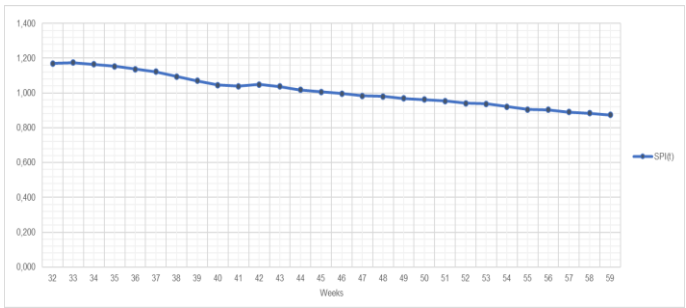
The SV(t) curve at week 58 ends in a -6,699 trend of decline during project implementation, which can be said to be a project not according to the planned schedule (project is slower). The results of the ESM analysis are in accordance with the results of the analysis of variance using the EVM method.

Analysis of Schedule Performance Index time (SPI(t))

This SPI(t) curve depicts the time performance during project implementation. SPI(t) continues to experience a decrease of less than one, which means the project is experiencing a delay from the planned duration. As in the 58th week, the trend shows the number 0.885. The results of the ESM analysis are also consistent with the results of the analysis of the performance index using the EVM.



SV(t) ES



SPI(t) ES

Figure 10. SV(t) Project Diagram of ESM

Analysis of Independent Estimated at Completion Time (IEAC(t)) against Baseline

Based on the figure, the project above can already be estimated for the duration of project implementation based on deviation data that occurred during implementation, on the 45th week control duration the estimated duration of work is 102 weeks, while on the 59th control duration the estimated duration of work is 118 weeks which is based on the duration which had been planned the final duration of the project was completed in week 103.

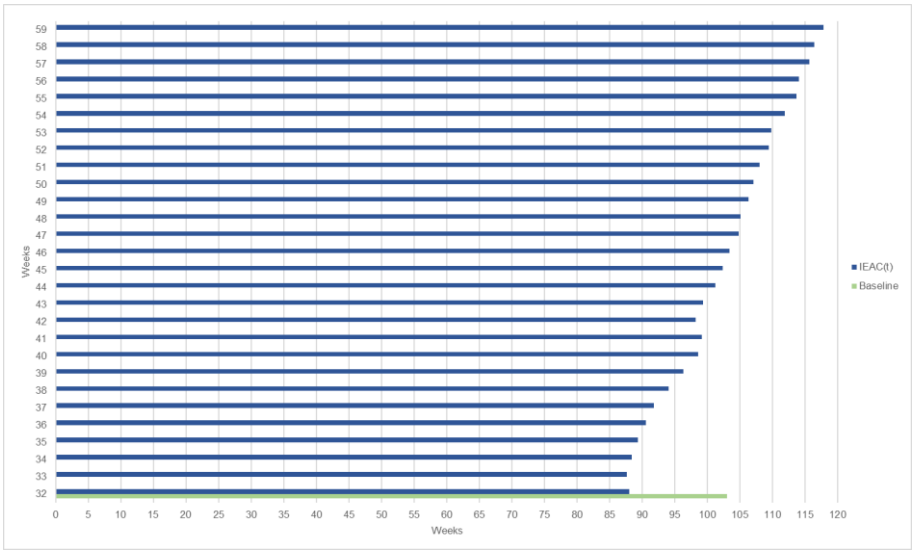


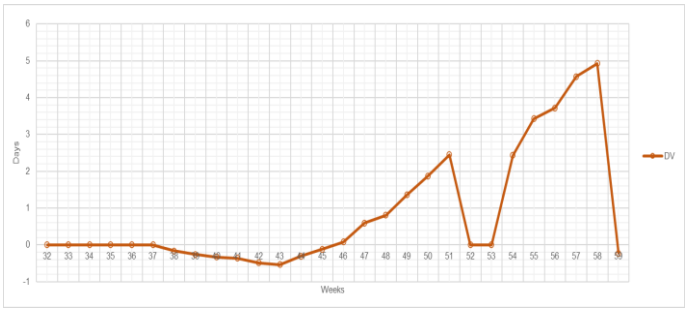
Figure 11. IEAC(t) Project Diagram of ESM

Earn Duration Management Analysis
Analysis of Duration Variance (DV)

