Concept Analysis of Earned Value at Construction Implementation Time (Case Study of Package 4 Development Project – APSLC, TILC, DLC, and FRC Buildings Gadjah Mada University Yogyakarta)

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Abstract. The implementation of a project is said to be successful in its management if the project can be completed with a predetermined quality or quality, so it is necessary for the existence of planning and scheduling techniques or methods that can help the management of project implementation. This research was conducted on Building Package 4 Gadjah Mada University Yogyakarta. In this study using time control methods with the concept of value results or *Earned Value Concept*. This method generates BCWP values, BCWS values, SV values, SPI values, and can predict project end time completion (ETC and EAC).

This research requires data such as Time Schedule and Cost Budget Plan, This study produces information that there are time deviations in the 4th and 5th weeks of etc and EAC calculation results can be predicted that the project is delayed in week 4 which is completed in week 65 and in the 5th week completed in week 59. This shows that the implementation of the project experiences slight deviations at the time of implementation of project activities.

Keywords: Earned Value Concept, BCWS, BCWP, SV, SPI, ETC, EAC.

1. INTRODUCTION

The development of the construction world can be seen from the many construction projects in Indonesian that are planned, are being worked on, and have been done by the government and private sector. Planning, implementation, and control of projects require construction management in their management, completed with a predetermined quality or quality, so it is necessary for the existence of techniques or methods of project control to obtain the final results in accordance with expectations.

PT. PP (Persero) Tbk which has been widely engaged in construction construction projects, has been working on the construction project of package 4 building - APSLC Building*(Anvanced Pharmacheutical Learning Center),*TILC Building (Teaching*Industrial Learning Center),*DLC Building (Dental*Learning Center),*FRC Building (Field*Research Center)*Universitas Gadjah Mada Yogyakarta.

2. LITERATURE REVIEW

2.1 Project

Construction project is a process of a series of activities that process project resources into a result of activities in the form of buildings. The process that occurs in the series of project activities involves parties directly or indirectly related. With so many parties involved in the construction project, the potential for conflict is so great that it can be said that the project contains a high enough conflict (Ervianto, 2002: 11).

Project management is planning, organizing, leading and controlling the company's resources to achieve predetermined goals (Suharto, 1999). Application of science, expertise, and skills, the best technical means and with limited resources in project management, to achieve the specified goals and objectives

in order to get optimal results in terms of cost performance, quality and time, and work safety on construction projects (Husen, 2009).

2.2   Construction Project Control

Control is a structured effort to define the right standards with planning goals and objectives, define information systems, compare implementation with standards, then take the necessary remedial actions so that all resources are used effectively and efficiently in achieving goals (R.J. Mockler, 1972).

2.3   Construction Project Irregularities

According to (Syafriandi et al, 2017) deviation is the analysis of data reporting the implementation of activities at a certain time and comparing with that have been planned. Differences in schedules mean deviations to time, differences in costs mean deviations to budgets. The difference between the plan and the implementation, then the difference is an deviation. Small or positive deviations become criteria for the results of a planning (planning error) or error of implementation (lack of implementation)
Deviation:
= zero (0), meaning good execution (according to the plan)
$\geq$ zero (0), meaning excellent execution (possibly incorrect planning)
$\leq$ zero (0), meaning poor implementation, needs to be evaluated. The further away from the value (0) then the performance of the implementation is less good.

2.4   Concept of Value Results

The concept of *Earned Value* is a method of control used to systematically control costs and schedules. The Concept of Value Results can provide information whether the progress of the implementation of project work is worth the budget that has been used (Lenggogeni & Irika, 2013). The Earned *Value* method has the following 3 elements:

1.   ACWP *(Actual Cost Work Performance)* is the actual amount of work that has been done.
2.   BCWS *(Budget Cost of Work Schedule)* is a cost budget that is allocated based on a work plan that has been prepared over time.
3.   BCWP *(Budgeted Cost for Work Performed)* is the value received from completion of work over a period of time.

