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PROJECT DELAY PREDICTION WITH EARNED VALUE METHOD: A CASE ON THE CSS-APARTMENT PROJECT IN SURABAYA-INDONESIA

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Abstract

The risk of delay is very likely to occur in a construction project. Especially in large-scale infrastructure projects that are accompanied by high complexity. Careful planning and prediction both related to aspects of design, implementation, including scheduling are very important. Problems that often arise in large-scale and complex construction projects are early predictions related to delays in the final completion of a project. This study aims to predict the occurrence of delays in project completion. Based on secondary data obtained from construction contractors and by using appropriate analytical procedures, the result is that the CSS-Apartment project is predicted to experience a delay of 57 weeks from the planned 146 weeks. The data is obtained directly from the project site. After all the data has been obtained, the processing is carried out using the Earned Value Method. Literature study is done by reading literature related to this writing Based on the case of an apartment project called CSS-Apartment Project in Surabaya - Indonesia, and using the Earned Value method.

Keywords: *earned value method, delay, construction project, indonesia*

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INTRODUCTION

Surabaya is one of the major cities in Indonesia that has a high level of population density. Like other major cities in Indonesia, residential infrastructure development is now also being carried out to meet the increasingly difficult housing needs due to limited land in this city. One of the infrastructures being built at this time is the CSS-Apartment Project as a residence that has luxurious facilities, entertainment and services with complete facilities like a five-star hotel. With time and cost constraints, good and mature control is needed (Jayady, Subekti, Smyshlyaev, Protasova, & Artha, 2021).

The CSS-Apartment Project consists of 39 floors plus three basements with a construction plan duration of 146 weeks with a project value of Rp. 207,000,000,000. With such a large project size, CSS-Apartment Project must have interdependence between complex works, which has an impact on difficult control. So the possibility of project delays is very likely. Based on these reasons, a method is needed in analyzing performance and predicting delays in a construction project (Jayady, 2018).

One way to determine project performance is the Earned Value method. The Earned Value method combines elements of schedule, cost and physical development work performance that has been carried out in the field so that the cost and time to complete the project can be estimated. This method can detect as early as possible if there are cost overruns or delays that may occur in the implementation of a project, so

that the relevant parties can immediately anticipate and take steps to overcome them so that the project is completed on time with the remaining costs (Bulo, Balaka, & Sriyani, 2013).

Based on the case in the CSS-Apartment Project and by using the earned value method, this study aims to predict the occurrence of late completion of the project. With this method, in addition to predicting delays that can be identified early, it is also expected to know the cost requirements based on the remaining time and the estimated time for project completion based on actual conditions in the field.

Definition of Earned Value Method

According to (Sufa'atin, 2017) explaining Earned Value Management (EVM) is one method that can be used to control project costs and time during project execution. In addition, this method can integrate time and cost so that it can find out the progress of a project faster or slower than the project schedule should and to find out whether the budget is bigger or smaller than the budget. EVM adds steps that must be included in the management process, namely the control process, and processes related to the purpose of calculating, analyzing, forecasting, reporting costs and schedule performance for the evaluation and action of project stakeholders. It is expected that by using the EVM method the cost and time of project work can be controlled and the project can be completed on time and the costs incurred are in accordance with the project budget

Flemming and Koppelman cited by (Maromi & Indryani, 2015) explain the concept of earned value compared to traditional cost management. Traditional cost management only presents two dimensions, namely a simple relationship between actual costs and planned costs. With traditional cost management, the performance status cannot be known. In contrast, the earned value concept provides a third dimension besides actual costs and planned costs. This third dimension is the amount of physical work that has been completed or is called earned value / percent complete. With this third dimension, a project manager will be able to better understand how much performance has resulted from a number of costs that have been incurred.

