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Measurement of Project Cost and Time Efficiency with Earned Value Approach In The Implementation of Baggage Handling System at Sultan Hasanuddin International Airport Makassar

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ABSTRACT
The installation of the Baggage Handling System (BHS) at Sultan Hasanuddin International Airport, Makassar, faces challenges related to cost and time inefficiencies, particularly delays in project completion. This study aims to evaluate these inefficiencies by applying the Earned Value Method (EVM) to assess project performance and identify areas for improvement. Utilizing EVM metrics, the research identifies that the Schedule Performance Index (SPI) is below 1, indicating a delay in the project timeline, with the actual duration extending to 556 calendar days compared to the planned 546 days. This delay underscores the need for a more robust project management approach. The study employs the Critical Path Method (CPM) in conjunction with Microsoft Project to improve scheduling accuracy, alongside recommendations for project acceleration using the Crashing Program method. The findings highlight that early implementation of EVM can help mitigate discrepancies in cost and time, enabling better control and monitoring throughout the project lifecycle. The study concludes that integrating advanced scheduling techniques and real-time performance metrics is essential to achieving efficiency and minimizing delays in similar infrastructure projects.

Introduction

Baggage handling systems have a very important role in supporting the smooth operation of airports. With the increasing number of flight movements, both in terms of passengers and aircraft, the technology used to handle baggage has also experienced rapid development. Currently, various modern airports have adopted Automatic Baggage Handling Systems (BHS) as an efficient, effective, and more sophisticated solution in baggage handling. As a service improvement measure, PT Angkasa Pura I plans to implement an automated BHS system with five security levels at Sultan Hasanuddin

Airport, Makassar. 5.1.1 General Features BHS covers various technical and operational aspects designed to ensure efficiency and security in the baggage handling process (V. S. Pratama, 2022).

The system is expected to automatically identify and make corrections or improvements to various conditions, including the handling of "Oversize and Overweight Bags" in the check-in area. The oversize baggage is transported using a vertical lift conveyor. The placement of the conveyor motor position is adjusted to the availability of space and the ease of the maintenance process both preventive and corrective. Conveyors that are in a hanging or high position, equipped with a proper walkway or platform at each conveyor position complete with stairs or access to the maintenance path in the area according to maintenance needs (Rekiek, 2023).

Types and Standards of Baggage handled Generally the system will handle plastic, leather, fabric, backpacks, travel bags, boxes/cartons, steel and aluminum luggage. Uncommon shapes or sizes will be placed in the Baggage Tray bin and will be handled manually through the OOG facility. This specialized equipment is proposed to be used on a limited basis in small quantities. The system is designed to handle an assortment of baggage types as per IATA standards with dimensions Maximum length 900mm and minimum 300mm maximum height 700mm minimum 200mm Maximum width 470mm 75mm Weight 50kg 0.5kg Baggage that does not fall within the above sizes such as pushchairs, golf bags, skateboards, loose materials, etc. will be handled separately and categorized as OOG (Out of gauge). This kind of baggage will be treated specially and checked separately (Janizar, 2023).

BHS equipment is also required to be able to work in redundancy when one or part of the system is not functioning so that it will not interfere with overall operations. BHS can track baggage and allocate baggage according to predetermined destinations. Load Design For sizing motor drives, shaft bearings etc., load limitations need to be considered. Belt Conveyors, Static load, Dynamic Load, Walkways and Maintenance Platform Superload-Walkways, Superload-Platforms min. 100 kg, min. 40 kg, min 150 kg/m2, min 370 kg/m2.

PPUPG Baggage Handling System (BHS) Installation Work at Sultan Hasanudin International Airport Makassar is realized in 2023. This work is in parallel with other Sultan Hasanudin airport development work. This work package started on July 13, 2023 and was expected to end on January 08, 2025. In reality, the implementation of this project did not go as smoothly as expected. This project also depends on other projects such as the unfinished mechanical electrical part so that the monitor installation work will be stopped, as seen from the monitoring of the weekly report of PT. Dexter Wika Sinergi (PT DWS) which is the provider on this project from week 1 to the week the researcher goes to the field almost all progress plans are delayed (Dewaji et al., 2023).

The peak in week 44 occurred a deviation of 16.232% due to the arrival of new materials in April the process of installing conveyors and installations and acknowledging field progress against the agreement in the progress rules The project delay also continued until week 63 dated September 17, 2024. From week 44 to week 66, the reason for the delay or lack of progress is because the OOG LINE could only be completed in M.54 due to the installation process, the spiral chute was installed late due to the production and delivery process from Italy and was only completed in M.64. Redundancy LDL A-B new installation process completed in M48 EDL BA just completed, M48 ETD new recon room completed in M54, Clear line BA just completed in M48 Domestic Arrival completed in M46, domestic OOG just completed in M48, Main Terminal Min Ops

Integration just completed in M.55, new structural work completed in M60. This week, even though the material has been installed, if there is no Commissioning test for a small test, the progress of the work still cannot be considered installed so the progress remains even though the goods are already on site (Sari et al., 2021).

Scheduling planning that faces problems with limited labor resources must be evaluated thoroughly. One way to overcome scheduling with limited resources is to systematically try to determine standards that are by planning objectives or consider the possibility of differences between project standards and implementation that must be carried out at the beginning and end of the project development process (J. Pratama & Sandro, 2022).