The use of results value concept elements is used to analyze project performance, including:

1.   Schedule Variant (SV)
    Schedule Variance (SV) is the part of work that can be done with the planned work section.
2.   Schedule Performance Index (SPI)
    Schedule Performance Index (SPI) is a comparison between the completion of work in the field with the work plan in a certain period of time.

2.4.1 Assessment of Project Performance with Concept of Yield Value (Earned Value)

According to (Syafriandi, 2017) the concept of value results can be used to analyze performance and make estimates of goal achievement. Some of the terms associated with this assessment are Cost Variance, Schedule Variance, Cost Performance Index, Schedule Performance Index, Estimate at Completion and Variance at Completion.
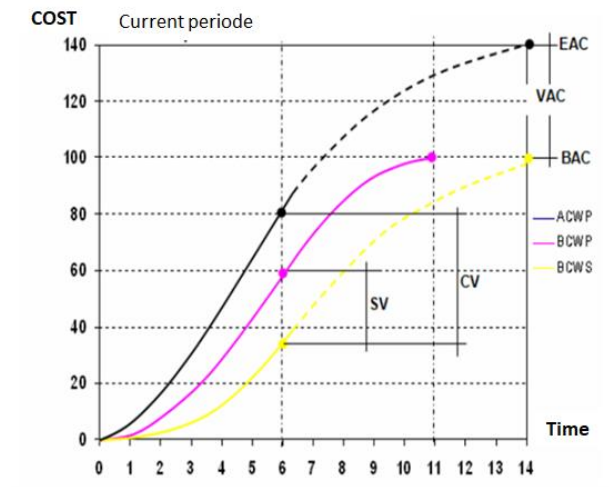
Figure 1. S *Earned Value* curve graph
(Source: Soemardi B.W, et al, 2007)

1. SV*(Schedule Variance)*
   SV is used to calculate deviations between BCWS and BCWP. Positive value indicates good job performance, because the work packages that have been completed faster than planning. Conversely, negative values show poor job performance because the work packages are carried out more slowly than planning.

   $$\textbf{SV = BCWP – BCWS}$$

   SV = 0: project on time
   SV > 0: faster projects
   SV < 0: slower projects

2. SPI*(Schedule Performance*Index)
   SPI is a factor in the efficiency of performance in completing work can be shown by a comparison between the value of work that has been physically completed (BCWP) and the cost expenditure plan incurred under the work plan (BCWS).

   $$\textbf{SPI = BCWP/BCWS}$$

   SPI = 1: project on time
   SPI > 1: faster project
   SPI < 1: late project

3. ETC (*Estimate to Complite*)
   ETC is an estimated cost for the remaining work, assuming that the project performance trend will remain (constant) until the end of the project.

   $$\textbf{ETC = (plan time – reporting time)/SPI}$$
   $$\textbf{ETC = (remaining time)/SPI}$$

4. EAC (*Estimate at Completion*)
   EAC*(Estimate at Completion)*is also that the final completion cost of the project. There are many methods for predicting project completion costs (EAC). EAC calculations with SPI and CPI are easier and faster in their use. One of the formulas is:

   $$\textbf{EAC = reporting time + ETC}$$

2.4.2 Indicator-indicators used in research
The concept of value results can be used to analyze performance and make achievements of predetermined goals. The indicators used are actual cost,*earned value* and budget schedule (*planed value*).

1. BCWP *(Budget Cost Of Work Performanced)* is obtained from the value of the completed work against the budget provided to carry out the work. When the ac figure compared to ev can be compared between the costs that have been incurred for work that has been done against the costs that should be incurred for that purpose.
2. BCWS *(Budgeted Cost of Work Schedule)* displays the budget for one work package that is structured and associated with the implementation schedule. Here there is a combination of costs, schedules, and scope of work, where in each job has been given a cost allocation and schedule that can be a benchmark for job reporting.
3. *Schedule Variance (SV)* is used to calculate deviations between BCWS and BCWP. Positive values show that the work packages that have been implemented are more than the plan. Conversely, negative values indicate poor job performance or deviations because the work packages are carried out less than the schedule that has been planned. The formula for *Schedule Variance* is

$$\text{Schedule Variance (SV)} = EV - PV \text{ or } BCWP - BCWS \qquad 1)$$

Negative (-)   = late to schedule
Zero (0)   = on time
Positive (+)   = ahead of schedule