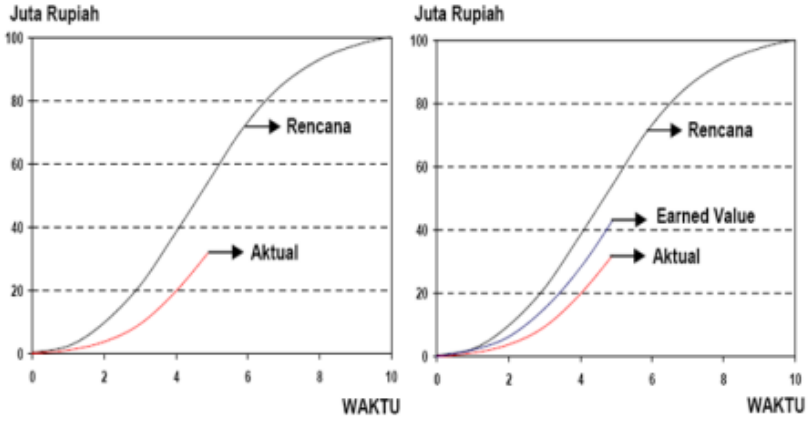

Figure 1. Graph of Differences in Traditional Cost Management and the Concept of Earned Value
Source : https://manajemenproyekindonesia.com/?p=769

Earned Value Analysis (EVA) is a method that allows the project manager to measure the amount of work actually performed on a project beyond the basic review of cost and schedule reports. EVA provides a method that permits the project to be measured by progress achieved. The project manager is then able, using the progress measured, to forecast a project's total cost and date of completion, based on trend

analysis or application of the project's "burn rate". This method relies on a key measure known as the project's earned value (Verzuh & Association, 2021).

Assessment Of Project Performance With The Concept Of Earned Value

The use of the concept of Earned Value in project performance appraisal is explained in Figure 2. Several terms related to this assessment are Cost Variance, Schedule Variance, Cost Performance Index, Schedule Performance Index, Estimate at Completion, dan Variance at Completion.

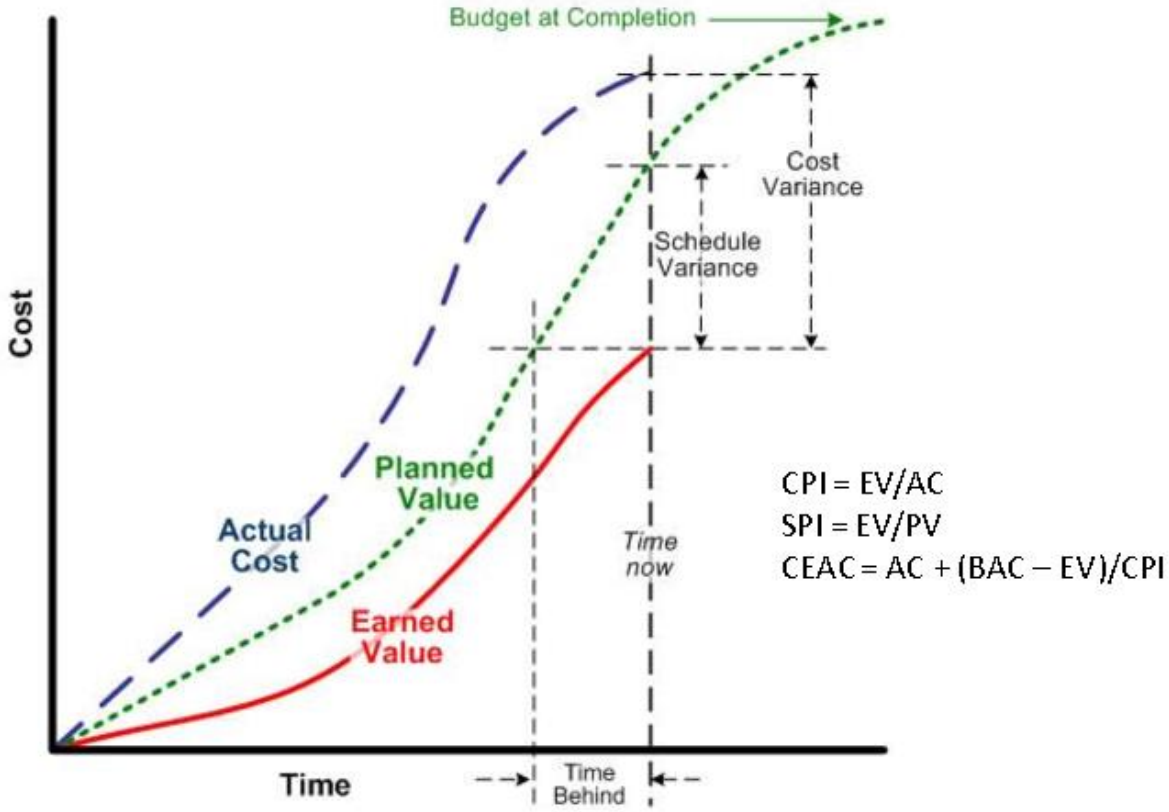

Figure 2. Earned Value S Curve Graph
Source : Semantic Scholar (2015)

