

Improving Project Time and Cost Performance Based on Limited Budget

A Case Study of the Construction Industry in Indonesia

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Abstract:- During project implementation, deviation from schedule is unavoidable due to uncertainty and limited budget. The actual value of the project being worked on is still below the predetermined target, there is a difference (gap) between the actual value and the planned value. This study using Earned Value Management (EVM) and add a dimension of Quality by allocating budget control for each activity and tracking period. This research focuses on providing an overview of project efficiency and effectiveness to provide project quality requirements based on the time spent and costs incurred. Tracking throughout the implementation phase of the project. Quality is almost stable from week 13 to week 19. A control budget allocation approach is proposed to determine the amount of budget consumption allowed in each phase of project or activity control. In terms of cost-effectiveness, the hybrid strategy has the highest performance (0.062 compared to 0.029 and 0.028. Meanwhile, in terms of time efficiency the hybrid strategy has the highest performance (0.126 compared to 0.088 and -0.013 for intervention and preventive strategies following each Earned Value Management value)

Keywords : Cost, Earned Value Management, Quality Performance, Project Management, Time.

I. INTRODUCTION

In the implementation of construction projects, the objectives of project management or contractors (project management) in addition to meeting quality requirements are costs and schedules. The construction industry relies heavily on the subcontracting model of project organization and subcontractors are responsible for between 80% and 85% of all construction work [1]. In architectural, engineering, and construction projects are often criticized for the ineffectiveness of delivering the goals that have been set [2]. Construction projects in Indonesia are also often criticized by stakeholders for having poor construction quality (Willar et al., 2015). Many obstacles during the project process such as uncertainty and risk often cause delays and budget overruns during the project. That error caused by measuring progress decreases over time, which can be explained by the reduction in uncertainty as the amount of work performed increases in

cost and time [4]. With the required specifications, and in terms of achieving the final output with the satisfaction of the stakeholders the project is considered successful [5]

Quality of time and cost as interrelated concepts occur because, all three have become central in the construction literature [6]. Each project is a combination of different activities that are interconnected and have several success criteria, including time, cost and quality which are more significant in project completion, because they have a significant effect on the results obtained. On the other hand, quality is the final key that confirms success [7]

Monitoring and controlling schedule and cost performance is very important in any job production process. boosting performance and progress in a timely manner is essential to ensure project success, as it makes it possible to identify and anticipate problems and adapt ways to reduce quality and cost deviations (Oliveira, 2019).

Separating schedule and cost performance measures and developing a number of indices to measure progress and schedule and cost performance, as well as plan effectiveness and efficiency at each project level (Khamooshi & Golafshani, 2014). Project forecasting is an important aspect of project control to accurately predict project ending duration and costs (de Andrade et al., 2019). Project control requires that project progress is monitored during project execution to predict project final results and to take corrective actions that will be conducted by Perdana Home.

The project being implemented by Perdana Home is a Classic American Residential House with a value of IDR 2,700,000,000, - with a duration of 37 weeks. The value of the planned work is still below the target that has been planned with a cumulative value of the fifth week of 4.74% while the target value is 6.6% or if it is cashed, Perdana Home will experience an overpayment of IDR 51,879,927.64. Project expansion is mainly related to time and cost expansion. The traditional way of estimating the budget expenditure plan is to explore the difference between the projected costs and the actual costs incurred by the Perdana Home project, facing many projects that are being implemented due to great uncertainty as shown in Figure 1.