According to Imam Suharto, the indicator of the concept of value results is held as follows:

Table 1 Integrated Variance Analysis

Schedule Variance SV = BCWP – BCWS	Information
Positive	Work is done faster than scheduled.
Zero	Work is done on schedule.
Negative	Work done late

(Source: Ayuhalinda EP, 2018)

2.4.3   Productivity and Performance Index

Project managers often want to know the resources used, it can be expressed as a productivity index or performance index. Schedule Performance Index =*SPI)*. The SPI value indicates how much work is planned.

$$\text{Schedule Performance Index (SPI)} = BCWP/BCWS \qquad 2)$$

With the criteria of performance index*(Performance Index)* as follows:

The performance index < 1, meaning spending greater than the budget or implementation time is longer than the planned schedule. If the budget and schedule have been made realistically, then there is an irregularity in the implementation of activities.

The performance index > 1, then the performance of project activities is better than planning, in the sense that spending is smaller than the available budget or schedules ahead of the plan.

The performance index the greater the difference from number 1, the greater the deviation that occurs in the field from basic planning or budget. Even if the numbers are too high to mean the achievement of the implementation of the work is very good, it needs to be studied more deeply whether it is possible that the planning is actually unrealistic.

2.4.4   Projected Project Completion Timeframe

Estimated time for the remaining workers*(Estimate to Completion)*Estimate of the project's remaining work schedule. ETC can be calculated by the following formula:

$$\text{ETC} = \text{(plan time – reporting time)/SPI}$$

$$\textbf{ETC = (remaining time)/SPI} \qquad\qquad \textbf{3)}$$

Estimated time until the end of the project*(Estimate At Completion)*

It is the estimated schedule of project completion. EAC can be calculated by the following formula:

$$\textbf{EAC = reporting time + ETC} \qquad\qquad \textbf{4)}$$

Information:

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

ETC (*Estimate to Completion*) **=** Estimated time of remaining work

EAC*(Estimate At Completion)* = Project time forecast

3.   RESEARCH METHODS

3.1 Data Source

This research data was taken on the construction project of package 4 building of Universitas Gadjah Mada Yogyakarta built by PT. PP (Persero) Tbk. The data used in this study is the Time Schedule and Budget Plan of the construction project of building package 4 of Universitas Gadjah Mada Yogyakarta. The project value amounted to Rp. 236,214,335,000 (Two Hundred and Thirty-Six Billion Two Hundred Fourteen Million Three Hundred and Thirty-Five Thousand Rupiah). Project implementation time of 56 Weeks or 13 Calendar Day Months from the signing of the Work Start Warrant (November 12, 2019 - December 05, 2020).

