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EVALUATION OF PROJECT COST AND TIME USING EARNED VALUE APPROACH: A CASE OF MILITARY INFRASTRUCTURE PROJECT

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ABSTRACT
This research aims to optimize the performance of construction projects at Yohanis Kapiyau Airbase so that the work can be completed on time, meet quality standards, and in accordance with the predetermined budget. This research addresses key questions regarding the evaluation of project cost and time control, specifically examining project cost performance through Cost Variance and Cost Performance Index (CPI) indicators, as well as project time performance using Schedule Variance (SV) and Schedule Performance Indices (SPI) indicators. The implementation of the Earned Value Management (EVM) method has proven its effectiveness as an analytical instrument that integrates cost and cost dimensions comprehensively. Through the comprehensive analysis that has been conducted, the method successfully identified with precision that the fundamental challenge of the project lies in the aspect of time management, while cost management shows excellent efficiency. It can be concluded that the achievement of excellent cost efficiency has a positive impact on the overall project performance. Based on the results of the comprehensive evaluation, several strategic recommendations can be formulated for the optimization of project implementation in the future.

Keywords: construction management, earned value management, military infrastructure, project control, project performance analysis

INTRODUCTION

Lanud Yohanis Kapiyau has a significant historical value as an operational base for various TNI military missions, one of which is Operation Mapnduma. This strategic operation aims to free 26 researchers who are members of the 95th Lorentz Expedition held hostage by the Free Papua Organization (OPM) in Mapnduma Village, Jayawijaya Regency. This momentum became an important milestone in efforts to uphold state sovereignty in Papua (Malaiholo et al., 2022). As a type C base, Lanud Yohanis Kapiyau plays an important role in supporting the operations of Koopsud III TNI AU in Timika, Mimika Regency, Central Papua. Currently, the base still utilizes aviation infrastructure belonging to Mozes Kilangin Airport managed by PT Freeport Indonesia. Its strategic position makes it the main gateway for TNI operations in Central Papua for logistics interconnection, personnel mobilization, and SAR operations (Susanti et al., 2019).

Papua, located in the easternmost part of Indonesia, is a region that mesmerizes with its stunning natural beauty and diverse cultural richness. It is no wonder that the region is nicknamed "Little Paradise" for its extraordinary natural charm. Some important cities such as Sorong, Merauke, and Jayapura have developed into leading tourist destinations that offer panoramic views of Papua's nature (Fazis & Tugiah, 2022; Kadir, 2024; Muller & Pickell, 2013). In the implementation of project monitoring methods, Earned Value Method (EVM) has proven to be effective for comprehensive project performance control. Evaluation of project duration, calculation of required costs, and estimation of completion time are carried

out based on planned progress, realized progress, and actual costs that have been used (Arekete et al., 2023; Kang et al., 2022; Venkataraman & Pinto, 2023). This methodology is relevant for estimating project duration while supporting more efficient decision making (Tariq et al., 2020).

Entering 2023, Lanud Yohanis Kapiyau again showed its strategic role in the pursuit of the Armed Criminal Group (KKB) in the Papua Mountains. This operation was held after the hostage incident of Susi Air pilot, Philip Mark Mehrtens, at Paro Airstrip, Nduga Regency. Timika's strategic position, located between major Papuan cities such as Biak and Jayapura, supports TNI combat power in the region (Rizqie et al., 2022). Construction is a fundamental component in infrastructure development (Hu et al., 2023; Wang & Yin, 2022; Willar et al., 2021). Many construction projects in Indonesia require special attention, given the rapid development of the construction services industry. The reality in the field shows that delays in project completion are still common, which often result in cost overruns and implementation time (Gómez-Cabrera et al., 2024; Natalia et al., 2021).

Indonesia, as a unitary state, consists of various provinces divided into districts and cities. Inequality in education and the economy remains a challenge, especially in Papua, which experiences significant disparities compared to other regions. The government implements various programs, including comprehensive infrastructure development to address this issue (Lumentah et al., 2020). Forward Operating Bases (FOBs) are specifically designed to provide optimal support for strategic and tactical operations. An FOB is generally equipped with comprehensive support facilities, such as air bases, hospitals, maintenance centers, and logistics facilities. With the presence of a FOB, troop response time to the area of operations can be significantly cut (Soemardi et al., 2007).