Schedule Variance (SV)

Schedule variance is used to calculate the deviation between BCWS and BCWP. Positive value indicates that more project work packages have been implemented than planned. Conversely, negative value indicates poor work performance because fewer work packages have been carried out than the planned schedule.

BCWS – BCWP = SV

Variance With S Graph

Another way to demonstrate the presence of variance is to use S graph and will depict the progress of the volume of work completed throughout the project cycle. The S graph is very useful for use as monthly

reports and reports to project leaders, because this graph can clearly show project progress in an easy-to-understand form.

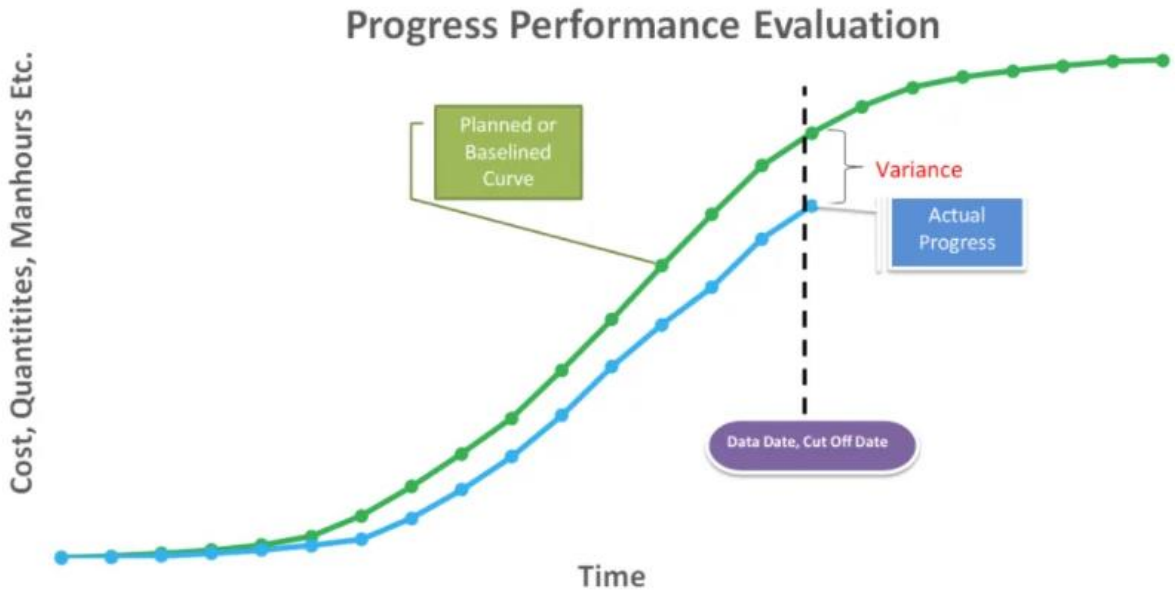

Figure 3. S Graph
Source : Monday (2022)

Cost Variance and Integrated Schedule

Cost Variance (CV) and Schedule Variance (SV) are formulated as follows :
Cost Variance (CV) = EV – AC atau CV = BCWP – ACWP
Schedule Variance (SV) = EV – PV atau SV = BCWP – BCWS

Prediction of Project Final Completion Costs / Estimate At Completion (EAC)

The importance of calculating CPI and SPI is to predict statistically the costs required to complete the project. There are many methods of predicting project completion costs (EAC). However, the calculation of EAC with SPI and CPI is easier and faster to use.