3.2   Research Flow Chart

Stages in the analysis of time control with the concept of Yield value *(Earned Value)*. This research begins by identifying the problem and knowing the purpose of the research. The next step is to determine the object of the research and collect data. The study used two indicators: variance (SV) and work index (SPI), data analysis to determine deviations in project time. The study was also able to analyze the project's estimated total time of ETC and EAC after knowing the sv and SPI results. Research discussion to find out whether the project to build the package 4 building of Universitas Gadjah Mada Yogyakarta there is a time deviation or not. In this study in full presented in Figure 3.1 as follows.
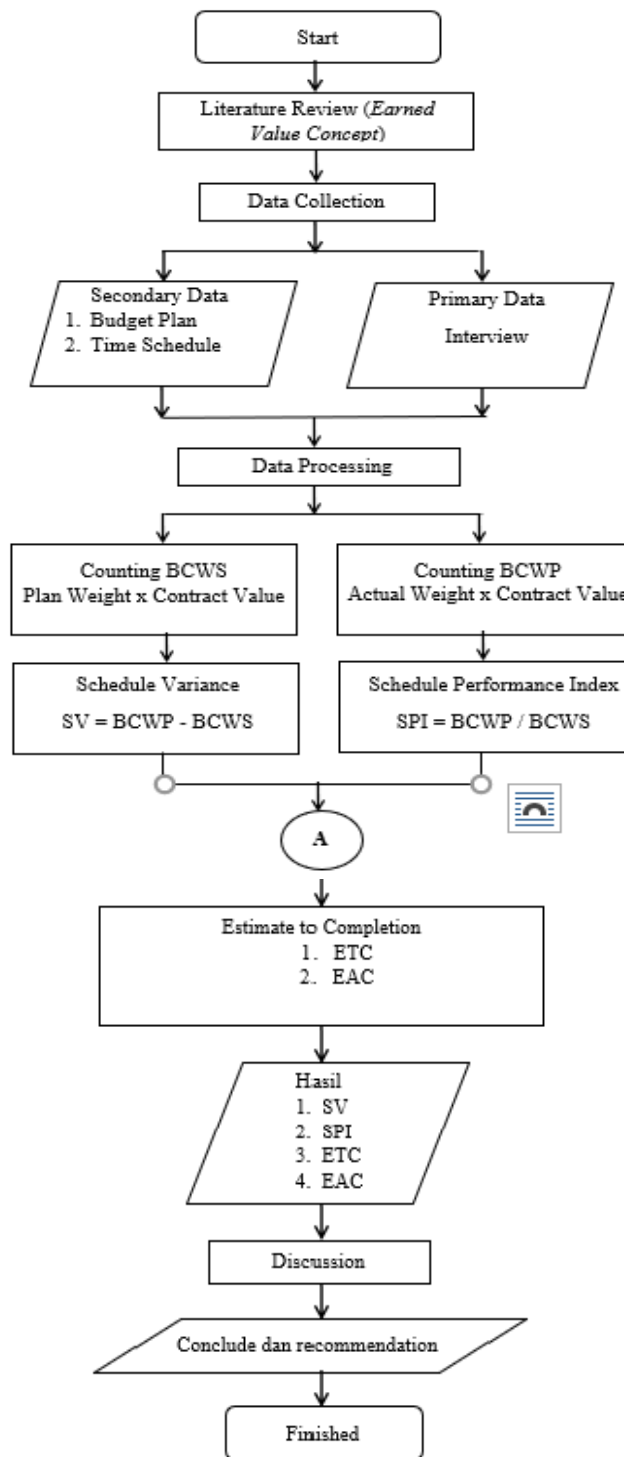
Figure 2. Research Flow Chart

4. ANALYSIS, RESULTS AND DISCUSSION

4.1 Project Data

4.1.1 Cost Budget Plan

The budget plan on the construction project of package 4 of Universitas Gadjah Mada Yogyakarta amounted to Rp.236,214,335,000 (Two Hundred and Thirty-Six Billion Two Hundred Fourteen Million Three Hundred and Thirty-Five Thousand Rupiah).

4.1.2 BCWS and BCWP data

BCWS data is obtained from the weight of the activity plan contained in the Time Schedule and BCWP obtained from the weight of work that has been realized in accordance with the data of the building construction project package 4 Universitas Gadjah Mada Yogyakarta. There is the same weight value due to the termination of work activities within 2 weeks due to the Covid-19 pandemic.

4.1.3 Project Implementation Schedule

The schedule for the construction of package 4 building project of Universitas Gadjah Mada Yogyakarta began on November 12, 2019 with an implementation time of 56 weeks.