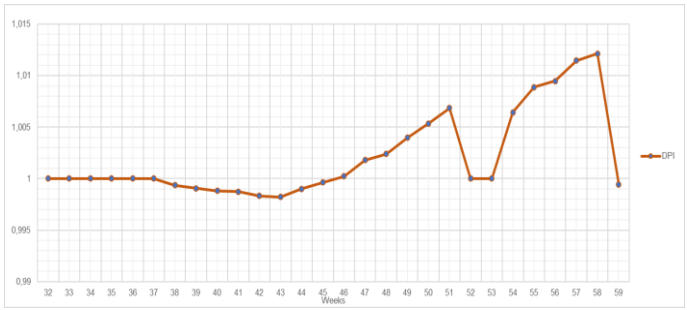
Based on the graph above, there is a difference between the trend of EDM's DV, which has a different trend from ESM's SV(t) value, and EVM's SV. The DV curve at week 58 ends in day 5, which means that during project implementation it can be interpreted as running faster than planned.

Analysis of Duration Performance Index (DPI)

Based on the following project image, there is a difference between EDM's DPI (Duration Performance Index) trend, which is similar to ESM's SPI(t), and EVM's SPI value. Meanwhile, the 58th week DPI curve is at a value of 1,012, which means the project is completed on time.



DV



DPI

Figure 12. Project Varians and Performance Indicator od EDM

Analysis of Estimated Duration Time at Completion (EDAC(t)) against Baseline

Based on the picture above, it can be seen that the differences in the estimated final duration of project implementation using the EDM method (EDAC(t)), the ESM method (IEAC(t)) and the EVM method (EAC(t)) produce the same trend in the estimated final duration of project implementation. In (EDAC(t)) the estimated final project duration is 103 weeks, which in reality the project finished in 103 weeks.

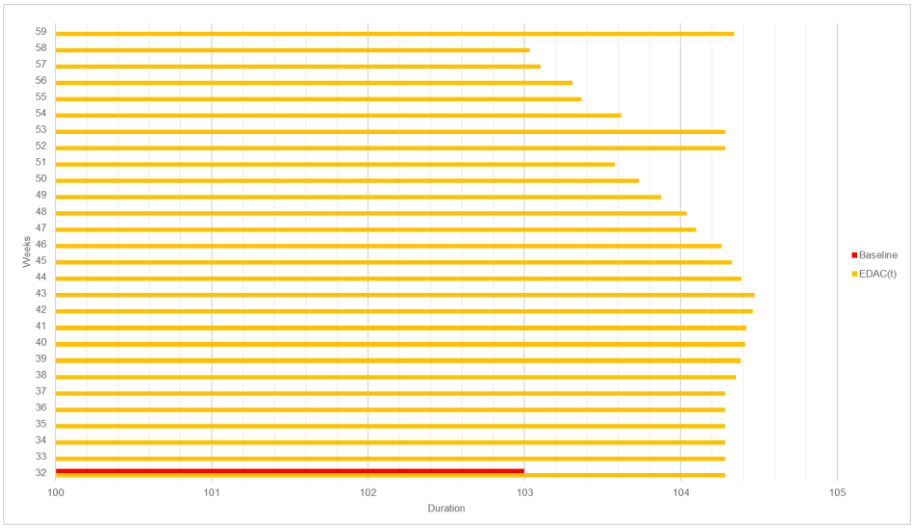
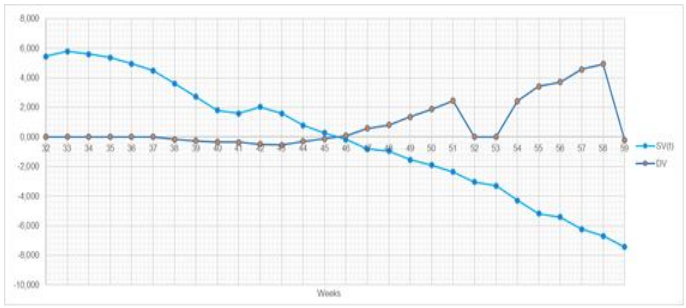