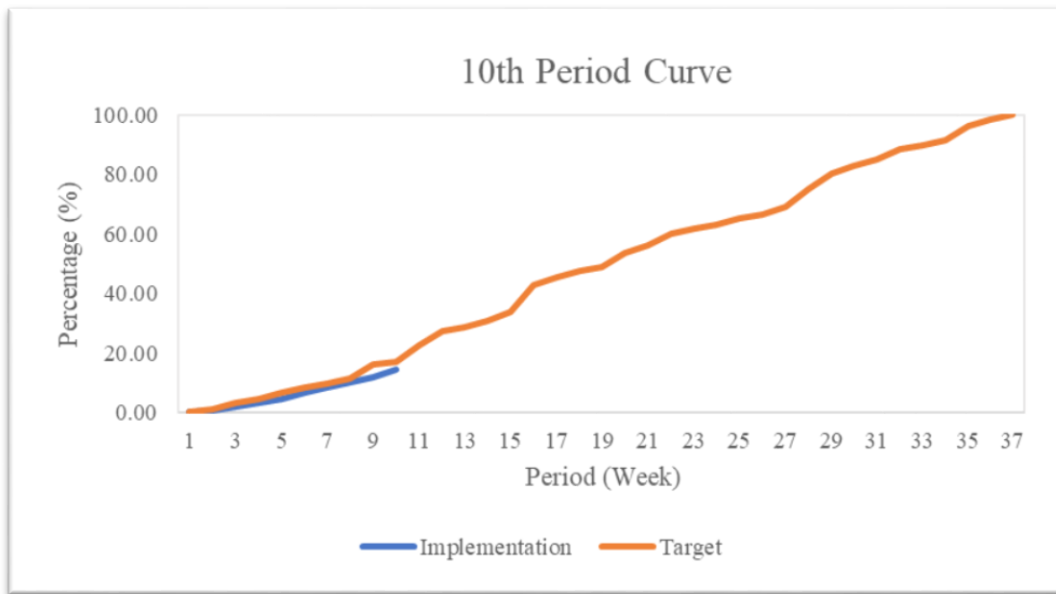


Fig. 1: Project S Curve

II. RESEARCH METHODOLOGY

A. Earned Value Management

The basic concept of return value can be used to analyze performance and make predictions about achieving goals. For this reason, 3 indicators are used, namely, ACWP (actual cost of work performed), BCWP (budgeted cost of work performed), and BCWS (budgeted cost of work scheduled). So here there is a combination of costs, schedules, and scope of work, where each work element has been allocated a cost and schedule that can be used as a benchmark in project implementation such as (Project Management Institute., 2019):

Step 1. Integrated cost variance (CV) and schedule variance (SV);

$$\text{Cost variance (CV)} = \text{BCWP} - \text{ACWP} \quad (1)$$

$$\text{Schedule variance (SV)} = \text{BCWP} - \text{BCWS} \quad (2)$$

Step 2. Monitor variance changes against standard figures

Step 3. Productivity and performance index

$$\text{Cost Performance Index (CPI)} = \text{BCWP}/\text{ACWP} \quad (3)$$

$$\text{Schedule Performance Index (SPI)} = \text{BCWP}/\text{BCWS} \quad (4)$$

Step 4. Estimated cost of implementing the project

B. Control Budget

Budgetary control is a widely applied mechanism for assessing the performance of subordinates and for communicating the goals, strategies, and planning processes by which the organization can achieve the desired results while monitoring expenditures. Therefore, this is also often used by organizations as a tool to shape, process and shape the behavior of officials so that it is aligned with organizational goals (Nylinder, 2009). To illustrate how allowable budget consumption is generally determined according to Figure 2 (Song et al., 2020).

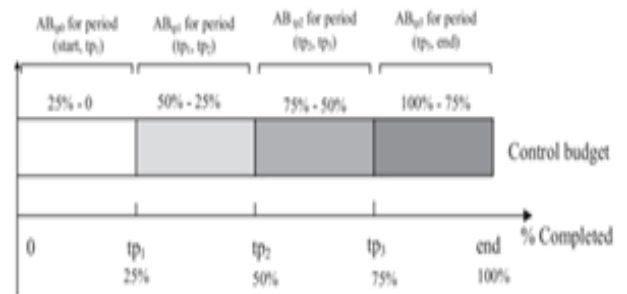


Fig. 2: Control Budget Concept

The calculation steps that will be used to allocate budget control are as follows:

Step 1. Activity of SSI value i

$$SSI_i = \left[\sqrt{\frac{\text{Var}(d_i)}{\text{Var}(C_{max})}} \right] \times CI \quad (5)$$