4.1.4 BCWS and BCWP Value Data Analysis Results

1. BCWS and BCWP Value Analysis

The bcws value per week obtained from the weekly weight in the time schedule planning the construction project of building package 4 of Universitas Gadjah Mada Yogyakarta, can be calculated as follows:

For the calculation of BCWS work in the 1st week of the period 12 November 2019 using the formula:

Yield Value = (% plan) x (budget)

Total Project Budget = Rp.236,214,335,000

BCWS weight = 0.010%

BCWS = % Plan x Budget = 0.010% x 236,214,335,000 = Rp. 23,621,433.50
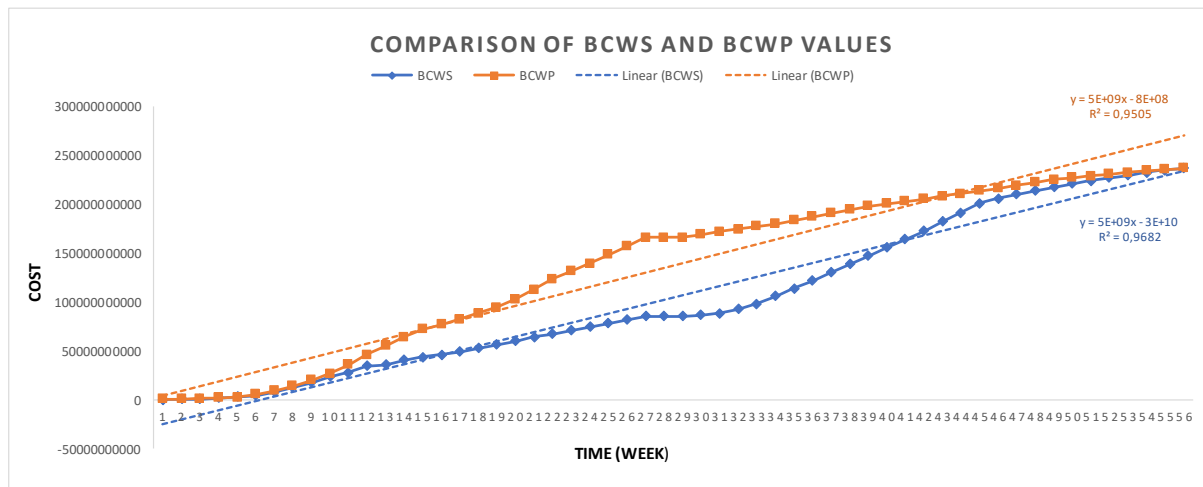
For the calculation of BCWP work in the 1st week of november 12, 2019 using the formula:

Yield Value = (% settlement) x (budget)

Total project budget = Rp. 236,214,335,000 = Rp. 248,025,051.75 – Rp. 23,621,433.50 = Rp.224.403.618.25

$SV(\%) = - BCWP_1(\%)BCWS_1(\%) = 0.105\% - 0.010\% = 0.095\%$

Figure 3. Comparison of BCWS and BCWP Values

2. Analysis of Time Deviations (SV)

The calculation of employment for the 1st week in the period 12 November 2019 to 28 March 2021 is as follows.

BCWS   = Rp. 23,621,433.50

BCWP   = Rp. 248,025,051.75

SV_1 = - $BCWP_1$ $BCWS_1$

From the formula above can be obtained calculations to find out that the 1st to 3rd week of work implementation on the project is quite good, these results can show that the implementation of work on the project runs faster than the planned schedule. In week 4 and week 5 sv results are negative which shows that the implementation of work The project is delayed. But in the 6th to 56th week the implementation of project work is better because sv value results are higher and continue to increase. Schedule deviations (SV) per week can be calculated in the same way that the calculation above can be seen in Figure 4.
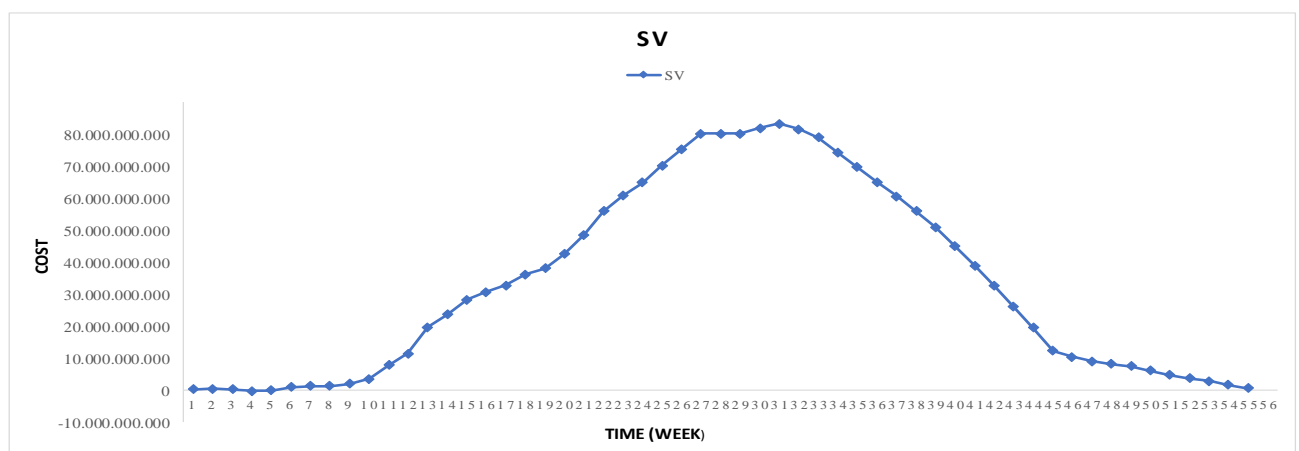
Figure 4. Schedule Deviation Graph (SV)

