Earned value concept analysis on project monitoring (Case study: Faculty of Forestry Universitas Sumatera Utara building construction phase 1)

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Abstract. Construction projects have a high level of project complexity. Sometimes there are some late progress or cost overruns on project construction. Monitoring is the first step to control the project so that it can be seen as a large deviation in costs and schedules that occur. Therefore, to improve the effectiveness of monitoring, the earned value concept method can be used. The research began with data collection from the research location. After obtaining supportive data, it is continued with ACWP, BCWP, and BCWS data analysis. It is closing with the final results of all analyzes conducted. From the study of the concept of the value of the works reviewed until the 20th week, the BCWS value was IDR 14,816,705,720, the BCWP value was IDR 4,614,975,520, and the ACWP value was IDR 4,153,562,199. The CPI value is 1.111, while the SPI is 0.311, which means that the project is experiencing delays in terms of schedule but incurs actual costs that are less than the work already done. The final estimated project cost (EAC) is IDR 20,301,199,616, while the ECD value is 52 weeks for the project completion time.

1. Introduction

Construction projects have a high level of project complexity. Sometimes there are some late progress or cost overruns on project construction. The monitoring, in general, separates between the accounting system for cost and project schedule construction system. The two reports are complementary but can provide different information about the condition of the project, so we need a system that can integrate time and cost information [1, 2].

Monitoring is the first step rather than controlling project implementation. Therefore, to improve the effectiveness on monitoring project construction, the earned value method can be used, which is a method that connects between time and cost and so the relationship between time, cost, and progress of the project, so that describe the condition of the continuity of the current project reporting [2, 3, 4].

The Universitas Sumatera Utara Phase 1 Forestry Building Construction Project has a high contract value. This project is planned to be completed within 30 weeks of the calendar period. But in its implementation, the project indicated delays in its work. According to interviews with the contractor, in the performance of this project was carried out in weather conditions where rainfall is still very high. It disrupts worker productivity and makes the results achieved are less than optimal.

2. Literature Review

2.1. Project

Project activities can be interpreted as a temporary activity in a limited time period, with the allocation of specific resources intended to produce products whose quality criteria have been clearly outlined [5, 6, 7].
2.2. *Time Management*
Project time management is a system that concentrates on planning and scheduling work. Such an approach is a useful early warning tool to detect when and where a project might be behind schedule [8, 9].

2.3. *Cost Management*
Project cost management is a system that concentrates on income and expenses, gains or losses, and general financial accounting goals, each project that is handled separately and individually [10, 11].

2.4. *Monitoring*
Project monitoring is monitoring project implementation that has been planned and planning as a project control tool. In implementing the project, the most important thing is to monitor the progress of each work activity. For this reason, it is necessary to know the data and information from the contractor’s reports that enter each predetermined construction period [12].

2.5. *Earned Value Concept*
The method of earned value concept is the concept of calculating the number of costs according to the budget by the work that has been completed or carried out [13, 14].

| Table 1. The Element of Earned Value Concept |
|---------------------------------------------|
| No  | Indicator | Variance | Value | Performance | Value | Valuation          |
|-----|-----------|----------|-------|-------------|-------|-------------------|
| 1   | Cost      | CV       | 0     | CPI         | = 1   | Actual Cost = Plan Cost |
|     |           | CV       | +     | CPI         | > 1   | Under Budget      |
| 2   | Time      | SV       | 0     | SPI         | = 1   | On Schedule       |
|     |           | SV       | +     | SPI         | < 1   | Under Schedule    |
|     |           |          |       |             |       |                   |

3. *Method*
3.1. *Preliminary survey*
There are searching, recognizing, gathering information, and determining the existing problems. Researchers conduct initial investigations to get information directly from the field. Researchers determine the topics to be discussed that are considered essential to be studied. The issue discussed was regarding project costs and schedules.

3.2. *Study of literature*
A literature study is conducted after the author determines the research topic and has established a problem statement and is carried out before plunging into the field to collect the required data. The author searches various books, journals, articles, or documents relevant to the problem under research.

3.3. *Data collection*
There are two types of data to be processed, namely:
   a. **Primary Data**
Primary data is data obtained through review, direct observation in the field and interviews with the implementing contractor, which will be used later in evaluating the project.
   b. **Secondary Data**
Secondary data include: schedule, statements of weekly work, the budget plan (RAB), and the recapitulation of the actual monthly cost.

3.4. *Data analysis*
This analysis includes three parts, namely:
a. Preliminary Data Analysis

After the required data has been collected, data processing can then be performed including analysis of ACWP (Actual Cost Work Performed) calculations, BCWP (Budgeted Cost of Work Performed), BCWS (Budgeted Cost of Work Schedule).

b. Analysis of Change

Based on these three indicators, it is possible to analyze schedule deviations, and analyze cost deviations. The values sought are SV (Schedule Variant), SPI (Schedule Performance Index), CV (Cost Variant), CPI (Cost Performance Index).

c. Estimated Analysis

This analysis is carried out to estimate the schedule and cost of project completion. The values sought are EAC (Estimate At Completion) and ECD (Estimate Complete Date).