In national development, infrastructure plays a crucial role in driving economic growth. The availability of quality infrastructure can reduce poverty and improve people's welfare. Therefore, the government shows its strong commitment in developing infrastructure to accelerate the development of the business sector (Hidiyati et al., 2023). One of the strategic infrastructure projects is the Infrastructure Improvement Construction Work and Infrastructure Facilities of Yohanis Kapiyau Airbase (YKU). The strategic position of Koopsud III in Biak, Papua, has special significance in maintaining the sovereignty of Indonesia's airspace, especially in the Pacific region. A great responsibility is borne by Koopsud III to ensure the operational preparedness of TNI AU units (Jatnika & Johari, 2022).

The infrastructure development project of Yohanis Kapiyau Airbase is currently implemented by PT Surya Manunggal Wisesa with a contract value of Rp118,611,726,000.00. The project is scheduled to be completed in 240 calendar days, starting from April 22, 2024 to December 17, 2024. The Ministry of Defense appointed PT Binamitra Bangunsarana Pratama as the supervisory consultant (TRAK/417/III/2024/PUSKON PDN). In the development of defense capabilities, the Air Force developed a strategic plan to make Yohanis Kapiyau Airbase in Timika, Central Papua, a secure forward operating base (FOB). This base is designed to support various advanced operations as well as become a strategic tactical center, especially to support the Indonesian Air Force.

This research aims to optimize the performance of construction projects at Yohanis Kapiyau Airbase so that the work can be completed on time, meet quality standards, and in accordance with the predetermined budget. The results of the research are expected to fulfill the agreement in the executor's work contract, prevent losses, and ensure that the infrastructure built can support the economy of the surrounding community and advance Papua like other regions in Indonesia.

This research addresses key questions regarding the evaluation of project cost and time control, specifically examining project cost performance through Cost Variance (CV) and Cost Performance Index (CPI) indicators, as well as project time performance using Schedule Variance (SV) and Schedule Performance Index (SPI) indicators. It also explores how the Earned Value method can assist project managers in making strategic decisions related to cost and time. By analyzing these performance metrics and estimating project completion based on actual performance data, the study can provide valuable insights and references for enhancing the management of construction projects in the future.

The hypotheses used were:

1) H1 (Focus on Cost Efficiency): The project will achieve cost efficiency (CPI>1) when the value of work completed (EV) exceeds the actual costs incurred (AC).
2) H2 (Focus on Schedule Performance): When the SPI value is above 1, it indicates a correlation with faster than planned project schedule progress.
3) H3 (Focus on the Benefits of the Method): The implementation of Earned Value analysis as a control tool can reduce cost and time deviations in the implementation of the Yohanis Kapiyau Airbase facility construction project.
4) H4 (Focus on Prediction Accuracy): EVM projection parameters of ETC and EAC can produce precise estimates of final costs and project duration, despite location and logistical constraints.
5) H5 (Focus on the Root of Delay): The emergence of a negative SV value caused by EV being lower than PV is a key indicator of the cause of project delay.

RESEARCH METHOD

The research location is in the construction project of the Yohanis Kapiyau Airbase Infrastructure and Sarpras Improvement Project, Timika, in Fiscal Year 2023/2024. This location was chosen because of the relevance of the data in analyzing the performance of construction projects.

This study used secondary data obtained from the implementing contractor and project supervision consultant. The data collected includes the project implementation schedule (Time Schedule), S Curve as a reference and actual project, Cost Budget Plan (RAB), weekly project reports, and actual costs which include direct costs such as materials, labor, and tools, as well as indirect costs such as office and field overheads. These data were analyzed to evaluate the project performance.

Data collection was conducted through secondary data documentation, such as weekly reports, daily reports, time schedules, and RAB provided by the implementing contractor. Primary data in the form of goods prices, workers' wages, and equipment rental costs were

collected through direct observation and interviews with relevant parties in the field. This procedure ensures the accuracy and relevance of the data used in the research.

