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The Performance of Traditional Boatbuilding Project in East Java, Indonesia

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Abstract

Traditional shipyards in East Java, Indonesia have produced a lot of wooden boats. The performance of schedule and cost are the most critical in the boat building process. In this study, we aim to evaluate the performance of project management at traditional shipyard by using the S-curve, schedule performance index, and cost performance index. Based on the overall performance, the results showed that the boat building project still spent more cost than the budgeted costs and completes the boat building activities less than had been planned. The biggest gap between planning and realization is in the hull construction activities, frame installation, and hatch installation. Several caused factors are only a few people who are proficient in bending process, no special precision tools in bending process, and simple equipment/manually usage. This paper provides a new insight for calculating more than one boatbuilding project in S-curve. Future research could be done by sensitivity analysis for tolerated day's number of each activity in manufacturing process in order to gain the good CPI and SPI values.

Keywords

Traditional shipyard, schedule performance index, cost performance index, S-curve, Indonesia

1. Introduction

Traditional shipyards in East Java, Indonesia have produced wooden boats and have been being a cluster for shipbuilding industries. The industry is labor intensive. They work outdoor at the dockyard along the coastal lines. Mostly they rent the dockyard daily to the association office of fisherman. The traditional shipyard has several suppliers such as driving machine, wood, stainless steel, bolts and nuts, and welding in the local city and nearby. The owner and project leader who head 5-7 workers in a team have a target when the construction of a boat is planned to be completed. But the realization sometimes cannot meet the planned schedule.

The project management tool for controlling and managing the construction project by measuring time/schedule efficiency and effectiveness is known as schedule performance index or known as SPI. Meanwhile, cost performance index or known as CPI is a tool in project management for controlling, and managing the construction project by measuring the cost effectiveness and efficiency of expenses spent on a project like ship construction (Tijanic and Car-Pusic, 2017; Kerzner and P.Saladis, 2017). In ship construction project management, the *S*-Curve is very suitable to be used as a monthly project report that is ongoing and to project/company leaders because the *S*-Curve can display the cumulative progress of work, expressed in units of cost, labor hours, percentage of progress, etc., in relation to time clearly (PMI, 2008).

There are several literatures which initiate this study. Cristobal (2017) provided the S-curve envelope to be used as an early warning system to determine whether the S-curve from the actual progress is reasonable. Cioffi (2005) proposed a tool for managing projects to produce an analytic parameterization of the S-Curve. Subsequently, Cioffi

(2006) modified an earned value approach that weights quantities according to their position in a project's timeline. Warburton (2011) provided a formal method for including time dependence into earned value management.

To the best of our knowledge, the performance of project building at traditional shipyard has not been studied yet. The aim of this study is to measure the performance of project building by cost performance index (CPI), schedule performance index (SPI), and *S*-curve. Furthermore, the results would be analyzed and the improvement solutions would be discussed.

The remaining of the paper is organized as follows. Section 2 discusses the literature review. Section 3 describes the research methodology. Results and discussions of the project building performance are presented in Section 4. Finally, conclusions and future research are described in Section 5.

2. Literature Review

2.1 Schedule Performance Index (SPI)

SPI is the performance efficiency factor in completing work can be shown by a comparison between value of work physically completed or earned value (EV) with a planned value (PV) (Maromi and Retno, 2017). The SPI describes what portion of the ships construction planned schedule was actually accomplished (Kerzner and P.Saladis, 2017). The formula to calculate the value of SPI is as follows:

$$\textit{Schedule performance index} = \frac{BCWP}{BCWS} \text{ or } \frac{EV}{PV} \quad (2.1)$$

Budgeted cost of works performance (BCWP) is the amount that had been planned to be spent for the work (ship construction) that has been completed. Whereas budgeted cost of work schedule (BCWS) or known as planned value is the budgeted amount of work that has been scheduled to be completed at the time of measurement (Kerzner and P.Saladis, 2017). A value of 1.0 SPI would indicate the ship construction meeting the schedule (Kerzner, 2017). Value less than 1.0 is undesirable, it indicates the project is delay (Meredith et al. 2017). While the value more than 1.0 is a good thing because the project or ship construction could finish faster than schedule planned. When the project finish before the deadline and deliver the ships toward customer faster, it will increase the customer satisfaction. Deliver the product faster will influence the order fulfillment lead time attribute.