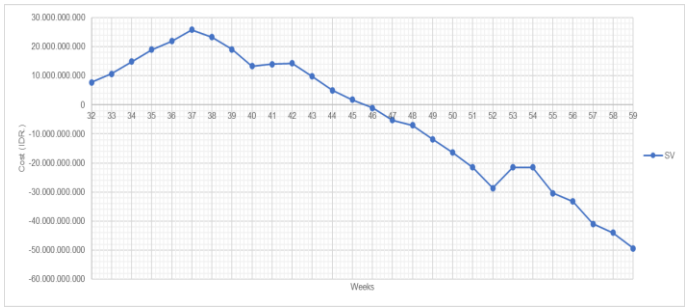
Figure 13. EDAC(t) Project of EDM

Comparison 3 Methods
Comparison *Schedule Variance* (SV), *Schedule Variance Time* (SV(t)), dan *Duration Variance* (DV

Based on the graph above, there is a difference between the value of EDM's DV, ESM's SV(t), and EVM's SV on the Y-curve SV filled with a different cost trend than DV and SV(t). The DV curve in the last week of control points to number 5 which means the project is according to plan. The SV(t) curve at week 58 ends at -6.699. while the SV curve has decreased during project implementation, which can be said to be the project not according to the planned schedule.



SV(t) form ESM dan DV from EDM



SV from EVM

Figure 14. Comparison of Variances 3 Methods

Analysis of Schedule Performance Index (SPI), Schedule Performance Index Time (SPI(t)), and Duration Performance Index (DPI)

Based on the project image above, there is a difference between EDM's DPI (Duration Performance Index) value, which is similar to ES's SPI(t), and EV's SPI value. These three curves equally describe the time performance during project implementation. But the SPI and SPI(t) values have decreased by less than one, which means the project is experiencing a delay from the planned duration, while the DPI curve is stable, which means the project is completed on time.

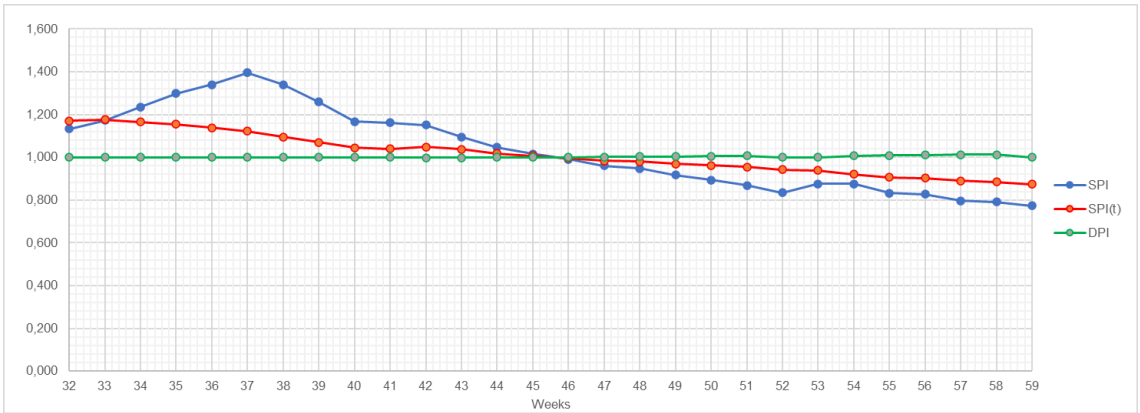


Figure 15. Comparison SPI, SPI(t), and DPI

Estimated Time at Completion (EAC(t)), Independent Estimated Time at Completion (IEAC(t)), and Estimated Duration Time at Completion (EDAC(t)) analysis against Baseline

Based on the picture above, it can be seen that the differences in the estimated final duration of project implementation using the EDM method (EDAC(t)), the ESM method (IEAC(t)) and the EVM method (EAC(t)) produce different values in the estimated final duration of project implementation. In (EAC(t)) the estimated final project duration is week 115 which means the project is delayed 12 weeks from schedule, while in (IEAC(t)) week 116 which means the project is predicted to experience a delay of 13 weeks from the project plan duration. In (EDAC(t)) the estimated final project duration is 103 weeks, which in reality the project is completed in the 103rd week, which means the estimated final project duration is in accordance with the duration of the project plan. In forecasting the final duration of the project the project will experience delays if using the EVM method, ESM while using the EDM method the project is according to the planned schedule.