Project delays can lead to cost increases. Therefore, a management approach is needed to monitor the time efficiency of the project completion duration against the project budget. This monitoring effort aims to minimize the risk of delays and cost overruns, one of which is by applying the Earned Value Analysis method. This method is used to evaluate the actual cost of completed work in accordance with the project budget allocation (Christy et al., 2023). This research is expected to be able to assess time requirements to assess losses or delays at the end of the project by estimating construction parameters through the earned value analysis approach.

Erratic delays and lack of ability to manage resources, at least still have an influence on project activities both in terms of cost, and implementation time. The costs incurred in the implementation process must be anticipated in such a way as to avoid cost overruns at the end of the project (Cost Overrun). To control the performance of the Baggage Handling System (Bhs) PPUG Installation Work at Sultan Hasanudin International Airport Makassar so as not to experience delays and not exceed the budgeted costs based on the bid RAB, the researchers used the Earned Value Method.

Problem Formulation

From the background above, the following problem formulation can be made:

1. How is the time performance during monitoring in terms of Schedule Performed Index?
2. What is the estimated total project implementation time until the project ends in review and Estimated All Schedule (EAS)?

Research Objectives

The objectives of this research are as follows:

1. Time productivity index (Schedule Performed Index), in the construction of the Baggage Handling System (BHS) PPUPG Installation Work building at Sultan Hasanudin International Airport Makassar.
2. Knowing the estimated project time estimate until the project ends in terms of the Estimated All Schedule (EAS).

Literature Review

Project

A project is an undertaking that produces a series of deliverables within a specified time, cost, and quality. A project is a unique endeavor that produces a single unit of output. In general, projects involve several people whose activities are interconnected and the primary project sponsor is generally concerned with the effective use of resources to complete the project efficiently and on time. Projects have a clear objective or scope of work, based on the technical and administrative requirements that have been developed. Projects are implemented by project contractors on a temporary basis which will be disbanded after the project ends. (Rahman et al., 2022).

Project Management

Project management is a project strategy starting from planning, controlling and implementing projects for more efficient and effective achievement. success of good project management can improve the quality of a project so that there is a positive relationship between project management success and project quality (Ritonga et al., 2023).

According to (Bambang Siswanto & Afif Salim, 2019), project management is a process of planning, organizing, directing and controlling company resources with short-term goals to achieve specific objectives.

Project management is the application of science, skills, tools, and techniques to the activities of a project with the intention of meeting or exceeding stakeholder needs and expectations of a project. according to (Siswanto & Salim, 2019), project management is all the planning, implementation, control, and coordination of a project from the beginning (idea) to the completion of the project to ensure project costs are carried out on time, at the right cost, and at the right quality.

Project Cycle

Project cycle, i.e. conceptual stage, PP/Definition stage, implementation stage, project termination. Each stage has different types of activities and intensity. The main activity at the conceptual stage is feasibility assessment, while the following stages are successively planning and stabilization, (PP or Definition), design-engineering, procurement, manufacturing and construction, and finally commissioning before handing over to the project owner (Nugroho et al., 2019).

The project cycle describes the sequence of steps from the beginning of the process to the end of the project**.** To better understand the stages of activities in the project cycle, below is explained the cycle of construction projects, manufacturing and infrastructure projects based on the duration of time and costs to be incurred.

Figure 1: Construction Project Cycle

Source: (Bambang Siswanto & Afif Salim, 2019)

Construction Project Cycle:

1. Intellectual Idea Stage This stage consists of activities, idea formulation, terms of reference, preliminary feasibility study, preliminary indication of project dimensions, cost and schedule.
2. Feasibility Study Stage: Feasibility study with the aim of obtaining a decision on the continuation of investment in the project to be carried out. Information and data in the implementation of project planning are more complete than the steps above, so that the determination of project dimensions and costs is more accurate with a comprehensive review of social, cultural, economic, financial, legal, technical and administrative aspects.
3. Detail Design Stage: This stage consists of activities, deepening various aspects of the problem, engineering design and development, creating master schedules and budgets and determining resource planning, early purchasing, preparing equipment and determining project participants with a tender program. The purpose of this stage is to establish a complete and detailed planning document, technically and administratively, to facilitate the achievement of project goals and objectives.

4. Procurement stage: This stage is to select the implementing contractor by including planning documents, complete technical and administrative rules, detailed design stage products. From this process, competitive bids obtained from contractors with a good level of accountability and transparency.
5. Implementation Stage: This stage consists of activities, detailed engineering design, development of specifications and criteria, purchase of equipment and materials, fabrication and construction, quality inspection, testing, start-up, demobilization and project closing report. The ultimate goal of the project is to obtain the maximum cost, quality, time and safety performance, by carrying out a more careful and detailed planning, scheduling, implementation and control process than the previous process. At this stage the contractor has a dominant role with the ultimate goal of achieving project goals and getting maximum profit. The role of owning the project at this stage is carried out by the owner's agent as an implementation supervisory consultant, with the aim of reducing all kinds of deviations and taking the necessary corrective actions.
6. Operation and Maintenance Stage This stage consists of routine operations and observations of the project's final achievements and maintenance of building facilities that can be used for the social and economic interests of the community. The costs incurred at this stage are routine and the value tends to decrease and at this stage there is an income of funds from project operations.

Time Management

Time performance standards are determined by referring to all stages of project activities along with the duration and use of resources. From all the information and data that has been obtained, a scheduling process is carried out so that there will be output in the form of complete report formats regarding time progress indicators, as follows:

1. Barchart, a bar chart that can simply show information on the project schedule plan and its duration, then compared with the actual progress so that it is known whether the project is late or not.
2. Network Planning, as a network of various activities, can show critical activities that require close supervision so that their implementation is not delayed. The Network Planning format is also used to determine activities that are loose in completion time based on their total float, so that all of them can be used to improve the schedule and so that the allocation of resources becomes more effective and efficient.