2.2 Cost Performance Index

The cost performance index, can be calculated as follow

$$\textit{Cost performance index} = \frac{BCWP}{ACWP} \quad (2.2)$$

Budgeted cost of works performance (BCWP) is the amount that had been planned to be spent for the work (ship construction) that has been completed. Whereas actual cost of work performance (ACWP) indicates the amount expended (in terms of fully burdened direct labor or direct cost) on work that has been completed within a given time period. It is also known as AC, or actual cost. A value of CPI is 1.0 indicate the expenses according to plan. When the value less than 1.0 it means that, the project has consumed more money than planned. While the value greater than 1.0, indicate the performance of shipyard is good because it can manage the expenses less than what have planned and there have been savings (Czarnigowska, 2008).

2.3 *S*-Curve

S-Curve is a curve that shows the cumulative growth of the selected variable or amount of work over a given time period. Thus on the S-curve can be described as the progress of the volume of work completed throughout the project or work in a part of the project.

S-curves can be utilized for few purposes. The purposes are to evaluate and screen the actual progress toward the schedule plan, to figure the likely project duration once the contract cost and aggregate use are known, to oversee cash flow, current execution status, future fundamental costs/duration, etc. (Cristobal, 2017).

Visualization of the S curve can provide information about the progress of the project by comparing it to the planned schedule. From this it is known whether there is a delay or acceleration of the project schedule. This indication can be preliminary information to make corrective actions in the schedule control process. But the information is not detailed and is only limited to assessing project progress.

3. Research Methodology

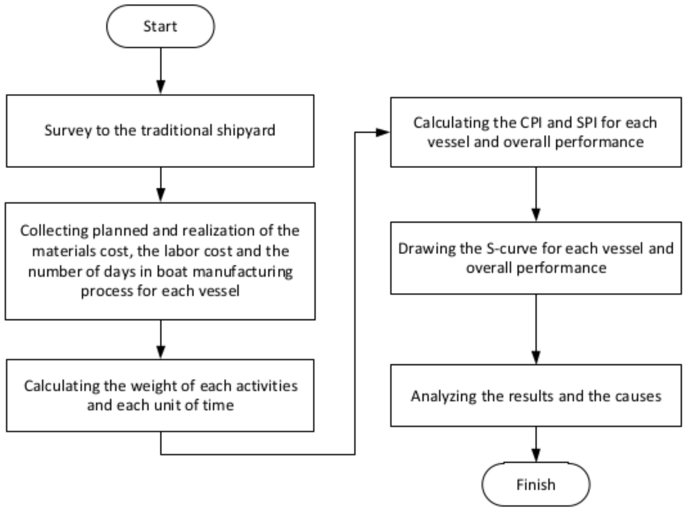


Figure 1. Research Methodology

Based on Figure 1, firstly the research is started by conducting a survey to the traditional shipyard in Lamongan regency, East Java province. We observed the largest traditional shipyards. Secondly, the planned and realization of the material cost, the labor cost, and the number of days would be collected in boat manufacturing process for each vessel. Thirdly, the weight of each activities and each unit of time from the time the project starts to the time the project is completed would be calculated at this stage. Fourthly, we calculated the SPI and CPI values for each vessel and overall performance. Finally, the *S*-curve for each vessel and overall performance would be mapped to analyze all the results and the causes.

4. Results and Discussions

4.1 Cost Calculation

Before making the S Curve, it is necessary to calculate the cost of shipbuilding. The costs include labor costs and material costs. The cost is calculated from the planned costs to the real cost. The calculation is carried out to determine whether there is a difference between the planned costs and real costs. The calculation steps as follow:

4.1.1 Calculation of Total Labor Costs

The calculation of total labor costs is obtained from the sum of labor costs in each type of shipbuilding activity. Based on data from interviews with shipyard owners and project leaders, it is known that there are 3 types of labor shipbuilding activities, namely beginner, medium, and expert. The three types of labor have different prices and workers' needs. So that labor costs can be calculated for each type of activity using the formula:

(((total beginner workers*standard beginner costs) + (total medium workers* standard costs) + (total expert workers * standard cost experts)*number of days)).. ...(4.1)