3.5. Graphic projection

After all the data has been successfully analyzed, the next step is to process the data into a graphic. The result of variance analysis can be presented by projecting the data ACWP, BCWP, and BCWS.

3.6. Conclusions and recommendations

After all, data has been successfully analyzed and processed into a graphic, the final step is to offer a conclusion in the form of the results of the discussion and analysis of the data. Then provide suggestions in the way of solutions that are shown to solve the problems obtained from the effect of data analysis.

4. Results and Discussion

4.1. Data analysis

The data obtained from the weekly work report can be seen below.

- Budget plan = IDR 22,556,517,547
- % Work progress plan (week 20) = 4,265 %
- % Actual work progress (week 20) = 2,325 %

Project performance is reviewed through to the 20th week of 30 weeks of work time. The last 10 weeks will be spent solving the problem.

a. Preliminary Data Analysis

Data processing can then be performed including analysis of ACWP (Actual Cost Work Performed) calculations, BCWP (Budgeted Cost of Work Performed), BCWS (Budgeted Cost of Work Schedule).

1. BCWS (Budgeted Cost of Work Schedule) [1]

\[
BCWS = \% \text{ Work progress plan} \times \text{Budget plan} = 4,265 \% \times \text{IDR 22,556,517,547} = \text{IDR 962,009,420}
\]

2. BCWP (Budgeted Cost of Work Performed) [1]

\[
BCWP = \% \text{ Actual work progress} \times \text{Budget plan} = 2,325 \% \times \text{IDR 22,556,517,547} = \text{IDR 524,508,958}
\]

3. ACWP (Actual Cost Work Performed)

This value is obtained from the actual cost project. At week 20, ACWP obtained is IDR 324,096,299

Until the 20th week, BCWS was IDR 14,816,705,720, BCWP was IDR 4,614,975,520, and ACWP was IDR 4,153,562,199

b. Analysis of Change

Based on these three indicators, it is possible to analyze schedule deviations, and analyze cost deviations. The values sought are SV (Schedule Variant), SPI (Schedule Performance Index), CV (Cost Variant), CPI (Cost Performance Index).
1. CV (Cost Variant) [1]
\[ CV = BCWP - ACWP \]
\[ = IDR 4,614,975,520 - IDR 4,153,562,199 \]
\[ = IDR 461,413,321 \]

2. SV (Schedule Variant) [1]
\[ SV = BCWP - BCWS \]
\[ = IDR 4,614,975,520 - IDR 14,816,705,720 \]
\[ = - IDR 10.201.730.200 \]

3. CPI (Cost Performance Index) [1]
\[ CPI = \frac{BCWP}{ACWP} \]
\[ = \frac{IDR 4,614,975,520}{IDR 4,153,562,199} \]
\[ = 1,111 \]

4. SPI (Schedule Performance Index) [1]
\[ SPI = \frac{BCWP}{BCWS} \]
\[ = \frac{IDR 4,614,975,520}{IDR 14,816,705,720} \]
\[ = 0,311 \]

The conclusion of the above calculations can be seen in table 1, where the time indicator is under schedule, and the cost indicator is under budget.

c. Estimated Analysis
This analysis is carried out to estimate the schedule and cost of project completion. The values sought are EAC (Estimate At Completion) and ECD (Estimate Complete Date).

1. ETC (Estimate to Complete) [3]
\[ ETC = \frac{Budget plan - BCWP}{CPI} \]
\[ = \frac{IDR 22,556,517,547 - IDR 4,614,975,520}{1,111} \]
\[ = IDR 16,147,637,417 \]

2. EAC (Estimate At Completion) [3]
\[ EAC = ACWP + ETC \]
\[ = IDR 4,153,562,199 + IDR 16,147,637,417 \]
\[ = IDR 20,301,199,616 \]

3. ECD (Estimate Complete Date) [7]
\[ ECD = \frac{Remaining time}{SPI} + Time that has been used \]
\[ = (10/0,311) + 20 \]
\[ = 52,106 weeks \]
\[ \approx 52 weeks \]

The estimated project completion time increased from 30 weeks to 52 weeks. While predictions of the cost for the remaining work (ETC) is IDR 16,147,637,417, and the total project cost (EAC) is amounted to IDR 20,301,199,616.