An Earned Value curve that can express time progress based on a predetermined baseline for a given period according to the actual progress of the project. If there are indications that the time is later than planned, it can be corrected by rescheduling the project and forecasting how long the duration required for project completion will be due to the deviation, as well as by increasing the number of alternate time labor.

Project Control and Scheduling

Project scheduling is the activity of determining the period of project activities that must be completed, raw materials, labor and time required by each activity. Microsoft Project is a software product created for project management developed by the Microsoft company. Microsoft Project is designed to assist the work process in scheduling, determining human and material resources, viewing work progress, controlling and managing budgets and analyzing weights or loads. on existing jobs, so Microsoft Project can be a tool for creating good reporting and controlled planning. The things that must be considered in managing a project using Microsoft Project are as follows:

1. Setting Objectives

Goal setting is the main thing in scheduling because the goal is the direction in which a project work will be directed so that it can determine the completion time of the work and has a predetermined goal by carrying out the work in a focused manner so that it can cause efficiency in a long period of time. work completion time;

2. Set priorities

Prioritization is a process or action to organize work by prioritizing interrelated or urgent work to be done first to avoid time delays, but the work must be in accordance with the normal order of work, in accordance with technical specifications and work methods.

3. Avoid Procrastination

In scheduling, you should avoid delaying work because delaying work can disrupt the work cycle and result in delays in achieving work goals.

4. Minimize Wasted Time

Avoid work that takes a long time but provides maximum impact or benefits from the work (Wahyusetianingsih et al., 2023).

Earned Value Method

The Earned Value concept is one of the tools used in project management that integrates cost and time. The Earned Value concept presents three dimensions, namely the physical completion of the project (the percent complete) which reflects the planned absorption of costs (budgeted cost), the actual costs that have been incurred or called Actual Cost and what is obtained from the costs that have been incurred or called Earned Value. Of these three dimensions, with the concept of Earned Value, it can be connected between cost and time performance derived from the calculation of variance from cost and time (Mahulae et al., 2022). Of the three dimensions, with the concept of Earned Value, it can be connected between cost performance and time derived from the calculation of variants of cost and time (Nono et al., 2019).The basic concept of Earned Value can be used to analyze performance and make estimates of goal achievement. The indicators used are actual cost and earned value. The indicators used to perform Earned Value analiysis are stated as follows:

1. Actual Cost

Actual Cost (AC) or Actual Cost of Work Performed (ACWP) refers to the total actual costs incurred for completed work within a specific reporting period. These costs are compiled based on accounting records or project financial data as of the reporting date, such as the end of the month. The records include all actual expenditures, including costs from work packages or accounting codes, plus the calculation of overheads and other components. As such, Actual Cost (AC) represents the total funds that have factually been used to carry out the work within a given time period.

ACWP = Direct Cost + Indirect Cost.....(1)

2. Result Value

Earned Value (EV) or Budgeted Cost of Work Performanced (BCWP) is the value of the work that has been completed against the budget provided to carry out the work. When the AC number is compared to the Earned Value (EV), it will show a comparison between the costs that have been incurred for the work carried out against the costs that should have been incurred for this purpose.

BCWP = % (Realization Weight) x Contract Value (RAB) ..... (2)

3. Budget Schedule

Budget Schedule (Planned Value = PV) or Budgeted Cost of Work Schedule (BCWS) shows the budget for a work package that is compiled and linked to the implementation schedule. Here there is a combination of cost, schedule and scope of work, where each work element has been given an allocation of costs and schedules that can be a benchmark for reporting the implementation of the work.

BCWS = % (Plan Weight) x Contract Value (RAB) ..... (3)

Project Performance

Performance standards are needed as a reference to control resource utilization in a project. The aim is to ensure that available resources can be used optimally and efficiently during project implementation.

a. Schedule Performance Index (CPI)

The performance efficiency factor in completing the work can be shown by the comparison between the value of the work that has been physically completed Earned Value (EV) with the planned cost expenditure incurred based on the work plan Planned Value (PV).

SPI = BCWP / BCWS..... (4)

Where,

SPI	:	Schedule Perfomance Index, a performance efficiency factor in completing work.
BCWP	:	Budgeted Cost Of Work Performance Earned Value, The budgeted cost of work performed...
BCWS	:	Budgeted Cost Of Work Schedule / Planned Value, the budgeted cost of work scheduled for a specific period.

The Schedule Performance Index (SPI) value shows how much work can be completed (relative to the overall project) against the planned unit of work. A Schedule Performance Index (SPI) value of less than 1 indicates that the work performance is not as expected because it is unable to achieve the planned work target.

Predicted Project Completion Time

The Earned Value method can also be used to estimate the final time of the project. Estimates are calculated based on performance trends and the assumption that these trends will not change until the end of the project.

a. **Estimate to Schedule (ETS**)

The ETS is an estimate of the project completion time. The assumption used to estimate the completion time is that the project performance trend will remain as it was at the time of the review.

ETS = SAC - tBCWP /SPI.....(5)

b. Estimate at Schedule (EAS)

Is an estimate of the total completion time until the end of the project (Rifatul Muniroh et al., 2024)

EAS = tBCWP + ETS .....(6**)**

The urgency of this research arises from the critical need to enhance project management practices in large-scale infrastructure projects like the Baggage Handling System (BHS) installation at Sultan Hasanuddin International Airport, Makassar. Delays and cost overruns in such projects not only disrupt operational timelines but also increase financial burdens, affecting overall efficiency and stakeholder confidence. Addressing these inefficiencies through advanced project management methodologies is essential to ensure timely completion and budget adherence.