Besides, based on the results of interviews with shipyard owners and project leaders, it is also known that labor cost are paid in bulk (complete installation) in installing net engine and driving engine activities, so that labor costs are relatively the same or unchanged at Rp 1.800.000 and Rp. 750.000. So, in engines installation activity the labor costs can be calculated by using the formula:

(Standard cost of labor * number of machines to be installed)... (4.2)

Table 1. Total Labor Cost

Activities	The worker			Standard cost of labor			Number of days	Total labor cost
	Beginner	Medium	Expert	Beginner	Medium	Expert		
Cutting Woods	1	2	1	Rp90.000	Rp100.000	Rp110.000	9	Rp 3.600.000
Hull Construction	1	5	1	Rp125.000	Rp150.000	Rp200.000	60	Rp 64.500.000
Frame Installation	1	5	1	Rp125.000	Rp150.000	Rp200.000	18	Rp 19.350.000
Hatch Installation	1	5	1	Rp125.000	Rp150.000	Rp200.000	72	Rp 77.400.000
Driving Engines Installation (3 Engines)		1	1	Rp1.800.000			5	Rp 5.400.000
Net Engine Installation		1	1	Rp750.000			1	Rp 750.000
The Wheelhouse Building Installation		1	1	Rp125.000	Rp150.000	Rp200.000	10	Rp 3.500.000
							175	Rp 174.500.000

Table 1 shows the detailed total labor costs for fishing boat with the size of 53 Gross Tonnage (GT). Then, the results of the calculation of labor costs in each type of shipbuilding activities are added up. Thus, the results of the calculation of the total labor costs in shipbuilding, namely:

4.1.2 Calculation of Total Cost of Wood Material

Based on data from interviews with shipyard owners and project leaders, it is known that there are several types of wood used, the amount of wood, and the price of wood material for shipbuilding. So with this data, the total cost of wood material can be calculated using the formula:

((Amount of teak wood material * Price of teak wood material) + (Amount of mahogany wood material * Mahogany wood material price)) .... (4.3)

Thus, the results of the calculation of the total cost of wood material for ships are shown in Table 2.

Table 2. Total Cost of Wood Material

Wood Material		Price of Wood Material		Total Cost of Wood Material
Teak	Mahogany	Teak	Mahogany	
28	35	Rp 13.000.000	Rp 4.000.000	Rp 504.000.000

4.1.3 Calculation of Total Cost of Materials Used for Shipbuilding

In calculating the cost of materials used in shipbuilding, it is necessary to have some data, namely the material costs for net engine and driving engine, the total cost of wood materials, and the percentage of wood used in each type of shipbuilding activities. Based on interviews with shipyard owners and ship project leaders, it is known that the cost of materials for engines is Rp. 40,000,000 and the percentage of total wood used in each type of shipbuilding activity are shown in Table 3.

Table 3. Total Cost for Each Activity

Activities	%
Cutting Woods	20%
Hull Construction	25%
Frame Installation	20%
Hatch Installation	25%
The Wheelhouse Building Installation	10%
	100%

So based on the data above and in Table 2 and Table 3, it can be calculated the cost of materials used in the installation of the engines as follows:

(Machine material costs * number of machine installation) .... (4.4)

And the calculation of material costs used in each type of other shipbuilding activities, namely:

(Total cost of wood material * Percentage of each type of activity) .... (4.5)

Then the results of the calculation of material costs used in each type of shipbuilding activity are added up. Thus, the results of the calculation of the total cost of materials used in shipbuilding are shown in Table 4.

4.1.4 Calculation of Total Costs for Shipbuilding

At this stage, to calculate the total cost of shipbuilding required data on labor costs for each type of activity and material costs used for each type of shipbuilding activity. The data has been shown in Table 1 and Table 2, so based on the data above, the total cost of the ship can be calculated using the formula:

(labor costs for each type of activity + material costs used)... (4.6)

Then the results of the calculation of the total cost of shipbuilding for each type of activity are added up. Thus, the results of the calculation of the total cost of the entire ship are shown in Table 4.

The method of calculating the shipbuilding total cost of 53 GT for the real cost is the same as the calculation of the total plan cost. The difference is only on the number of days needed in each activity. Based on the method of calculating the planning and realization of shipbuilding total cost of 53 GT above, the calculation result of the planning and realization the shipbuilding total cost of 22 GT, 31 GT, and 16 GT analog and can be displayed in Table 4.