Step 2. Project activity risks in tracking period tp

$$AR_t = \begin{cases} 0 & \text{if } t = 0 \\ AR_{t-1} + \sum_{i=1}^n \frac{SSI_i}{d_i} \times 1_i(i, t), & \text{if not} \end{cases} \quad (6)$$

$$1_i(i, t) = \begin{cases} 1 & \text{if } S_i < t \leq S_i + d_i \\ 0, & \text{if not} \end{cases}$$

Step 3. Total project activity risk value

$$\text{TAR} = \text{AR}_{PD} \quad (7)$$

C. Quality Performance

Time effectiveness and cost effectiveness will be measured to evaluate time and cost performance, respectively. Time effectiveness shows the relative average reduction in delays that can be achieved on a project (Vanhoucke, 2019).

Step 1. Time Effectiveness

$$\text{Time effectiveness} = \frac{\text{DelayNo} - \text{DelayYes}}{\text{DelayNo}} \tag{8}$$

$$\text{DelayNo} = \sum \text{ARPCtp} > 50\% \tag{9}$$

(Activity value after the tracking period)

$$\text{DelayYes} = \sum \text{ARPCtp} < 50\% \tag{10}$$

(Activity value before the tracking period)

Step 2. Cost Effectiveness

$$\text{Cost effectiveness} = \frac{\text{CostNo} - \text{CostYes}}{\text{Effort}_\epsilon} \tag{11}$$

$$\text{CostNo} = \frac{\text{EAC Value}}{\text{Number of weeks worked}} \tag{12}$$

$$\text{CostYes} = \frac{\text{Total Predicted Cost on Completed Project}}{\text{Number of weeks to work}} \tag{13}$$

$$\text{Effort}_\epsilon = \text{Total Predicted Cost on Completed Project} \tag{14}$$

III. RESULT AND DATA ANALYSIS

A. Earned Value Management

This EVM method can be used to analyze performance and make estimates of achieving targets in project scheduling. There are 3 indicators in it, namely:

- Budgeted Cost of Work Schedule (BCWS) Percentage of cumulative plans at week 19 = 48.81%
 BCWS value = % plan achievement x budget plan
 = 48.81% x IDR 2,700,000,000
 = IDR 1,317,870,000
- Actual Cost Work Performed (ACWP)
 From the bookkeeping of the project, it was found that the funds that had been issued amounted to = IDR 1,346,895,000
- Budgeted Cost of Work Performed (BCWP) Cumulative actual percentage at week 10 = 48.195%
 BCWP value = % actual achievement x planned budget
 = 48.195% x IDR 2,700,000,000
 = IDR 1,301,265,000

From the BCWS calculation, the amount is IDR 1,317,870,000, and the value of the ACWP or actual costs incurred is greater, amounting to IDR 1,346,895,000, while the value of the project obtained is IDR 1,301,265,000. This implies there will be a cost increase in the project when it is completed later based on Figure 3.