Data was analyzed using the Earned Value Management (EVM) method to evaluate project performance through three main indicators: Planned Value (PV), Earned Value (EV), and Actual Cost (AC). The analysis involved variance calculations such as Cost Variance (CV) and Schedule Variance (SV), as well as performance indices such as Cost Performance Index (CPI) and Schedule Performance Index (SPI). Calculation of cost and time estimates for project completion was carried out using Estimate to Complete (ETC), Estimate at Completion (EAC), and Time Estimate (TE) indicators. This analysis provides project performance projections and recommendations for improvement if potential delays or cost overruns are found.

RESULT AND DISCUSSION

In implementing the construction of the Yohanis Kapiyau Airbase Infrastructure and Facilities Improvement Project, the project management applied the Earned Value Management (EVM) methodology as a comprehensive analysis instrument to measure project performance from the time and cost dimensions. Based on the evaluation conducted until the 25th week period, it was noted that the Planned Value (PV) - which represents the amount of budget that should have been absorbed for the planned volume of work - reached Rp 62,621,502,489.57. However, the actual achievement reflected in the Earned Value (EV) parameter - which indicates the financial value of the work that has been successfully realized - only reached IDR 49,655,551,634.79. This gap resulted in a negative Schedule Variance (SV) of -Rp 12,965,950,854.78, confirming a deviation in the form of a significant delay in the project implementation progress compared to the pre-planned timeline. This analysis becomes very relevant to answer the formulation of problems related to the evaluation of cost, time control, as well as the utilization of the Earned Value method in overall project strategic decision making.

Table 1. Planned Value

Week	Plan Weight (%)		Budget (Rp)	Planned Value (Rp)	
	Weight	***Cumulative***		***Plan***	***Cumulative***
1	0,0436	0,0436	106.857.410.810	46.578.131,87	46.578.131,87
2	0,044	0,087	106.857.410.810	46.578.131,87	93.156.263,74
3	0,188	0,275	106.857.410.810	201.111.778,77	294.268.042,51
4	0,304	0,579	106.857.410.810	324.738.696,29	619.006.738,80
5	0,333	0,912	106.857.410.810	355.645.425,67	974.652.164,47
6	0,390	1,302	106.857.410.810	417.095.415,87	1.391.747.580,34
7	0,218	1,520	106.857.410.810	232.949.155,57	1.624.696.735,91
8	0,262	1,783	106.857.410.810	280.180.131,15	1.904.876.867,05
9	0,546	2,328	106.857.410.810	583.227.748,21	2.488.104.615,26
10	0,396	2,725	106.857.410.810	423.369.061,63	2.911.473.676,89

Source: Processed by Researchers 2024

Based on a comprehensive analysis of the financing aspects of the project, it was noted that the Actual Cost (AC) that had been absorbed reached Rp 40,195,101,488.78. When a comparison is made between Earned Value (EV) and Actual Cost (AC), a positive Cost Variance (CV) of Rp 9,460,450,146.01 is found, indicating expenditure efficiency where the actual costs incurred are still below the budget allocation for the volume of work that has been realized. Visualization of the comparison of PV, EV, and AC parameters up to week 25 confirmed that despite the optimization in cost control, the project implementation progress still deviated from the planned timeline.