Table 4. Total Cost for Planning and Realization of Shipbuilding

Activities	Number Of Days	Total Labor Cost	Total Cost of Wood Material	Total Material Cost of Material Usage	Total Cost
PLANNING 53 GT					
Cutting woods	9	Rp3.600.000		Rp100.800.000	Rp104.400.000
hull construction	60	Rp64.500.000		Rp126.000.000	Rp190.500.000
frame installation	18	Rp19.350.000		Rp100.800.000	Rp120.150.000
hatch installation	72	Rp77.400.000		Rp126.000.000	Rp203.400.000
driving engine installation (3 engines)	5	Rp5.400.000		Rp120.000.000	Rp125.400.000
net engine installation	1	Rp750.000		Rp40.000.000	Rp40.750.000
the wheelhouse building installation	10	Rp3.500.000		Rp50.400.000	Rp53.900.000

Activities	Number Of Days	Total Labor Cost	Total Cost of Wood Material	Total Material Cost of Material Usage	Total Cost
	175	Rp 174.500.000	Rp504.000.000	Rp664.000.000	Rp838.500.000
REALIZATION 53 GT					
Cutting woods	9	Rp3.600.000		Rp100.800.000	Rp104.400.000
hull construction	78	Rp83.850.000		Rp126.000.000	Rp209.850.000
frame installation	24	Rp25.800.000		Rp100.800.000	Rp126.600.000
hatch installation	84	Rp90.300.000		Rp126.000.000	Rp216.300.000
driving engine installation (3 engines)	11	Rp5.400.000		Rp120.000.000	Rp125.400.000
net engine installation	1	Rp750.000		Rp40.000.000	Rp40.750.000
the wheelhouse building installation	16	Rp5.600.000		Rp50.400.000	Rp56.000.000
	223	Rp215.300.000	Rp504.000.000	Rp664.000.000	Rp879.300.000
PLANNING 22 GT					
Cutting woods	5	Rp2.000.000		Rp38.200.000	Rp40.200.000
hull construction	24	Rp25.800.000		Rp47.750.000	Rp73.550.000
frame installation	65	Rp69.875.000		Rp38.200.000	Rp108.075.000
hatch installation	10	Rp10.750.000		Rp47.750.000	Rp58.500.000
driving engine installation (3 engines)	5	Rp3.000.000		Rp120.000.000	Rp123.000.000
net engine installation	3	Rp750.000		Rp40.000.000	Rp40.750.000
the wheelhouse building installation	7	Rp2.450.000		Rp19.100.000	Rp21.550.000
	119	Rp114.625.000	Rp191.000.000	Rp351.000.000	Rp465.625.000
REALIZATION 22 GT					
Cutting woods	5	Rp2.000.000		Rp38.200.000	Rp40.200.000
hull construction	36	Rp38.700.000		Rp47.750.000	Rp86.450.000
frame installation	71	Rp76.325.000		Rp38.200.000	Rp114.525.000
hatch installation	16	Rp17.200.000		Rp47.750.000	Rp64.950.000
driving engine installation (3 engines)	11	Rp3.000.000		Rp120.000.000	Rp123.000.000
net engine installation	3	Rp750.000		Rp40.000.000	Rp40.750.000
the wheelhouse building installation	7	Rp2.450.000		Rp19.100.000	Rp21.550.000
	149	Rp140.425.000	Rp191.000.000	Rp351.000.000	Rp491.425.000
PLANNING 31 GT					
Cutting woods	8	Rp3.200.000		Rp47.400.000	Rp50.600.000