The research gap lies in the limited application of integrated performance evaluation methods, such as the Earned Value Method (EVM), within Indonesian infrastructure projects. While EVM has been extensively utilized in global contexts to monitor cost and time efficiency, its adoption remains inconsistent domestically. Moreover, studies focusing on combining EVM with tools like the Critical Path Method (CPM) and project management software, such as Microsoft Project, are scarce, leaving room for further exploration of their synergistic potential in mitigating delays and improving project outcomes.

The novelty of this study lies in its approach to integrating EVM with CPM and Crashing Program methods to evaluate and optimize project performance comprehensively. By applying these methods in a real-world context, the research not only assesses their effectiveness but also proposes an adaptable framework for managing similar infrastructure projects in Indonesia. This approach bridges theoretical knowledge and practical application, providing actionable insights for future projects.

The study aims to evaluate the cost and time efficiency of the BHS installation project using EVM and propose strategies for optimizing performance. The findings benefit project managers, contractors, and stakeholders by offering improved tools and methodologies for project monitoring and control. Ultimately, this research contributes to advancing project management practices, fostering greater accountability, and ensuring the successful delivery of critical infrastructure projects.

Research Methods

Research Location

The research location is the PPUPG Baggage Handling System (BHS) Installation Work at Sultan Hasanudin International Airport Makassar.

Data

The data in this study was collected through two approaches, namely primary and secondary data. Project observation is the approach to collect primary data. Then, secondary data includes data taken outside of observation, namely the Cost Budget Plan, Actual Cost, and Project Progress Report Per Week, and Project Implementation Schedule. It is mentioned that Actual Cost is one of the data sources for this research. The cost is formed by the sum of direct costs including material costs; labor costs; and tool costs, as well as indirect costs including office overhead costs and field overhead costs.

Data Analysis Technique

a. BCWS (Bugeted Cost Of Work Scheduled) is the amount of budgeted costs for work scheduled for a certain period of time and specified in the budget, obtained by multiplying the percentage of progress plans contained in the time schedule with the project implementation costs listed in the RAB. The BCWS value is calculated using equation 2.
b. BCWP (budgeted cost of work performed) is the amount of costs incurred, for work that has been carried out, obtained by multiplying the percentage of progress that has been carried out by the BCWP Value budget.
c. ACWP (Actual Cost Of Work Performed) is the actual cost expenditure, of work that has been done up to a certain period of time. These costs are obtained from accounting data on the reporting date, records of all direct costs, non-overhead costs and other costs. This calculation is only an estimate or estimate that is assumed to be the real cost used.

d. Schedule (Schedule Performed Index) / Cost Index Productivity and performance, a comparison between the cost provided according to budgeting for work activities that have been carried out (BCWP) and the actual cost of work activities that have been carried out (ACWP).
e. Projected Period of Project Completion, making a forecast of the project completion schedule based on the indicators obtained at the time of reporting, will provide an indication of the length of estimated project completion time (Estimate All Schedule =EAS) calculated by equation 6. The forecast or schedule is very useful because it provides an early warning of things that will happen in the future, if the trends that existed at the time of reporting do not change. If the remaining work is considered to be performing as it was at the time of reporting,
f. Estimate Time Schedule (ETS) calculated by equation 5, the calculation is continued by calculating the amount of cost needed to complete the project without any additional time assuming that the estimated project completion time (Estimate All Schedule = EAS) is the same as the Implementation Time Plan (T total) calculated using formula 6.

Results and Discussions

Budgeted Cost of Schedule (BCWS) Analysis

BCWS or often called Planned Value is obtained from multiplying the percentage of the work plan by the total project cost budget or contract value and then accumulated every week. Where BCWS week 66 is as follows.

BCWS = % (Plan weight) x Contract value (RAB)

= 0.024% X IDR 366,500,000,000

= Rp. **8,679,290,309.78**

The cumulative BCWS value at reporting week 66 is

= **99.980%** X Rp. 366,500,000,000 = Rp. 366,425,788,571.43 Analysis for other weeks can be done in the same way as the calculation above. The results of the calculation can be seen in Table 1 as follows:

Table 1. BCWS Recapitulation

Sunday	Realization Weight %		Value	BCWS (Rp)	
to-	Weekly	Cumulative	Contract	Weekly	Cumulative
1	0.000	0.000	366.500.000.000	-	-
2	0.000	0.000	366.500.000.000	-	-
3	0.000	0.000	366.500.000.000	-	-
4	0.000	0.000	366.500.000.000	-	-
5	0.000	0.000	366.500.000.000	-	-
6	0.000	0.000	366.500.000.000	-	-
7	0.000	0.000	366.500.000.000	-	-
8	0.000	0.000	366.500.000.000	-	-
9	0.000	0.000	366.500.000.000	-	-
10	0.000	0.000	366.500.000.000	-	-
11	0.000	0.000	366.500.000.000	-	-
12	0.000	0.000	366.500.000.000	-	-
13	0.000	0.000	366.500.000.000	-	-
14	0.000	0.000	366.500.000.000	-	-
15	0.000	0.000	366.500.000.000	-	-
16	0.000	0.000	366.500.000.000	-	-
17	0.000	0.000	366.500.000.000	-	-
18	0.000	0.000	366.500.000.000	-	-