3. Schedule Performance Index (SPI)

For the calculation of BCWS work in the 1st week of the period 12 November 2019, namely:

$BCWP_1$ = Rp.248.025.051.75

$BCWS_1$ = Rp.23,621,433.50

SPI = BCWP : BCWS = Rp.248.025.051.75 : Rp.23,621,433.50 = 10.5

For the calculation of BCWS work in the 4th week of november 12, 2019, which is$BCWP_4$ = Rp.1,355,870,282.90

$BCWS_4$ = Rp.1,608,619,621.35

SPI = BCWP : BCWS = Rp.1,355,870,282.90 : Rp.1,608,619,621.35 = 0.842

From the calculation above shows that the value of SPI in the 1st week is >1, meaning that the implementation of project activities is better than project planning. Compared to the SPI value in the 4th week with a value of <1, it means that the implementation of project activities is late from project planning. For the calculation of SPI in the week before and after in the same way as above can be seen in Figure 5.
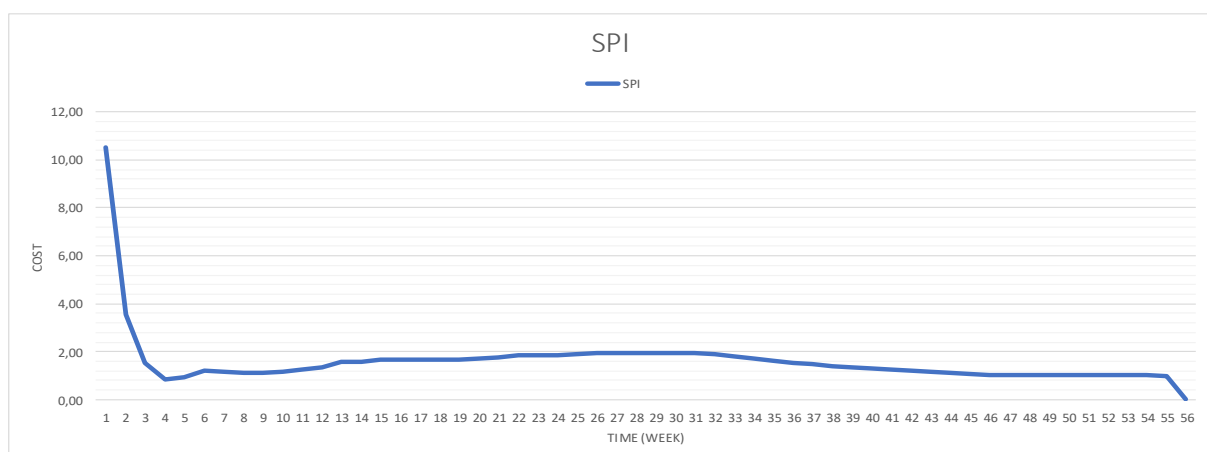
Figure 5. SPI Value Graph

4. Time Forecast for Total Projects

The forecast of the remaining work time is assumed at the time the activity takes place as when the evaluation is carried out. To get etc values by calculating reporting time, plan time and SPI value. Perthitungan ETC in week 1 using the formula:

ETC= (remaining time) / SPI

5. Project Total Time Forecast

EAC values can be calculated using reporting time and ETC values. To obtain EAC values are calculated based on completed time or reporting time summed up with ETC results.