Activities	Number Of Days	Total Labor Cost	Total Cost of Wood Material	Total Material Cost of Material Usage	Total Cost
hull construction	72	Rp64.800.000		Rp59.250.000	Rp124.050.000
frame installation	6	Rp5.400.000		Rp47.400.000	Rp52.800.000
hatch installation	84	Rp75.600.000		Rp59.250.000	Rp134.850.000
driving engine installation (3 engines)	6	Rp4.500.000		Rp120.000.000	Rp124.500.000
net engine installation	1	Rp750.000		Rp120.000.000	Rp120.750.000
the wheelhouse building installation	12	Rp4.500.000		Rp23.700.000	Rp28.200.000
	189	Rp158.750.000	Rp237.000.000	Rp477.000.000	Rp635.750.000
REALIZATION 31 GT					
Cutting woods	8	Rp3.200.000		Rp47.400.000	Rp50.600.000
hull construction	84	Rp75.600.000		Rp59.250.000	Rp134.850.000
frame installation	12	Rp10.800.000		Rp47.400.000	Rp58.200.000
hatch installation	96	Rp86.400.000		Rp59.250.000	Rp145.650.000
driving engine installation (3 engines)	12	Rp4.500.000		Rp120.000.000	Rp124.500.000
net engine installation	1	Rp750.000		Rp120.000.000	Rp120.750.000
the wheelhouse building installation	12	Rp4.500.000		Rp23.700.000	Rp28.200.000
	225	Rp181.250.000	Rp237.000.000	Rp453.300.000	Rp662.750.000
PLANNING 16 GT					
Cutting woods	4	Rp1.600.000		Rp27.600.000	Rp29.200.000
hull construction	24	Rp25.200.000		Rp34.500.000	Rp59.700.000
frame installation	36	Rp37.800.000		Rp27.600.000	Rp65.400.000
hatch installation	8	Rp5.000.000		Rp34.500.000	Rp39.500.000
driving engine installation (3 engines)	2	Rp1.800.000		Rp120.000.000	Rp121.800.000
net engine installation	1	Rp600.000		Rp120.000.000	Rp120.600.000
the wheelhouse building installation	8	Rp2.600.000		Rp13.800.000	Rp16.400.000
	83	Rp72.000.000	Rp138.000.000	Rp364.200.000	Rp452.600.000
REALIZATION 16 GT					
Cutting woods	4	Rp1.600.000		Rp27.600.000	Rp29.200.000
hull construction	30	Rp31.500.000		Rp34.500.000	Rp66.000.000
frame installation	42	Rp44.100.000		Rp27.600.000	Rp71.700.000
hatch installation	14	Rp8.750.000		Rp34.500.000	Rp43.250.000

Activities	Number Of Days	Total Labor Cost	Total Cost of Wood Material	Total Material Cost of Material Usage	Total Cost
driving engine installation (3 engines)	8	Rp1.800.000		Rp120.000.000	Rp121.800.000
net engine installation	1	Rp600.000		Rp120.000.000	Rp120.600.000
the wheelhouse building installation	8	Rp2.600.000		Rp13.800.000	Rp16.400.000
	107	Rp88.350.000	Rp138.000.000	Rp364.200.000	Rp468.950.000

4.2 Performance Analysis of Shipbuilding

Performance analysis is carried out to control and evaluate the implementation of shipbuilding. There are 5 parameters used in analyzing shipbuilding performance, namely BCWP (Budgeting Cost Working Planning), BCWS (Budgeting Cost Working Schedule), ACWP (Actual Cost Working Planning), CPI (Cost Performance Index), and SPI (Schedule Performance Index).

To calculate the value of BCWP in shipbuilding requires some data such as the total cost of each activity in shipbuilding before the time planning is over and the planning for completing the shipbuilding. The calculation of BCWP values for n-activities can be written as follows:

n-activity BCWP = (total costs of the first activity in shipbuilding planning + total costs of the second activity in shipbuilding + total costs of subsequent activities in shipbuilding + …+ total costs of the n- activity in shipbuilding)

$$BCWP\ for\ n - activities = \sum_{i=1}^{n} total\ cost\ activities\ to - i \quad \text{.. (4.7)}$$

If at the end of the time planning there are still *k*-activities that have still not been completed, then the formula used is:

$$BCWP\ for\ n - activities = \sum_{i=1}^{n-k} total\ cost\ activities\ to - i + \left(\sum_{i=1}^{k} total\ cost\ activities\ to - i * (Number\ of\ days\ completed\ to - i / total\ realization\ days\ that\ required\ to - i)\right) \text{.....................(4.8)}$$

In BCWP calculation process, the value of the total cost of shipbuilding activities will not be added if the activity exceeds the specified shipbuilding planning time. So *n*-activities included in BCWP calculations are activities that have not exceeded or equaled with the time of shipbuilding planning was completed.