19	0.000	0.000	366.500.000.000	-	-
20	0.000	0.000	366.500.000.000	-	-
21	0.000	0.000	366.500.000.000	-	-
22	0.034	0.034	366.500.000.000	125.588.571,43	125.588.571,43
23	0.013	0.047	366.500.000.000	48.219.209,73	173.807.781,15
24	0.020	0.067	366.500.000.000	73.263.355,81	247.071.136,96
25	0.006	0.073	366.500.000.000	21.432.203,24	268.503.340,20
26	0.120	0.193	366.500.000.000	438.570.878,01	707.074.218,21
27	0.008	0.201	366.500.000.000	29.723.802,02	736.798.020,24
28	0.087	0.288	366.500.000.000	319.549.048,88	1.056.347.069,12
29	0.008	0.296	366.500.000.000	29.723.802,02	1.086.070.871,14
30	0.008	0.304	366.500.000.000	29.723.802,02	1.115.794.673,17
31	0.531	0.835	366.500.000.000	1.945.649.851,46	3.061.444.524,63
32	1.238	2.073	366.500.000.000	4.536.788.173,32	7.598.232.697,94
33	0.008	2.081	366.500.000.000	29.723.802,02	7.627.956.499,97
34	1.946	4.027	366.500.000.000	7.131.007.623,91	14.758.964.123,87
35	1.378	5.405	366.500.000.000	5.051.723.366,67	19.810.687.490,55
36	2.130	7.536	366.500.000.000	7.807.023.666,86	27.617.711.157,41
37	23.577	31.113	366.500.000.000	86.409.740.023,59	114.027.451.181,00
38	0.008	31.121	366.500.000.000	29.723.802,02	114.057.174.983,03
39	0.000	31.121	366.500.000.000	-	114.057.174.983,03
40	0.000	31.121	366.500.000.000	-	114.057.174.983,03
41	0.008	31.129	366.500.000.000	29.723.802,02	114.086.898.785,05
42	0.008	31.137	366.500.000.000	29.723.802,02	114.116.622.587,07
43	0.008	31.145	366.500.000.000	29.723.802,02	114.146.346.389,10
44	0.008	31.153	366.500.000.000	29.723.802,02	114.176.070.191,12
45	0.018	31.171	366.500.000.000	64.712.209,70	114.240.782.400,83
46	4.836	36.007	366.500.000.000	17.725.474.524,65	131.966.256.925,48
47	0.008	36.015	366.500.000.000	29.723.802,02	131.995.980.727,50
48	1.594	37.610	366.500.000.000	5.843.756.467,26	137.839.737.194,76
49	0.031	37.640	366.500.000.000	112.400.484,31	137.952.137.679,07
50	0.083	37.723	366.500.000.000	303.373.361,55	138.255.511.040,62
51	0.008	37.731	366.500.000.000	29.723.802,02	138.285.234.842,64
52	5.063	42.795	366.500.000.000	18.557.449.487,48	156.842.684.330,12
53	0.008	42.803	366.500.000.000	29.723.802,02	156.872.408.132,14
54	7.059	49.862	366.500.000.000	25.870.419.987,45	182.742.828.119,60
55	0.008	49.870	366.500.000.000	29.723.802,02	182.772.551.921,62
56	0.000	49.870	366.500.000.000	-	182.772.551.921,62
57	0.000	49.870	366.500.000.000	-	182.772.551.921,62
58	0.000	49.870	366.500.000.000	-	182.772.551.921,62
59	0.000	49.870	366.500.000.000	-	182.772.551.921,62
60	13.230	63.100	366.500.000.000	48.489.626.188,90	231.262.178.110,52
61	1.708	64.808	366.500.000.000	6.260.067.065,95	237.522.245.176,48
62	5.848	70.656	366.500.000.000	21.431.207.292,27	258.953.452.468,75
63	10.710	81.365	366.500.000.000	39.250.522.984,30	298.203.975.453,04
64	5.456	86.821	366.500.000.000	19.995.337.669,84	318.199.313.122,88
65	0.399	87.220	366.500.000.000	1.462.212.714,42	319.661.525.837,30
66	**2.262**	**89.482**	**366.500.000.000**	**8.289.869.356,17**	**327.951.395.193,47**
67	0.002	99.981	366.500.000.000	570.857.142,86	366.431.497.142,86
68	0.002	99.983	366.500.000.000	570.857.142,86	366.437.205.714,29
69	0.002	99.984	366.500.000.000	570.857.142,86	366.442.914.285,71
70	0.002	99.986	366.500.000.000	570.857.142,86	366.448.622.857,14
71	0.002	99.988	366.500.000.000	570.857.142,86	366.454.331.428,57
72	0.002	99.989	366.500.000.000	570.857.142,86	366.460.040.000,00
73	0.002	99.991	366.500.000.000	570.857.142,86	366.465.748.571,43

74	0.002	99.992	366.500.000.000	570.857.142,86	366.471.457.142,86
75	0.002	99.994	366.500.000.000	570.857.142,86	366.477.165.714,29
76	0.002	99.995	366.500.000.000	570.857.142,86	366.482.874.285,71
77	0.002	99.997	366.500.000.000	570.857.142,86	366.488.582.857,14
78	0.003	100.000	366.500.000.000	1.141.714.285,71	366.500.000.000,00

The table above is the project progress data obtained from the supervisory consultant up to week 66, while in week 67 until the last week the data is based on schedule plan data or progress plan data per week. In table 4.3 the BCWS value or budget planned up to week 66 is Rp. 366,425,788,571 while the Budget Cost planned until the project ends in week 78 is in accordance with the Contract value which is worth Rp. 366,500,000,000.