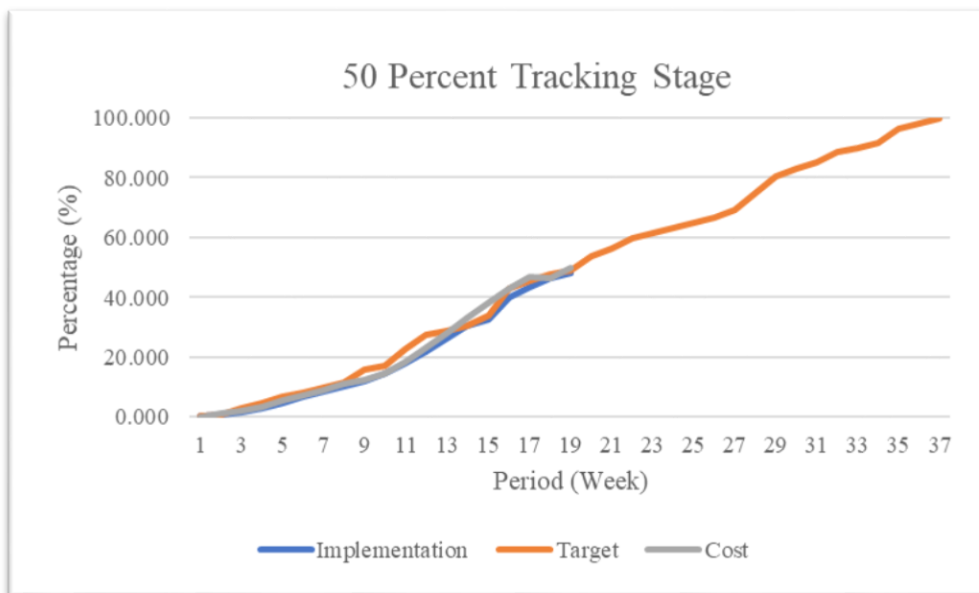


Fig. 3: Project Tracking

- SV (Schedule Variance)

The SV value is obtained from the difference between BCWP and BCWS
 $= BCWP - BCWS$
 $= IDR 1,317,870,000 - IDR 1,301,265,000$
 $= - IDR 16,605,000$

Negative results in the SV calculation results indicate that the job performance is not good because the actual work being carried out is slower than the scheduling plan that was prepared.

- SPI (Schedule Performance Index)

Obtained from the ratio between BCWP and BCWS
 $= BCWP/BCWS$
 $= IDR 1,301,265,000 / IDR 1,317,870,000$
 $= 0.987$

An SPI value of less than 1 (<1) indicates that the work performance is not as expected because it does not exceed the predetermined work targets.

- CV (Cost Variance)

Obtained from the reduction between BCWP and ACWP
 $= BCWP-ACWP$
 $= IDR 1,301,265,000- IDR 1,346,895,000$
 $= - IDR 45,630,000$

The negative value of the cost variation indicates that the costs incurred are greater than the actual value of the work done.

- CPI (Cost Performance Index)

Obtained from the ratio between BCWP and ACWP
 $= BCWP / ACWP$
 $= IDR 1,301,265,000 - IDR 1,346,895,000$
 $= 0.966$

An achievement score of less than 1 (<1) indicates a cost performance that exceeds not according to plan, because the costs incurred (ACWP) are greater than the expected value (BCWP) or in other words there is an increase in costs of IDR 45,030,000.

B. Estimate To Complete

Besides being able to be used to analyze project performance, it can also be used to estimate costs and project completion time. This forecast can be useful to provide an early warning about what will happen in the future. The following is the estimated final cost of the project at the 50% Stage:

$ETC = (RAB-BCWP) / CPI$
 $= (IDR 2,700,000,000- IDR 1,301,265,000) / 0.966$
 $= IDR 1,447,965,850$
 $EAC = ACWP + ETC$
 $= IDR 1,346,895,000 + IDR. 1,447,965,850$
 $= IDR 2,794,860,850$

Based on the calculation above, the estimated project completion cost is IDR 2,794,860,850, and the estimated cost of completion (EAC) of IDR

The estimated time for project completion is as follows:

Plan time (OD): 37 weeks
 Time taken: 19 weeks
 SPI index value: 0.987

Then the estimated project completion time (ECD) can be calculated as follows:

Estimated Completion Date (ECD)
 $= (Time / SPI) + Start date$
 $= ((37-19) / 0.987)) + 19$
 $= 37.48 weeks$

A grade point index of less than 1 (<1) indicates poor current cost performance and the project is predicted to be completed.

C. Control Budget

Table 1. shows the TAR value of 1,182, meaning that there is an acceleration in the time the project will be completed based on the calculation of the reduced duration of each activity using the Schedule Sensitivity Index. This can cut the project time from the project duration of 259 days or 37 weeks to 235 days, which means the project finished earlier in 21 or 3 weeks from the agreed schedule or to 34 weeks.