To calculate the value of BCWS in a shipbuilding requires some data such as the cumulative weight of the shipbuilding plan and the total cost of the shipbuilding plan. So the BCWS calculation can be written as follows:

BCWS = (cumulative weight of shipbuilding plan * total cost of shipbuilding plan)..................... (4.9)

To calculate the value of ACWP in a shipbuilding requires some data such as the cumulative weight of the realization of the shipbuilding and the total cost of the realization of the shipbuilding. So the ACWP calculation can be written as follows:

ACWP = (Cumulative weight of shipbuilding realization * total cost of shipbuilding realization).(4.10)

By using the formulas (4.7) to (4.10) and (2.1) to (2.2), the results of the performance analysis calculations on the construction of 53 GT, 22 GT, 31 GT and 16 GT can be displayed in Table 5.

Table 5. Calculation of the Performance Analysis

Parameter	Value of Ships			
	53 GT	31 GT	22 GT	16 GT

BCWP	Rp 736.171.428,57	Rp 590.693.750,00	Rp 366.441.477,27	Rp 404.046.428,57
BCWS	Rp 838.500.000,00	Rp 636.750.000,00	Rp 465.626.000,00	Rp 452.600.000,00
ACWP	Rp 771.800.000,00	Rp 616.343.750,00	Rp 388.613.352,27	Rp 415.700.000,00
CPI	0.954	0.958	0.943	0.972
SPI	0.878	0.929	0.787	0.893

So, based on the results of the calculation of the performance analysis above, it is known that the CPI and SPI values in the construction of 53 GT, 22 GT, 31 GT, and 16 GT ships have a value of less than one (<1), which means that shipbuilding project spent more costs than budgeted cost and the activities realization of shipbuilding less than planned activities.

4.3 Performance Analysis of Overall Shipbuilding

At this stage, the overall shipbuilding performance analysis will be carried out starting from 53 GT, 22 GT, 31 GT and 16 GT ships. It is known that the construction work plan of the four ships will end on the 30th Sunday on the 2nd day. The results of the calculation of the overall shipbuilding performance analysis can be displayed in Table 6.

Table 6. Calculation of the overall shipbuilding performance

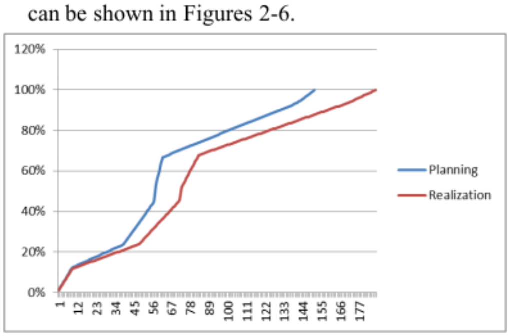
4 Ships Project	
Parameter	**Value**
BCWP	Rp 2.310.362.500
BCWS	Rp 2.392.475.000
ACWP	Rp 2.417.518.750
CPI	0.956
SPI	0.966

Based on the calculation results of the overall shipbuilding performance analysis in Table 6, it is known that the CPI and SPI values are still less than one (<1), which means that the overall shipbuilding project still spent more cost than the budgeted costs and completes the shipbuilding activities less than had been planned.

4.4 S CURVE

S curve is a graphic image consisting of planning graphs and realization graph on project. Both of these graphs are able to show whether the realization of project has been running accordingly, slower, or faster than planned. To illustrate the graph, we need some data, namely the cumulative weight of the plan and the cumulative weight of the realization.

Based on the data above, the results of the S curve for 53 GT, 22 GT, 31 GT and 16 GT shipbuilding projects can be shown in Figures 2-6.