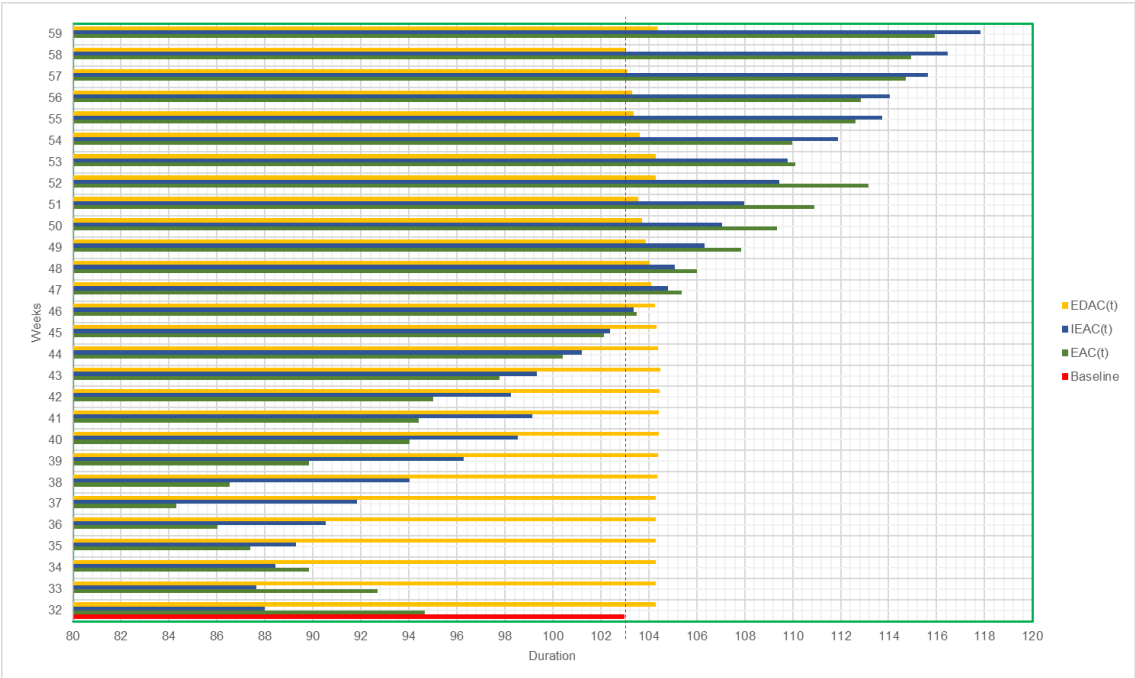


Figure 16. Comparison EAC(t), IEAC(t), EDAC(t), and baseline (real duration)

The research validation process is carried out by comparing the analysis results with actual conditions in the field. In this study, the EAC value was compared with the actual value of the duration of work in the field. The comparison results show that the EDAC(t) EDM value provides the closest estimated value to the real duration value in the field

CONCLUSION

Based on the analysis that has been carried out using the EVM method, it can be seen that the analysis of variance and index values is carried out in unit costs (in this study Rp). This causes the SV and SPI values to be irrelevant, so that in the 58th control week, the estimated duration of the project implementation finally experienced a delay of up to 12 weeks. While the analysis using the ESM method shows that the Schedule Variance Time and Schedule Performance Index Time values are carried out in units of time (weeks in this study), to assess time performance, the cost value is still used to estimate the final project duration, which causes the SV(t) and SPI values (t) becomes irrelevant, so that in the estimated final project duration IEAC(t) the project describes a performance delay of up to 13 weeks in the 58th control period. Then the analysis with the EDM method is the analysis of the variance value with the Duration Variance and the index value with the Duration Performance Index carried out in units of time (in this study weeks). This causes the DV and DPI values to be relevant, so that the estimated final project duration describes the final estimate of the EDAC(t) project in the control period of the 58 projects according to the planned duration, that is, no delays. The trend of SV, SV(t) values gives a negative value which shows the final duration of the project is behind schedule. SPI, SPI(t) shows a trend that is less than one, which means the estimated final project duration is late from the planned project duration. While the trend of DV and DPI values goes according to the conditions of project implementation.

The EDM method ultimately produces an accurate value in assessing the performance of the project implementation time, estimating the value of the duration of project completion compared to the EVM and ESM methods. As a recommendation, it can be said that to control project implementation costs you can continue to

use the EVM method, while to control project implementation schedules you can use ESM. For EDM, considering that this method is still unfamiliar to contractors, it is recommended that it is only used in certain situations, for example to assess claims that will be submitted, or others.

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