In the first week it is planned with a weight of 0.002% if converted in rupiah is worth Rp. 570. 857,142 The cumulative value in week 1 is still the same as the plan week while the weight of the plan in week 2 is 0.002% multiplied by the contract value so that the value of Rp. 570. 857,142 in the cumulative weight of the first week's value is added to the weight of week 2. And so on until the last week and the work weight reaches 100% or with an acquisition value of Rp. 366,500,000.

The planned week of no work activity as shown in week thirty-nine or week forty is due to the presence of a Muslim holiday, namely the moment of Eid al-Fitr in 2024 so that the progress of the work weight and the acquisition is still the same as week thirty-eight.

For more details, the table above can be made into a graph as follows.

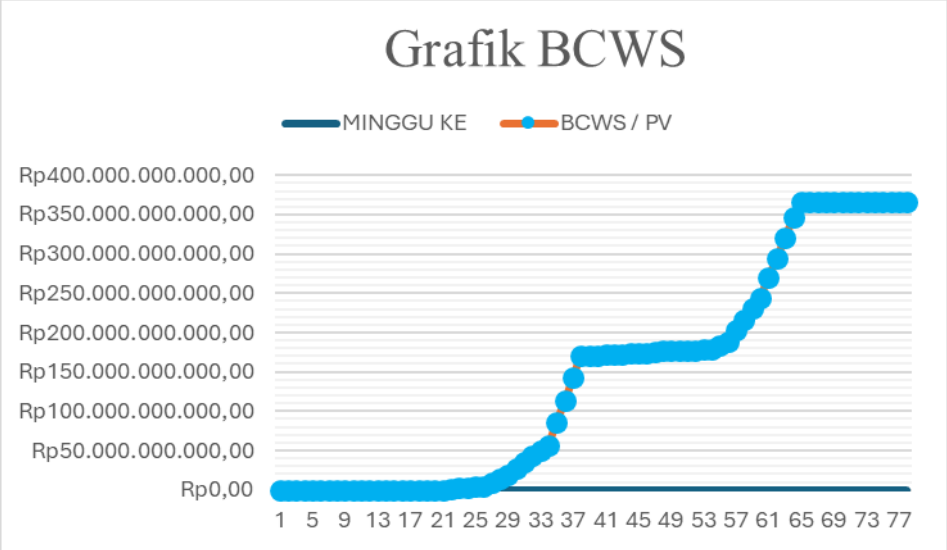

Figure 2. Cumulative BCWS Chart

Source: Processed by Researchers, 2024.

Figure 2 shows that as the implementation time increases, the implementation cost also increases. The increase is due to the increase in work for each planned week. The increase in work is shown in the increase in work weight for each week.

Budgeted Cost of Work Performance (BCWP) Analysis

Budgeted Cost of Work Performed (BCWP) or Earned Value is calculated by multiplying the percentage of progress achieved by the total project cost budget. The

analysis for week 66, the period October 09, 2024 to October 15, 2024, based on weekly reports, is as follows:

BCWP = % (Realization Weight) x Contract Value (RAB)
= 2.262% x Rp. 366,500,000,000
= IDR 8,289,869,356.17

While the cumulative BCWP value is:

BCWP = % (Realization Weight) x Contract Value (RAB)
= 89.482% x Rp. 366,500,000,000
= IDR 327,951,395,193.47

Through calculation, the BCWP value or cost budget shows that there is a realization that has been completed until the 66th week of data collection, which IDR 327,951,395,193.47.

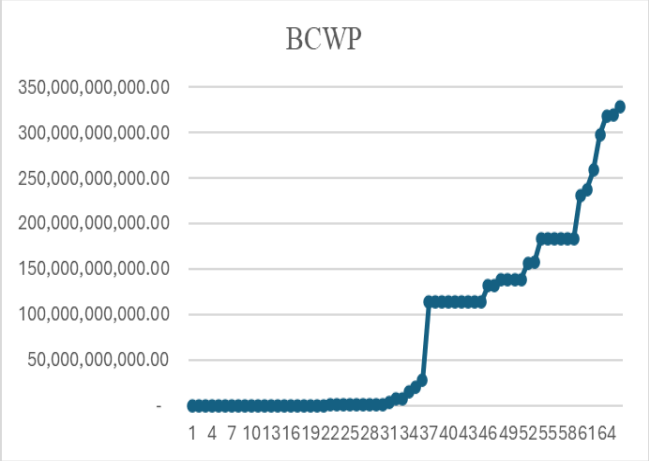

Figure 3. Cumulative BCWP Chart
Source: Processed by researchers, 2024.

The graph above illustrates that throughout the implementation of the project, the progress of the work continued to grow, which is reflected in the increase in costs proportional to the increase in the weight of the work. This indicates a corresponding increase in budget expenditure as more work is completed.

Analysis of Actual Cost of Work Performance (ACWP)

The data used to calculate the Actual Cost of PPUPG Baggage Handling System (BHS) Procurement and Installation at Sultan Hasanuddin International Airport Makassar includes direct and indirect costs obtained by researchers from PT Dexter Wika Sinergi. In the period October 09, 2024 to October 15, 2024 or in the first week to week 66, while the cost estimate for week 67 to the end of the project week 78 uses the progress estimate multiplied by the cost plan.