4.2. Result

| Week | BCWS (IDR) | BCWP (IDR) | ACWP (IDR) |
|------|------------|------------|------------|
| 1    | 28,570,034 | 11,503,824 | 1,860,600  |
| 2    | 64,054,948 | 16,917,388 | 4,367,600  |
| 3    | 99,539,862 | 33,158,081 | 125,175,600|
| 4    | 185,609,972| 79,489,168 | 348,694,500|
| 5    | 347,008,307| 242,572,790| 413,028,402|
| 6    | 858,548,740| 662,124,016| 436,785,902|
| 7    | 1,723,489,239| 1,065,434,550| 464,750,902|
| 8    | 2,731,279,912| 1,315,360,764| 466,867,902|
| 9    | 3,906,269,938| 1,393,857,445| 951,696,002|

Table 2. Cumulative values of BCWS, BCWP, and ACWP.
Table 3. Comparison of the plan and actual percentages.

| Week | Plan (%) | Actual (%) | Deviation (%) |
|------|----------|------------|---------------|
| 1    | 0.127    | 0.051      | -0.076        |
| 2    | 0.284    | 0.075      | -0.209        |
| 3    | 0.441    | 0.147      | -0.294        |
| 4    | 0.823    | 0.352      | -0.471        |
| 5    | 1.538    | 1.075      | -0.464        |
| 6    | 3.806    | 2.935      | -0.872        |
| 7    | 7.641    | 4.723      | -2.918        |
| 8    | 12.109   | 5.831      | -6.278        |
| 9    | 17.318   | 6.179      | -11.139       |
| 10   | 21.844   | 6.525      | -15.319       |
| 11   | 26.371   | 6.872      | -19.499       |
| 12   | 30.897   | 7.317      | -23.581       |
| 13   | 35.424   | 8.064      | -27.360       |
| 14   | 39.950   | 9.402      | -30.548       |
| 15   | 44.474   | 11.704     | -32.769       |
| 16   | 48.870   | 12.425     | -36.445       |
| 17   | 53.014   | 14.220     | -38.794       |
| 18   | 57.157   | 15.714     | -41.443       |
| 19   | 61.422   | 18.134     | -43.288       |
| 20   | 65.687   | 20.460     | -45.227       |

4.3. Variance and Performance Index

Table 4. The value of SV, CV, SPI, and CPI.

| Week | SV (IDR)  | CV (IDR)  | SPI     | CPI     |
|------|-----------|-----------|---------|---------|
| 1    | -17.066.211 | 9.643.224 | 0.403   | 6.183   |
| 2    | -47.182.673 | 12.504.675 | 0.263   | 3.863   |
| 3    | -66.426.894 | -92.062.632 | 0.333   | 0.265   |
| 4    | -106.165.917 | -269.250.445 | 0.428   | 0.228   |
Estimated Cost and Schedule for Final Project

Table 5. The value ETC and EAC.

| Week | ETC (IDR)  | EAC (IDR)  |
|------|------------|------------|
| 1    | 3,646,360,700 | 3,648,221,300 |
| 2    | 5,834,647,436  | 5,839,015,036  |
| 3    | 85,143,979,611  | 85,269,155,211  |
| 4    | 98,655,610,574  | 99,004,305,074  |
| 5    | 38,018,796,079  | 38,431,824,481  |
| 6    | 14,447,158,301  | 14,883,944,203  |
| 7    | 9,376,207,877   | 9,840,958,779   |
| 8    | 7,540,028,428   | 8,006,896,330   |
| 9    | 14,451,345,973  | 15,403,041,975  |
| 10   | 16,508,257,814  | 17,660,655,315  |
| 11   | 17,347,158,393  | 18,627,226,294  |
| 12   | 16,458,399,651  | 17,757,642,552  |
| 13   | 16,682,960,882  | 18,146,203,783  |
| 14   | 18,587,493,774  | 20,516,390,675  |
| 15   | 16,181,934,568  | 18,327,009,269  |
| 16   | 17,332,499,554  | 19,791,685,255  |
| 17   | 16,514,721,059  | 19,252,493,959  |
| 18   | 17,227,757,660  | 20,439,730,560  |
| 19   | 17,287,705,487  | 21,117,171,387  |
| 20   | 16,147,637,417  | 20,301,199,616  |
4.5. Graphic Projection

The results of calculation concepts values are plotted into graphics that can be seen below.

![Schedule Variance (SV) graphic.](image1)

![Cost Variance (CV) graphic.](image2)

![Schedule Performance Index (SPI) graphic.](image3)

![Cost Performance Index (CPI) graphic.](image4)
5. Conclusion

- At the end of the review in the 20th week, the performance of the project schedule (SPI) was 0.311 less than 1. This indicates that the project experienced a delay of 45.227 % from the planned initial project plan of 65.687 % with the work realization of 20.460 %.
- Conditions, where the completion time has been delayed, must be anticipated by predicting the project’s progress at a later time, namely by calculating the project completion time (ECD). The estimated project completion time increased from 30 weeks to 52 weeks. While predictions of the cost for the remaining work (ETC) is IDR 16,147,637,417, and the total project cost (EAC) is amounted to IDR 20,301,199,616.
- In the actual situation, the project has been completed for 45 weeks (312 days) calendar period.

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