Table.1 Total Risk Activity

Critical Index : 52%				
Project Duration : 259 day				
SPI Value : 0.987				
No	Activity	Druration of Activity	SSI	Value
1	A31	7	0.086	0.999
2	A32	20	0.145	1.006
3	A33	7	0.086	1.019
4	A34	4	0.065	1.035
5	A35	7	0.086	1.047
6	A36	7	0.086	1.059
7	A37	30	0.177	1.065
8	A38	14	0.121	1.074
9	A39	25	0.162	1.080
10	A40	28	0.171	1.086
11	A41	7	0.086	1.099
12	A42	10	0.102	1.109
13	A43	24	0.158	1.115
14	A44	15	0.125	1.124
15	A45	15	0.125	1.132
16	A46	14	0.121	1.141
17	A47	14	0.121	1.149
18	A48	10	0.102	1.160
19	A49	10	0.102	1.170
20	A50	7	0.086	1.182
TAR				

Table 2. is the calculation of the Budget Control Allocation when tracking the work to be done. The Cost Sensitivity Index (CSI) value is positive because it is more than 1 (> 1) this shows the progress of the percentage of projects that will be completed each week in accordance with the budget issued. In the completion period the project will spend Rp. 1,314,900,000 of the additional budgets with a value of Rp. 1,350,000,000, meaning that the costs incurred do not exceed the agreed budget value when the project is completed.

Table 2 Schedule Sensitivity Index

No	Activity	Activity Duration	SSI	Finish Time
1	A31	7	0.086	6
2	A32	20	0.145	17
3	A33	7	0.086	6
4	A34	4	0.065	4
5	A35	7	0.086	6
6	A36	7	0.086	6
7	A37	30	0.177	25
8	A38	14	0.121	12
9	A39	25	0.162	21
10	A40	28	0.171	23
11	A41	7	0.086	6
12	A42	10	0.102	9
13	A43	24	0.158	20
14	A44	15	0.125	13
15	A45	15	0.125	13
16	A46	14	0.121	12
17	A47	14	0.121	12
18	A48	10	0.102	9
19	A49	10	0.102	9
20	A50	7	0.086	6
Time Total				238

$$\begin{aligned}
 \text{ABM20} &= (\text{PCM19}+1 - \text{PC19}) \times (\text{control budget} + \text{w19 budget}) \\
 &= (53.788\% - 49.885\%) \times (13500000 + 3105000) \\
 &= 70335000
 \end{aligned}$$

Table 3. Allocation of Project Budget Control at the time of tracking.

Week	Budget (Rp)	Target (%)	Budget Control Allocations	CSI
W19	3105000	48.81		
W20	135000000	53.79	70335000	1.023
W21		56.18	131760000	1.024
W22		59.92	232740000	1.022
W23		61.64	279180000	1.022
W24		63.17	320490000	1.021
W25		65.07	371790000	1.020
W26		66.69	415530000	1.020
W27		69.02	478440000	1.019
W28		74.98	639360000	1.018
W29		80.23	781110000	1.016
W30		82.81	850770000	1.016
W31		85.06	911520000	1.016
W32		88.55	1005750000	1.015
W33		89.88	1041660000	1.015

W34	91.54	1086480000	1.014
W35	96.45	1219050000	1.014
W36	98.23	1267110000	1.013
W37	100	1314900000	1.013

D. Performance Quality Forecast

➤ Time Effectiveness When Project Completed

Effectiveness affects productivity, so to achieve good work effectiveness, work time management is needed. Based on formula below we can find out how effective the development work process is.