Reporting time = Week 1

ETC = 5 Weeks

EAC = reporting time + ETC = 1 + 5 = 6 weeks

Perth leads the EAC in week 4 as follows.

Reporting time= Week 4

ETC = 61 weeks

EAC = reporting time + ETC = 4 + 61 = 65 weeks

Time difference = Implementation plan time – EAC = 56 Weeks – 61 Weeks = -5 weeks

From the calculation above using commutative calculations, the value of the analysis results for the 4th week is 65 weeks while the planned time is 56 weeks. This indicates that the completion time is 5 weeks later than planned. Likewise for the calculation of the 5th week that experienced a delay of 3 weeks. For calculations other than week 4 and 5 there is no delay in completion of the planned time.

4.2   DISCUSSION

4.2.1 BCWS and BCWP Data
BCWS represents the amount of planned costs on the weight of the planned work. As presented in Figure 3 the comparison of BCWS and BCWP values from the graph shows that the BCWS value is below the BCWP value in week 1 to week 56. The BCWS value is below the BCWP value indicates that the yield value indicator from the point of view of the value of the work that has been completed faster with the planned implementation schedule.

4.2.2   Schedule Variance (SV)
From the calculation of variance on time control, it can be obtained the condition of the project that occurs every week. A negative number on the schedule variance means that work is done late, a zero means work done on time, and a positive number means that the work done has accelerated from planning. As presented in Figure 4 can be seen the value of SV in the 4th and 5th weeks is negative, meaning the project is experiencing error or not in accordance with the planned time. In the 6th to 56th week, the positive value indicates that the work is running faster than planning, so there is a fairly high increase in work activity in the project work carried out. The results of the calculation of the SV value are used to determine the performance of the project every week. In the package 4 building construction project, Universitas Gadjah Mada Yogyakarta, the SV performance in the first week until the end was good, there were only a few problems in the early weeks of construction.

4.2.3   Time Performance Index (SPI)
In project time control, a schedule performance index that shows that the SPI value is less than one means that the work performance is not as expected due to delays in implementation and not in accordance with the planned targets. As presented in Figure 5 can be seen from week 1 to week 3 is worth more than 1, showing the performance of the work in accordance with the planned time, while in the 4th and 5th weeks it is worth less than one, but very close to the number 1, which means the implementation does not experience major deviations and can still be handled so that the implementation time is in accordance with the planning time. In week 6 to week 56 is worth more than 1 and has many improvements in job performance which means the implementation of the work is better than planning. At the beginning of the package 4 building construction project, Universitas Gadjah Mada Yogyakarta experienced a slight deviation, but it can be overcome by adding more work at the next time so as to produce a good SPI score.

4.2.4   ETC and EAC Analysis Results
1.   Results of *Estimate Time Completion* (ETC) Analysis
From the results of the analysis of time forecasts for residual work (ETC) showed that in the 4th week and the 5th week the project schedule performance index slightly deteriorated causing the ETC value to increase. It can be seen that the schedule performance (SPI) has not reached number one (<1), it shows that project performance in the 4th and 5th weeks is not good. In the 1st to 3rd week and the 6th to the 56th week in accordance with the duration of the ETC value project reached number one (>1) showing that the implementation of the project was going well and experiencing a fairly high increase every

week, it showed that the project of building package 4 of Universitas Gadjah Mada Yogyakarta was going quite well and the implementation could be completed according to the planned schedule.