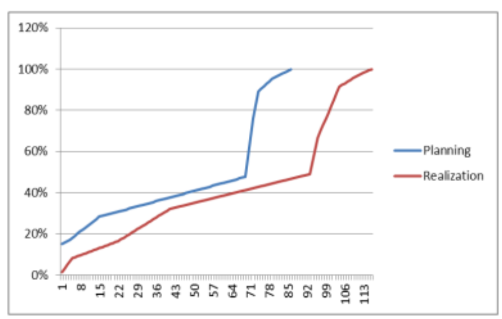
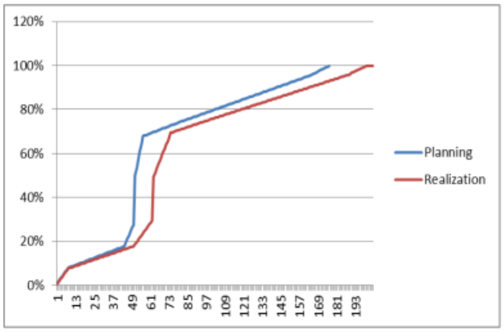


Figure 2. S Curve of Ship Size 53 GT

Figure 3. S Curve of Ship Size 22 GT



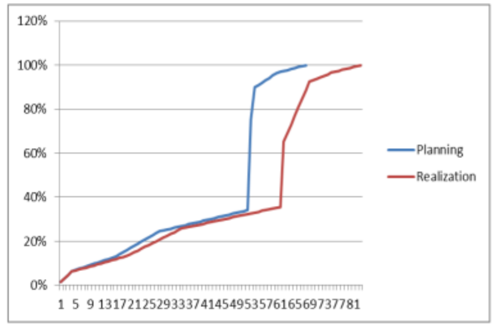


Figure 4. S Curve of Ship Size 31 GT

Figure 5. S Curve of Ship Size 16 GT

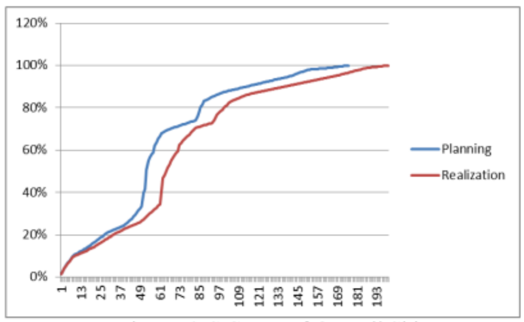


Figure 6. S Curve of Overall Ships

Based on the results of the S curve Figures 2-6, it is known that the realization line is still below the plan line. It means that, the realization of shipbuilding project has not yet reached the planned work weights. So the shipbuilding project has been delayed.

Based on data and analysis results in the field, the biggest gap between planning and realization is in the hull construction activities, frame installation, and hatch installation. Because these activities very related to the measurement and formation of wood into each part of the ship. At the time of direct observation, the shipyard still uses simple equipment, the activities are also still done manually, and there are only a few people who are proficient in bending. The process will automatically take a long time. Another example is burning the wood activity, when bending the wood the workers didn't use any special precision tools, so if the bending does not match what is planned the workers will automatically repeat the work until the results are appropriate.

Actually, if they have used the tool, although it is not sophisticated but can be used as a standard for the precision of a particular part of the ship's form, it may be able to cut time so that it does not happen often. Time cuts in shipbuilding activities greatly affects the costs incurred, especially for labor costs.

Another gap between planning and realization occurs in the driving engine installation. The shipyard waits for a long time because the engine of ship uses a used truck engine. Therefore, the finalization of the ship was delayed. Beside, installation of machines using welding also often delays. This is because the welder worker does not work in accordance with the order of incoming orders. Another factor that cannot be controlled is the weather. This traditional shipbuilding is outdoor. When it rains, the shipbuilding should stops first because there is a lot of electrical equipment used.

5. Conclusions and Future Research

We have described the performance measurement of traditional boat building in East Java, Indonesia by using schedule performance index (SPI), cost performance index (CPI), and *S*-curve. Based on the CPI and SPI values , which are less than one, it can be inferred that the shipbuilding project still spent more cost than the budgeted costs and completes the shipbuilding activities less than had been planned. *S*-curve showed that the realization progress is lower than the planned schedule. Based on data, the biggest gap between planning and realization is in the hull construction activities, frame installation, and hatch installation. Several caused factors are only a few people who are proficient in bending process, no special precision tools in bending process, and simple equipment/manually usage. Thus, it has the highly impact on the labor costs. Another gap occurs in the driving engine installation. It happened because of long lead-time in obtaining driving machine and welding process. This paper provides a new insight for calculating more than one boatbuilding project in *S*-curve. Future research could be done by sensitivity analysis for tolerated day's number of each activity in manufacturing process in order to gain the good CPI and SPI values.

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