According to the statement of the Project Manager of the implementing contractor, the calculation of costs incurred is not calculated per week. However, the calculation of the actual cost value is carried out according to the needs and adjusts when a meeting will be held. From the data above, a graph can be displayed

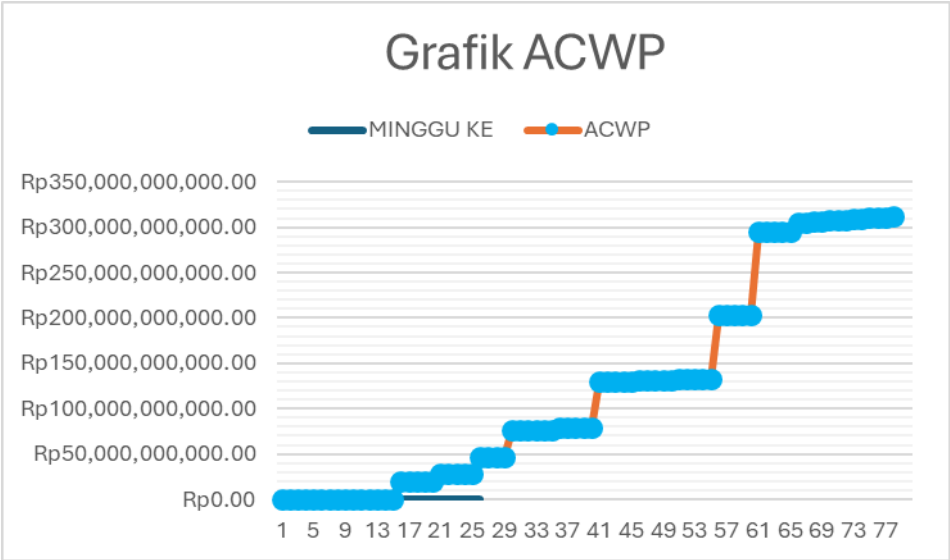

Figure 4. Cumulative ACWP Chart
Source: Processed by researchers, 2024

From the graph above, it can be seen that the project cost is getting longer and longer in balance with the progress that continues to grow. The costs incurred up to week 66 are worth Rp. 304,917,288,633 while for the prediction of week 67 to week 78 assuming progress is the same as the progress plan and expenses are also in accordance with the progress plan so that the cost obtained until the end of the project is assumed to be Rp. 312,338,431,489.84.

After knowing the results of the BCWP, and ACWP calculations. Then the cumulative value can be displayed in the following table:

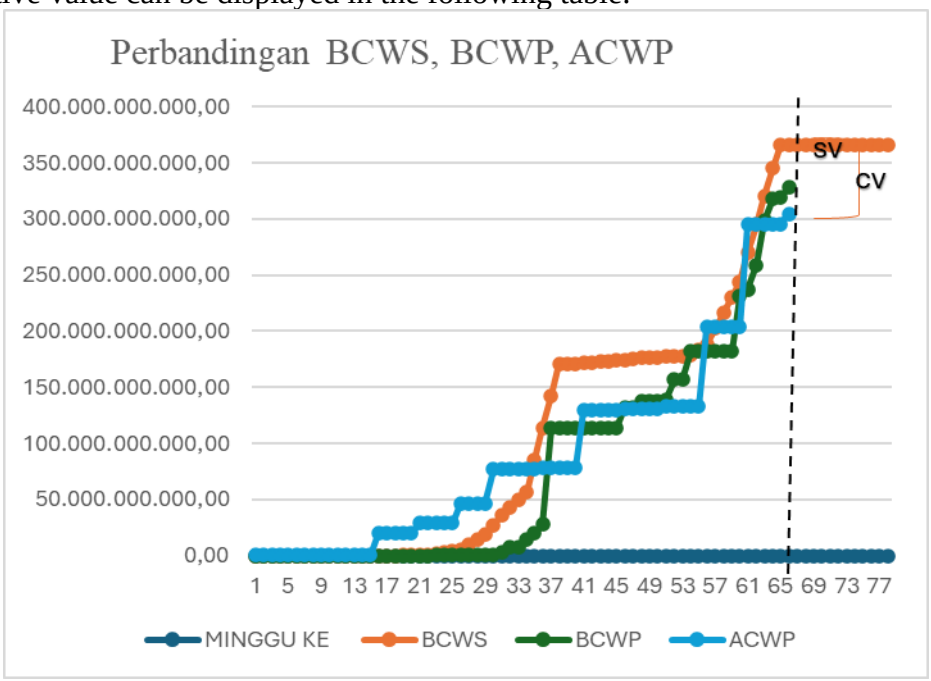

Figure 3. BCWP AND ACWP Graph
Source processed by researchers, 2024

From the graph above, it is known that if the ACWP graph is above the BCWS line, then in that week the project expenditure is above the planned one and if it is below it, the project expenditure is below the planned one and if the graph is sloping, then in that week no project expenditure is recorded. Likewise for time if it is below the BCWS graph then the time is not as planned. If the graph ramps in certain weeks, it means that there is no activity in those weeks.