2. EAC on schedule

EAC uses ETC as its main indicator, because the results of the EAC analysis are not much different from ETC. From the results of the analysis it is seen that the EAC value shows a large value in the 4th week and week 5 shows that the implementation of the package 4 building construction project of Universitas Gadjah Mada Yogyakarta is delayed and improvement action must be taken. But in the 6th to 56th week there is an increase in work activities which means that unfinished work can be completed according to the planning schedule.

4.3 PROJECT PROBLEM ANALYSIS

The results of the analysis on the package 4 building construction project of Gadjah Mada University Yogyakarta based on the planning S curve and the implementation S curve, there were a few problems at the beginning of the project such as the results of the analysis carried out using the concept of Earned Value. The package 4 building project at Gadjah Mada University Yogyakarta, this project underwent various changes in its implementation, namely the condition where the work was carried out faster or later than the planned schedule. During the implementation of this project, work activities were also suspended for 2 weeks due to the impact of Covid-19.

The implementation of the package 4 building construction project at Gadjah Mada University Yogyakarta in November to December, as it is known that in that month the rainy season occurs. Bad weather conditions cause delays in work activities, when it rains the workers cannot carry out their work optimally, this causes work activities to experience a slight delay at the beginning of the implementation of project activities. In the middle of the project implementation, work activities experienced a fairly high increase, so that the implementation of projects that experienced delays could be completed according to the planning schedule..

4.4 ALTERNATIVE REMEDIAL ACTION

Alternative action on the construction project of package 4 building of Universitas Gadjah Mada Yogyakarta is to accelerate the implementation of project work that is experiencing delays or delays, one way by increasing work time or labor. The addition of working hours or labor can be added or done on the next day or week that allows delayed work, can be done in conjunction with the work being carried out. However, with the addition of working hours or automatic labor project work will also increase.

5. CONCLUSION

The Construction Project of Building Package 4 of Universitas Gadjah Mada Yogyakarta can be concluded that the implementation of the work is quite good, this is indicated by the implementation of work activities experiencing a fairly high increase. But in this project has a slight deviation at the beginning of the implementation of the project, namely in the 4th week and week 5, the deviation can be controlled and the implementation of the work can be completed in accordance with the planned schedule. Based on the results of data collection, observation, and analysis on the Package 4 Building Development Project of Universitas Gadjah Mada Yogyakarta, the following conclusions can be drawn:

1. The performance of the Building Building Project Package 4 of Universitas Gadjah Mada Yogyakarta can be concluded as follows:
    a. SV analysis *(Schedule Variance)* produces values with various conditions where SV produces positive numbers and negative numbers. This shows that the project has a slight time deviation at

the beginning of the week of project work activities, which means that the implementation of the project in the 4th and 5th weeks is delayed because the SV analysis produces a negative value.

b. The Schedule Performance Index (SPI) on this project has both positive and negative values. In the conditions of project implementation in the 4th week and week 5 the SPI value is less than one (<1) which means the project has a delay, but very close to number one, which means the deviation in the implementation of project work activities is not too large. In the following week, the SPI value generated a value of more than one (>1) and experienced a fairly high increase in project work activities, which means that the time performance on this project is good and the project is carried out in accordance with the planning schedule.

c. The result of the forecast analysis of the time needed to complete the remaining work (ETC) and the amount of time to complete the remaining work (EAC) with a commutative calculation based on week 4 is 61 weeks, while the plan time is 56 weeks. Week 5 is 59 weeks, while the plan time is 56 weeks.

2. The problem encountered in the package 4 building construction project at Gadjah Mada University Yogyakarta is project delays. Project delays can be influenced by several factors including natural weather factors and temporary project termination due to PPKM in the area due to being affected by Covid-19.

3. The solution that can be done to overcome the problem in the construction project of package 4 building of Universitas Gadjah Mada Yogyakarta is to improve the management system of supervision and control of the project during the implementation of the project. 3. The solution that can be done to overcome the problems in the package 4 building construction project of Universitas Gadjah Mada Yogyakarta is to improve the project management and control system during project implementation. Acceleration of project implementation due to slight deviations at the beginning of the project can overcome project delays so that the package 4 building construction project of Universitas Gadjah Mada Yogyakarta can be completed according to the planning schedule.

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