Table 2. Earned Value

Week	Progress		Budget (Rp)	Earned Value	
	Realization	***Cumulative***		***Realization (Rp)***	***Cumulative(Rp)***
1	0,147	0,14752	106.857.410.810	157.641.248,16	157.641.248,16
2	0,101	0,248	106.857.410.810	107.630.671,32	265.271.919,48
3	0,362	0,462	106.857.410.810	386.569.038,78	494.199.710,10
4	0,278	0,640	106.857.410.810	296.946.526,62	683.515.565,40
5	0,548	0,826	106.857.410.810	585.321.685,74	882.268.212,36
6	0,257	1,083	106.857.410.810	274.570.117,08	1.156.838.329,44
7	0,172	1,254	106.857.410.810	183.367.316,95	1.340.205.646,39
8	0,254	1,508	106.857.410.810	271.417.823,46	1.611.623.469,85
9	1,367	2,875	106.857.410.810	1.460.740.805,78	3.072.364.275,63
10	4,330	7,205	106.857.410.810	4.626.498.458,46	7.698.862.734,10
11	2,081	9,285	106.857.410.810	2.223.275.289,33	9.922.138.023,43
12	1,528	10,814	106.857.410.810	1.633.101.809,42	11.555.239.832,85
13	0,836	11,649	106.857.410.810	893.007.382,15	12.448.247.214,99
14	1,273	12,923	106.857.410.810	1.360.401.697,03	13.808.648.912,03
15	1,464	14,387	106.857.410.810	1.564.606.209,09	15.373.255.121,12
16	3,831	18,218	106.857.410.810	4.093.644.812,95	19.466.899.934,07
17	4,221	22,438	106.857.410.810	4.509.993.394,77	23.976.893.328,84
18	0,989	23,427	106.857.410.810	1.056.592.080,24	25.033.485.409,08
19	3,198	26,625	106.857.410.810	3.416.836.789,24	28.450.322.198,33

Source: Processed by Researchers, 2024

Evaluation of project performance through Schedule Performance Index (SPI) and Cost Performance Index (CPI) indicators at week 25 showed contrasting dynamics. The SPI value was identified to be below the ideal threshold at 0.7929, confirming delays in project execution. In contrast, the CPI recorded a value of 1.2354 which surpassed the optimal standard, validating a significant level of efficiency in the management of the financial aspects of the project. This phenomenon underscores that despite the challenges in achieving time targets, the management has managed to optimize the use of the budget very effectively.

Table 3. Comparison of PV, EV, and AC

Week	Planned Value (Rp)	Earned Value (Rp)	Actual Cost (Rp)
1	46.578.131,87	157.641.248,16	-
2	93.156.263,74	265.271.919,48	3.546.297.162,08

3	294.268.042,51	494.199.710,10	3.546.297.162,08
4	619.006.738,80	683.515.565,40	3.546.297.162,08
5	974.652.164,47	882.268.212,36	3.546.297.162,08
6	1.391.747.580,34	1.156.838.329,44	3.546.297.162,08

Source: Processed by Researcher, 2024

Based on projection calculations using SPI data at week 25, assuming consistency in work speed, it is estimated that an extension of approximately 17 days is needed to complete the entire scope of work. From a financial perspective, the estimated final project cost is predicted to reach IDR 99,187,494,986.54, still much more efficient than the initial contract value set at IDR 106,857,410,810.81, giving a positive indication of the prospect of substantial budget savings.

The synthesis of all analytical parameters identified that the fundamental challenge in this project lies in the aspect of implementation time management. Nevertheless, the achievement of excellent cost efficiency attests to the effectiveness of the project's budget management. To accelerate the progress of the works, several strategies have been formulated, including intensification of working hours and optimization of works that have no dependency on material availability, in the hope of minimizing the impact of delays that occur.

Analysis

The implementation of the Earned Value Management (EVM) method in the performance evaluation of the Yohanis Kapiyau Airbase Infrastructure and Facilities Improvement Project has resulted in a comprehensive analysis that provides an in-depth perspective on the effectiveness of cost and time management. Through the comparison of three key parameters - Planned Value (PV), Earned Value (EV), and Actual Cost (AC) - a detailed quantitative evaluation of project achievements up to week 25 was obtained. The analysis indicated that the PV value significantly exceeding the EV confirmed the deviation from the planned timeline, reflected by a negative Schedule Variance (SV) of -Rp 12,965,950,854.78. The magnitude of this negative SV value underscores the reality that the volume of work that has been realized still lags behind the target set in the initial planning.

Table 4. Time Performance Index (SPI) and Cost Performance Index (CPI)

Week	Planned Value	Earned Value	Actual Cost	SPI	CPI
1	46.578.131,87	157.641.248,16	-	3,3844	#DIV/0!
2	93.156.263,74	265.271.919,48	3.546.297.162,08	2,8476	0,0748

Source: Researcher's Process, 2024

In terms of cost control, the evaluation showed a very encouraging achievement, evidenced by a positive Cost Variance (CV) of IDR 9,460,450,146.01, confirming that the actual cost realization was successfully controlled under the budget allocated for the completed works. This financial efficiency is reinforced by the Cost Performance Index (CPI) value of 1.2354, which validates that every rupiah invested in the project produces a value of

work greater than the nominal expenditure, demonstrating a highly effective optimization of budget use.