The EAC calculation is the sum of the actual costs that have been incurred and the remaining costs that will be needed to complete the project. The remaining costs that will be required are predicted statistically by taking into account the effectiveness of the use of costs (CPI) and work performance against the plan (SPI). From the EAC value, it can be obtained an estimate of the difference between the cost of the project completion plan (BAC) and the project completion cost based on the work performance that has been achieved (EAC) or what is called the variance at completion (VAC)

Criteria Earned Valued Management System

Although the concept of earned value looks simple, its implementation in project management is not easy because it must be supported by a management system that is able to provide complete data input in calculating project performance. If the project performance is poor, the system will be able to track down which parts are problematic which causes cost overruns and delays in project implementation. Management commitment. In the application of the earned value concept, there must be a determination from the project manager to utilize the earned value concept in the management system on the projects he handles.

Commitment must also exist in the company's main organization in supporting the decision to use the earned value concept in project management (Jayady, Hidayat, et al., 2021).

METHOD

Data Collection Methods

The type of data used in this research is secondary data. According to (Sugiyono, 2018), secondary data is research data obtained that is not directly related to providing data to data collectors. Secondary data was obtained from the relevant agencies. The data needed in the control process are the type of project activity, the start time of the activity, the duration of the activity, the volume of work, and the cost of each activity. The data is obtained directly from the project site. After all the data has been obtained, the processing is carried out using the Earned Value Method. Literature study is done by reading literature related to this writing.

Data Analisys Method

In determining project performance by means of Earned Value, the information displayed is in the form of indicators in quantitative form, which displays information on the progress of costs and the project schedule. Because there are indications that the project will be late or early and the costs to be incurred are more than or less than the budget, the progress of the project for the future needs to be forecasted in the following way:

Estimated Cost for Remaining Work (Estimated to Completion).
ETC = (Budget – BCWP) / CPI

Estimated Cost of Project Completion (Estimated at Completion)
EAC = ACWP + ETC

Estimated Project Completion Date (Estimated Completion Date)
ECD = Remaining Time/SPI + Time Use