Schedule Perfomance Index (SPI) calculation

Calculation of the Schedule Performance Index (SPI) value at the time of reporting on week 66 of the PPUPG Baggage Handling System (BHS) Procurement and Installation project at Sultan Hasanuddin International Airport Makassar:

$$\text{SPI} = \frac{BCWP}{BCWS} = \frac{Rp.327,951,395,193.47}{Rp.366,425,788,571.43} = 0.8950 < 1$$

Because the SPI value < 1, this means that the project is delayed or not as planned:

Table 2. SPI values

Week To	SPI	Week to	SPI
1	0,0000	40	0,6664
2	0,0000	41	0,6644
3	0,0000	42	0,6627
4	0,0000	43	0,6609
5	0,0000	44	0,6591
6	0,0000	45	0,6576
7	0,0000	46	0,7558
8	0,0000	47	0,7521
9	0,0000	48	0,7815
10	0,0000	49	0,7806
11	0,0000	50	0,7809
12	0,0000	51	0,7795
13	0,0000	52	0,8825
14	0,0000	53	0,8810
15	0,0000	54	1,0243
16	0,0000	55	0,9965
17	0,0000	56	0,9700
18	0,0000	57	0,9030
19	0,0000	58	0,8446
20	0,0000	59	0,7934
21	0,0000	60	0,9464
22	0,1109	61	0,8805
23	0,0817	62	0,8774
24	0,0792	63	0,9303
25	0,0652	64	0,9197
26	0,1384	65	0,8726
27	0,0783	**66**	**0,8950**
28	0,0745	67	0,8950
29	0,0586	68	0,8950
30	0,0411	69	0,8950
31	0,0856	70	0,8950
32	0,1765	71	0,8950

33	0,1519	72	0,8950
34	0,2607	73	0,8950
35	0,2325	74	0,8950
36	0,2426	75	0,8950
37	0,8003	76	0,8950
38	0,6664	77	0,8950
39	0,6664	78	0,8950

Project Performance Analysis

1. In the first week to week 21 the SPI value is 0 or SPI < 1, indicating that job performance is not as expected because it has not been able to achieve the planned work targets.
2. In the next to last week, the SPI value is still below 1 or SPI < 1,
3. indicating that the work performance is not as expected because it has not been able to achieve the planned work targets.
4. Week 66 of the study SPI value 0.8950 this value is less than 1 performance is not as planned.

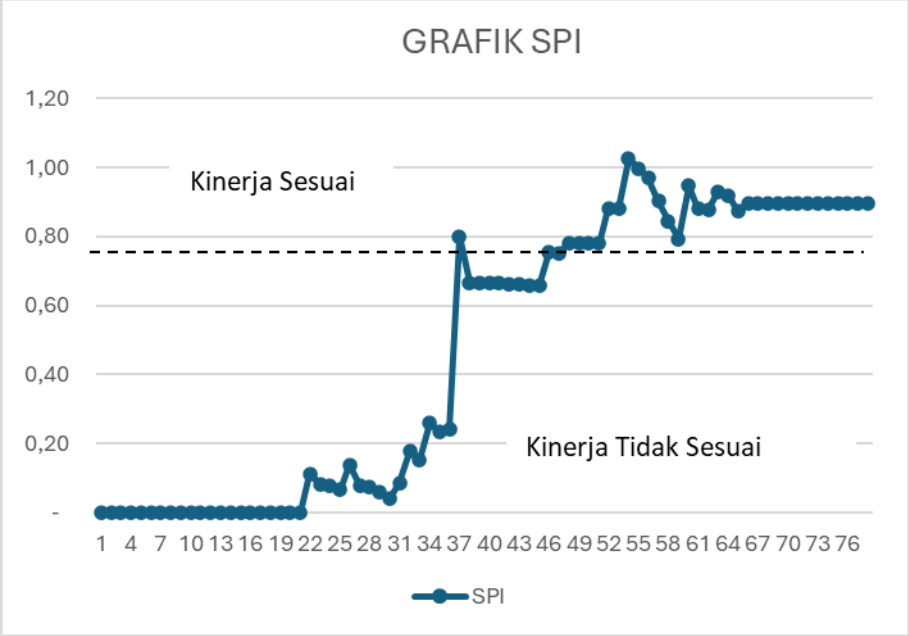

Figure 4. SPI graph

Source: Processed by researchers 2024

In the graph above, the position of SPI can be seen, where if the value is below the dotted line, this indicates less than optimal project performance. Conversely, if it is above the line, this indicates that the project performance is in good condition.

Estimate to Schedule (ETS) Remaining Time Calculation

The project was planned to last 546 days. The research analysis was carried out at week 66 of the project for 462 calendar days. Analysis to estimate the remaining project time (ETS), as follows

$$ETS = \frac{SAC - tBCWP}{SPI} = \frac{546-462}{0.895} = \frac{84}{0.895} = 93.85 \text{ days}$$

Rounded up to 94 days

Calculation of Total Final Time remaining Estimate At Schedule (EAS)

The projected total project completion time for week 26 refers to the data obtained in week 15 as follows:

EAS = tBCWP + ETS
= 462 + 94
= 556 calendar days

The difference between the Contract Time and the probability of completion is : EAS - contract time
Time difference: 556 - 546
= 10 Calendar days (Longer than Contract time)

Based on the analysis conducted, the project, which was planned to be completed in 546 days, had been underway for 462 calendar days by week 66. The estimated remaining project time (ETS) was 93.85 days, rounded to 94 days, with a projected total completion time of 556 calendar days. Thus, there is a time difference between the contract time and the estimated project completion, which is 10 calendar days longer than planned. In conclusion, the project is experiencing delays that are expected to affect the completion schedule, so mitigation measures are needed to minimize the impact of delays on the overall project budget and schedule.

Conclusion

Based on the Earned Value analysis, it can be concluded that the Schedule Performance Index (SPI) is less than 1, indicating that the project is delayed and the implementation time is slower than planned. The total estimated project duration is 556 calendar days, which exceeds the planned 546 days, resulting in a delay of 10 days. This reflects that the project's time performance is not optimal and requires corrective measures to improve adherence to the schedule.

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