However, the fundamental challenge faced by this project lies in the aspect of implementation time performance. The Schedule Performance Index (SPI) recorded at 0.7929 indicates that the project progress is experiencing significant delays compared to the planned schedule. Some of the potential factors contributing to this delay include constraints in the material supply chain, unoptimized coordination between stakeholders, and limited resources in the field. The implication of this condition is reflected in the projected completion time which requires an extension of up to 17 days from the original timeline. To overcome this challenge, several acceleration strategies have been formulated, including intensification of operational hours and prioritization of works that have no dependency on material availability.

Based on the comprehensive analysis that has been conducted, it can be concluded that although the project faces challenges in the aspect of timeliness, the achievement of excellent cost efficiency has a positive impact on the overall project performance. Through proper planning reformulation and effective implementation of mitigation strategies, there are significant opportunities to optimize the project's time performance going forward.

Model Test

In the case of the Yohanis Kapiyau Airbase Infrastructure and Facilities Improvement Project, the implementation of the Earned Value Management (EVM) methodology has proven its effectiveness as an analytical instrument that integrates cost and time dimensions comprehensively. This analytical framework operationalizes three fundamental parameters: Planned Value (PV), Earned Value (EV), and Actual Cost (AC), which collectively have succeeded in identifying with precision the problems of time delays and achieving cost efficiency in project implementation.

Model validation was conducted through continuous comparative analysis of PV, EV, and AC parameters throughout the duration of project implementation. The evaluation results up to week 25 confirmed that the EV magnitude was consistently below the PV indicating a deviation from the planned timeline. However, the recording of AC which was consistently lower than EV provided empirical validation of the achievement of efficiency in managing the financial aspects of the project. The visual representation through the comparison graph of the three parameters provides a very comprehensive picture of the project performance trajectory at each phase of its implementation.

A more granular evaluation was conducted through the use of Schedule Performance Index (SPI) and Cost Performance Index (CPI) indicators to measure time and cost performance more specifically. SPI values identified as below the 1.0 threshold confirmed delays in project execution, while CPI exceeding 1.0 validated significant levels of efficiency in budget management. The analytical model was also utilized to formulate the projected time and cost of project completion, where the calculation results indicated the need for a time extension of 17 days, with an estimated final total cost of IDR 99,187,494,986.54, which is still much more efficient than the initial contract value set. The implementation of EVM in this project has proven its reliability as a highly effective performance evaluation instrument.

This methodology is not only able to provide an accurate assessment of the project's actual performance, but also produces reliable projections for strategic decision-making in optimizing project implementation in the future.

Testing Results

A comprehensive evaluation of the performance of the Yohanis Kapiyau Airbase Infrastructure and Facilities Improvement Project up to week 25 produced very significant findings. Schedule Performance Index (SPI) analysis recorded a value of 0.7929, indicating a substantial deviation from the planned timeline. On the other hand, the Cost Performance Index (CPI) of 1.2354 provides empirical validation of the achievement of excellent efficiency in the management of financial aspects, where the realized expenditure is optimally controlled under the budget allocation for the volume of work that has been realized. The synthesis of these two parameters confirms that while the project faces challenges in timeliness, management has managed to optimize the use of the budget very effectively.

Table 5. Schedule Variance (SV) and Cost Variance (SV)

Week	Schedule Variance (SV	Description	Cost Variance (SV)	Description
1	111.063.116,29	Positive	157.641.248,16	Positive
2	172.115.655,74	Positive	-3.281.025.242,61	Negative
3	199.931.667,60	Positive	-3.052.097.451,98	Negative
4	64.508.826,60	Positive	-2.862.781.596,68	Negative

Source: Processed by Researchers, 2024

Based on projection calculations using the latest SPI data, the estimated project completion time indicates the need for a 17-day duration extension from the original timeline, bringing the total projected time to complete the entire scope of work to 257 days. From a financial perspective, the final project cost forecasting is predicted to reach IDR 99,187,494,986.54, a very encouraging achievement considering that the value is still far below the stipulated contract value, validating a very significant level of efficiency in managing the project budget.