Earned Value Mehod Flowchart

The Flowchart of Earned Value Method is presented in Figure 4 below

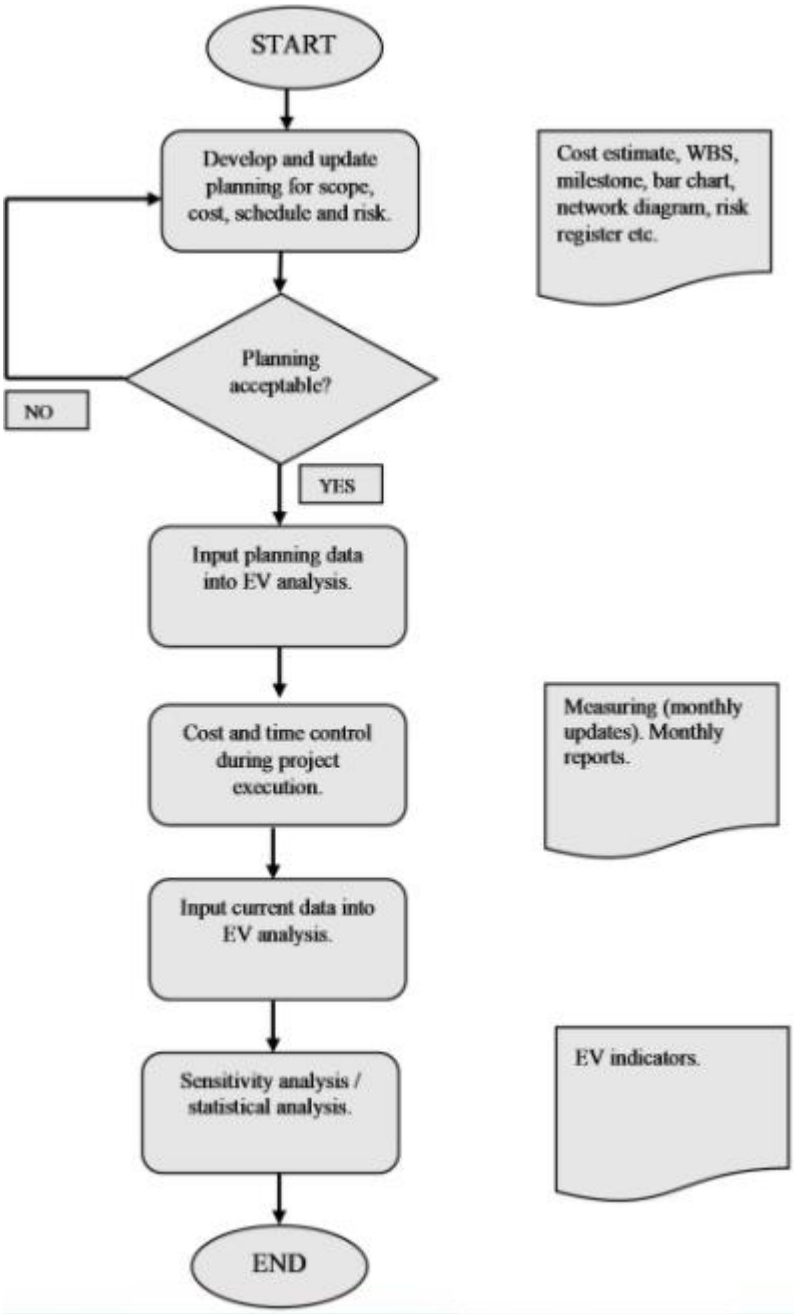

Figure 4. Earn Value Flowchart

Source : (Araszkiewicz & Bochenek, 2019)

RESULT AND DISCUSSION

BCWS (Budgeted Cost For Work Schedule) / PV (Planned Value)

BCWS (Budgeted Cost for Work Schedule) is a budget that is allocated based on a work plan that has been prepared against time. BCWS is calculated from the accumulation of the planned cost budget for the work in a certain period. In the data processing table, BCWS is obtained by using the equation.

(Weekly Plan Weight/Overall Plan Weight) x Plan Budget

BCWS can be calculated by multiplying the cumulative percentage of the plan's progress each week by the project value. The cumulative percentage of work plan progress is obtained from the S curve graph in which there is a job description, the percentage of work weights and the percentage of plan progress.

Table 1. BCWS at week 135 to 142

Weeks	% Cumulative Progres Plan	BCWS Value
135	94.204	195,002,280,000.00
136	94.904	196,451,280,000.00
137	95.591	197,873,370,000.00
138	96.199	199,131,930,000.00
139	96.810	200,396,700,000.00
140	97.408	201,634,560,000.00
141	98.001	202,862,070,000.00
142	98.519	203,934,330,000.00

BCWP (Budgeted Cost For Work Performed) / EV (Earned Value)

BCWP (Budgeted Cost For Work Performed) is the value received from the completion of work over a certain period of time. This BCWP is calculated based on the accumulation of completed work. BCWP is calculated using the formula: (Weekly Implementation Weight/Overall Plan Weight) x Plan Budget.

BCWP can be calculated by multiplying the cumulative percentage of realization progress by the total budget plan for a job (BAC). The cumulative percentage of realization progress is the cumulative project achievement that has been achieved in one week. The cumulative percentage of realization progress is obtained from the weekly progress report.

Table 2. BCWP at week 135 to 142

Weeks	% Cumulative Implementation Progress	BCWP Value
135	67.116	138,930,120,000.00
136	67.880	140,511,600,000.00
137	68.493	141,780,510,000.00
138	68.625	142,053,750,000.00
139	68.727	142,264,890,000.00
140	68.831	142,480,170,000.00
141	68.928	142,680,960,000.00
142	68.948	142,722,360,000.00

ACWP (Actual Cost For Work Performed) / AC (Actual Cost)

ACWP (Actual Cost For Work Performed) is the total actual cost of the work that has been carried out. This cost is obtained from accounting or project financial data on the reporting date so, ACWP is the actual amount of expenditure or funds used to carry out work at a certain time. ACWP calculation using the formula:

Analysis Factor = (Weekly Implementation Weight/Overall Plan Weight) x Implementation Budget

Table 3. ACWP at week 135 to 142

Weeks	% Cumulative Implementation Progres	ACWP Value
135	67.116	158,205,661,834.00
136	67.880	160,006,560,660.53
137	68.493	161,451,522,677.10
138	68.625	161,762,672,736.14
139	68.727	162,003,106,872.66
140	68.831	162,248,255,404.02
141	68.928	162,476,903,553.46
142	68.948	162,524,047,501.80