$$\text{Time Effectiveness} = \frac{\text{Delay}_{\text{No}} - \text{Delay}_{\text{Yes}}}{\text{Delay}_{\text{No}}} = \frac{20.310 - 15.906}{20.310} = 0.216$$

$$\begin{aligned}
 \text{Delay}_{\text{No}} &= \sum \text{ARPCtp} > 50\% \text{ (Activity value after tracking period)} \\
 &\text{based on Table 1 Risk Activity Value} = 0.999 + 1.006 + 1.019 + 1.035 + 1.047 + 1.059 + 1.065 + 1.074 + 1.080 + 1.086 + 1.099 + 1.109 + 1.115 + 1.124 + 1.132 + 1.141 + 1.149 + 1.160 + 1.170 + 1.182 = 20.310
 \end{aligned}$$

$$\begin{aligned}
 \text{Delay}_{\text{Yes}} &= \sum \text{ARPCtp} < 50\% \text{ (Activity value before tracking period)} \\
 &\text{based on Table 4.5 Performance Index Recap from Cost Perspective of Week 19} = 0.649 + 0.854 + 0.573 + 0.653 + 0.712 + 0.807 + 0.865 + 0.899 + 0.743 + 0.852 + 0.801 + 0.793 + 0.911 + 0.990 + 0.964 + 0.928 + 0.954 + 0.972 + 0.987 = 15.906
 \end{aligned}$$

With this can compare the presence of workers and the absence of work in the period before and after tracking. The higher the index value of an activity indicates that the activity is running effectively. With equation no.7, positive value of 0.216 is obtained.

➤ Cost Effectiveness at Project Completed

Based on Formula (11), you can find out how effective the development work process is, in terms of the costs that will be used.

$$\text{Cost effectiveness} = \frac{\text{Cost}_{\text{No}} - \text{Cost}_{\text{Yes}}}{\text{Effort}_{\text{E}}} = \frac{147097939.5 - 73050000}{131490000} = 0.062.$$

The calculation uses the formula that has been calculated in Formulas (12), (13) and (14). and Effort_E is effort in allocating costs as shown in Table 3.

$$\begin{aligned}
 \text{Cost}_{\text{No}} &= \frac{\text{EAC VALUE}}{\text{Number of weeks worked}} \\
 &= 2794860850 / 19 = 147097939.5 \\
 \text{Cost}_{\text{Yes}} &= \frac{\text{Total Control Budget Allocation on Completed Projects}}{\text{Number of weeks to work}} \\
 (13) &= 1314900000 / 18 = 73050000 \\
 \text{Effort}_{\text{E}} &= \text{Total Cost allocation on Completed Projects} \\
 &= 1314900000.
 \end{aligned}$$

IV. CONCLUSION

Based on the results of data processing and analysis of research data, it can be concluded as follows:

The model for implementing Earned Value Management, projects that are carried out at the 50% stage and are projected to be completed, will spend a value of IDR 2,794,860,850 or over budget. Whereas at the time of work it is projected that it will experience a delay in the period of 37.48 weeks. The performance quality measurement function allows the project team to monitor the quality performance of a project, and the performance comparison function allows comparison of projects within a project portfolio. The use of Quality-Earned Value Management as a tracking period for each period which has implications for the cost and processing time of project work.

Calculation of the control budget allocation at the stage of tracking the use of a limited budget to take corrective actions with the aim of maximizing the expected project results. More precisely, a control budget allocation approach is proposed to determine the amount of budget consumption allowed in each control phase of a project or activity. acceleration of project time will be completed based on the calculation of the reduction in the duration of each activity using the Schedule Sensitivity Index. This can cut project time from a project duration of 259 days or 37 weeks to $243,425 = 244$ days, which means the project was finished earlier at $15,575 = 15$ days from the agreed schedule or to 35 weeks. While the Cost Sensitivity Index (CSI) value is positive because it is more than 1 (> 1) this shows the progress of the percentage of projects that will be completed each week in accordance with the budget issued. In the completion period the project will spend Rp. 1,314,900,000 of the additional budget with a value of Rp. 1,350,000,000, meaning that the costs incurred do not exceed the agreed budget value when the project is completed.

Calculation of performance quality forecasts in terms of cost-effectiveness, the hybrid strategy has the highest performance (0.062 compared to 0.029 and 0.028. Meanwhile, in terms of time efficiency the hybrid strategy has the highest performance (0.126 compared to 0.088 and -0.013 for interventions and preventive strategies following the Earned value) Value Management respectively).

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