The results of this evaluation provide a very detailed and accurate assessment of the actual status of the project. Despite fundamental challenges in the aspect of implementation time management, the achievement of excellent cost efficiency has a positive impact on the overall project performance, while providing a strong foundation for strategic decision-making in the optimization of future project implementation.

Hypothesis Test

Based on the evaluation results using the Earned Value method, hypothesis testing showed varying results regarding project performance in terms of time and cost. Analysis of the Schedule Performance Index (SPI) which is consistently below the value of 1 indicates a negative deviation in the implementation schedule, so the hypothesis about the timeliness of project completion must be rejected. This answers the second problem formulation regarding

the evaluation of project time control, where Schedule Variance indicates delays that need to be addressed.

On the other hand, in answering the first problem formulation regarding the evaluation of cost control, the Cost Performance Index (CPI) which is consistently above the value of 1 supports the acceptance of hypotheses related to the efficiency of project cost management. This indicates that the Cost Variance is in a positive condition and the estimated total cost until project completion is still within acceptable limits.

Regarding the third problem formulation, the application of Earned Value method has helped identify that the main challenge of the project lies in the aspect of time performance, while cost management shows good efficiency. This information allows the project manager to take appropriate strategic decisions, such as the implementation of fast-tracking strategies, optimization of resource allocation, and schedule adjustments to address the identified delays, while still maintaining good cost management efficiency.

Discussion

The evaluation of project cost control shows very positive results, with a positive Cost Variance (CV) of Rp 9,460,450,146.01. This indicates that the actual costs incurred are still below the budget allocation for the volume of work that has been realized. The Cost Performance Index (CPI) recorded a value of 1.2354 which exceeds the optimal standard, validating significant efficiency in managing the financial aspects of the project. The estimated final project cost is predicted to reach IDR 99,187,494,986.54, still much more efficient than the initial contract value set at IDR 106,857,410,810.81, providing the prospect of substantial budget savings.

In terms of time control, the evaluation showed significant challenges in project implementation. The Schedule Variance (SV) was negative at -Rp 12,965,950,854.78, confirming a delay in the project implementation progress compared to the planned timeline. The Schedule Performance Index (SPI) was below the ideal threshold with a value of 0.7929, and based on projected calculations using SPI data at week 25, it was estimated that an extension of approximately 17 days would be required to complete the entire scope of work, with a total completion time of 257 days.

The application of the Earned Value method has proven effective in helping project managers make strategic decisions. Through a comprehensive analysis that integrates cost and time dimensions, the method successfully identified with precision that the fundamental challenge of the project lies in the aspect of time management, while cost management shows excellent efficiency. This information enabled management to formulate appropriate acceleration strategies, such as intensification of working hours and optimization of work that had no dependency on material availability. This methodology not only provides an accurate assessment of the project's actual performance, but also produces reliable projections for strategic decision-making in optimizing future project implementation.

CONCLUSION

The evaluation of the Yohanis Kapiyau Timika Airbase Infrastructure Improvement project reveals strong cost control performance, indicated by a consistently high Cost

Performance Index (CPI) above 1, suggesting effective financial management. However, time management faces significant challenges, as evidenced by a Schedule Performance Index (SPI) below 1 and a negative Schedule Variance (SV), indicating notable deviations from the planned timeline. The estimated cost to complete the remaining work is approximately Rp. 14,756,485,176.51, leading to a projected total final cost of Rp. 99,187,494,986.54, with an additional 82 calendar days required for completion, extending the total duration to 257 days—17 days beyond the initial schedule. To enhance future project implementation, it is recommended that service providers adopt the Earned Value Management (EVM) methodology from the project's outset to mitigate cost and time deviations, and consider integrating the Critical Path Method (CPM) for better scheduling accuracy. Additionally, future researchers should expand the literature on critical variables affecting project performance and conduct thorough cost analyses to develop more effective strategies for mitigating delays.

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