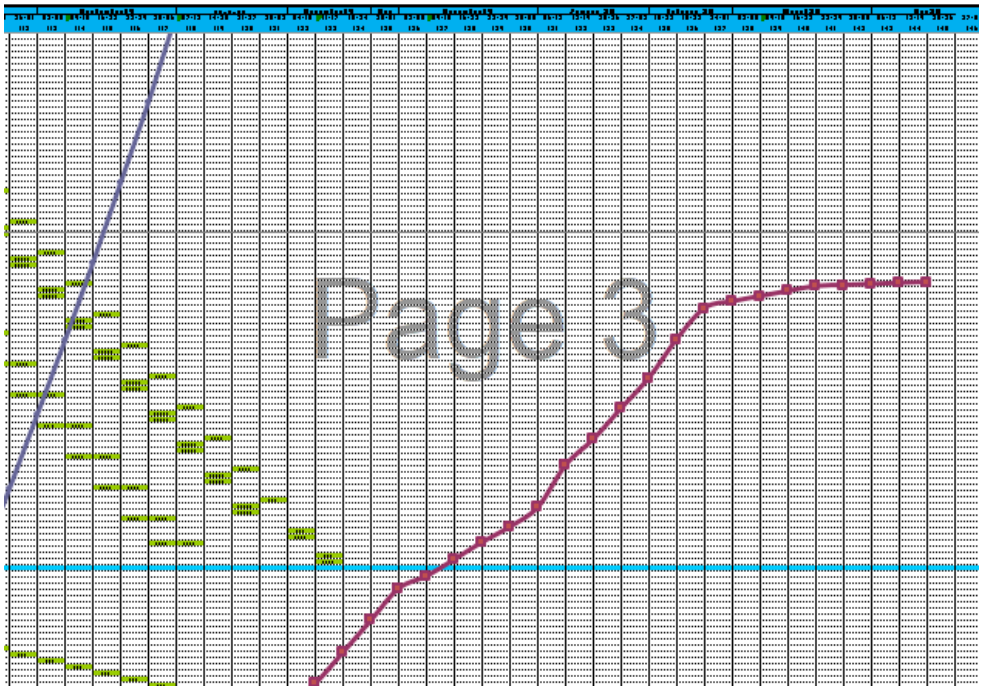

Figure 5. S Curve at week 135 to 142

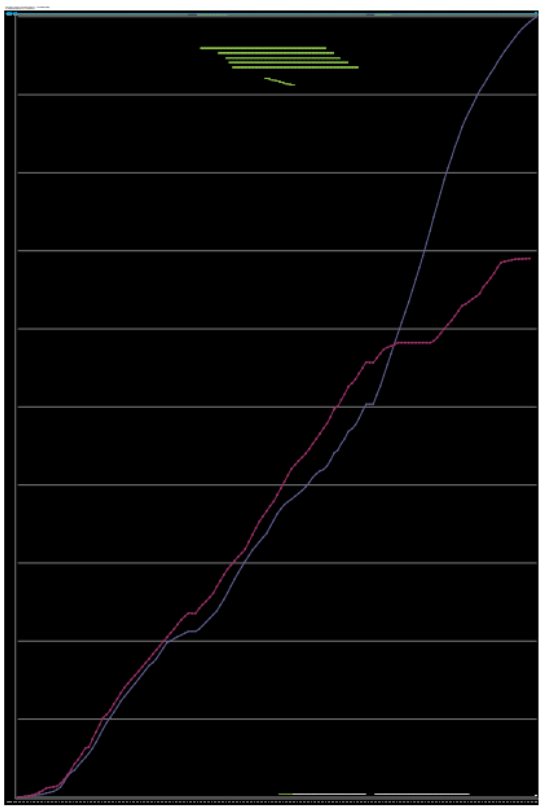

Figure 6. S Curve at week 1 to 146

CV (Cost Variance)

CV (Cost Variance) is the difference between the value obtained after completing work packages and the actual costs incurred during project implementation. A negative number on the cost variance, which indicates that costs are higher than the budget, is called cost overrun. Zero indicates work done according to cost. While a positive number means the work is carried out at a cost less than the budget, which is called a cost underrun. Equation used

$$CV = BCWP - ACWP$$

Table 3. CV at week 135 to 142

Weeks	CV
135	-19,275,541,834.00
136	-19,494,960,660.53
137	-19,671,012,677.10
138	-19,708,922,736.14
139	-19,738,216,872.66
140	-19,768,085,404.02
141	-19,795,943,553.46
142	-19,801,687,501.80

SV (Schedule Variance)

Schedule Variance is used to calculate the deviation between BCWS and BCWP. A positive value indicates that more project work packages have been implemented than planned. Conversely, a negative value indicates poor work performance because fewer work packages have been carried out than the planned schedule. Equation used:

$$SV = BCWP - BCWS$$

Table 4. SV at week 135 to 142

Weeks	SV
135	-56,072,160,000.00
136	-55,939,680,000.00
137	-56,092,860,000.00
138	-57,078,180,000.00
139	-58,131,810,000.00
140	-59,154,390,000.00
141	-60,181,110,000.00
142	-61,211,970,000.00

CPI (Cost Performance Index)

The cost efficiency factor that has been spent can be shown by comparing the value of the work that has been physically completed (BCWP) with the costs that have been spent in the same period (ACWP).

$$CPI = BCWP / ACWP$$

Table 5. CPI at week 135 to 142

Minggu ke	CPI
135	0.88
136	0.88
137	0.88
138	0.88
139	0.88
140	0.88
141	0.88
142	0.88

This CPI value shows the weight of the value obtained against the costs incurred. A CPI of more than 1 indicates good cost performance, because the costs incurred (ACWP) are smaller than the value obtained (BCWP), in the sense that expenditures are smaller than the budget.

SPI (Schedule Performance Index)

Performance efficiency factor in completing the work can be shown by the comparison between the value of the work that has been physically completed (BCWP) with the planned expenses incurred based on the work plan (BCWS).

SPI = BCWP / BCWS

Table 6. SPI at week 135 to 142

Minggu ke	SPI
135	0.71
136	0.72
137	0.72
138	0.71
139	0.71
140	0.71
141	0.70
142	0.70

This SPI value shows how much work can be completed against the planned work unit. An SPI value of more than 1 indicates that the work performance is running faster than the planned target.

Forecasting Using Earned Value Methods

Estimates of the final cost to complete the project can be done using the indicators obtained at the time of reporting to provide a final forecast of the project. This forecasting is useful in providing early warning about things that will happen in the future, based on the assumption that the trends that exist and are revealed at the time of reporting have not changed.

ETC (Estimate to Completion): estimated cost for remaining work, obtained by
ETC = (Budget – BCWP) /CPI
ETC = (207.000.000.000 – 142.722.360.000) / 0,88 = 73.195.694.190,20

EAC (Estimate at Completion) : Estimated total project cost, obtained by
EAC = 162.524.047.501,80 + 73.195.694.190,20 = 235.719.741.692

TE (Time Estimate) / Estimated Project Completion Schedule
TE = ATE + ((OD – (ATE x SPI)) / SPI)
TE = 146 + ((142 – (146 x 0,7)) / 0,7)
TE = 202,86 weeks → 203 weeks

CONCLUSION

Based on the results of project data processing using the Earned Value method, the following conclusions can be drawn:

1. The results of the CV (Cost Variance) calculation show a negative number, this means that the cost to complete the project is greater than the plan / cost overrun.
2. The results of the SV (Schedule Variance) calculation show a negative number, this means that the implementation is slower than planned.
3. The results of the calculation of the CPI (Cost Performance Index) of 0.88 < 1, indicating poor performance in planning, in the sense that expenditure is greater than the budget.
4. The calculation result of SPI (Schedule Performance Index) is 0.7, indicating that the execution of work is slower than the planned work schedule.
5. ETC (Estimate To Completion) value of Rp. 73.195.694.190.20, indicating the estimated cost to complete the remaining work.
6. The EAC (Estimate At Completion) value is Rp. 235,719,741,692 represents the estimated total cost of implementing the project to completion.
7. If this condition continues until the project is completed, then the estimated time and cost of project completion is 203 weeks. The results show the project was 57 weeks late from the planned 146 weeks. This means that delays in the completion of the project will occur.

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