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Implementation of Critical Chain Project Management (CCPM) and Critical Path Method (CPM) on Scheduling Ship Repair Project

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Abstract: Project scheduling is an essential element in order that the shipyard companies can make more profit. The most commonly used analysis is the Critical Path Method (CPM). But in reality, using CPM methods and other traditional methods is considered less efficient because it does not consider the productivity of each job in it and adds a safety times that causes the duration of the project becomes longer than it should be. According to that problem, there is another method to analyze project schedule is Critical Chain Project Management (CCPM). CCPM is a project planning method that emphasizes the resources needed to perform project tasks. This method is done by eliminating multitasking, student syndrome, Parkinson's Law and give buffer at the end of the project. In this study will be done by comparing of the duration and the cost of CCPM with Critical Path Method (CPM) in project repair BC30002 ship. Initial project scheduling uses the traditional method of Gantt chart which is then breakdown in more detail and complete with the relationship between its activities into CPM form and then it will be compared with the duration of the result of CCPM scheduling which has done by eliminated multitasking, safety time on each activity and giving buffer in the end of the process. Based on the analysis, obtained the duration using the CCPM method is 27days faster than CPM and saves cost as much of Rp. 342,380,000,00.

Key words: Project scheduling, critical path, critical chain project management, student syndrome, duration, Gantt chart

INTRODUCTION

The ship in this study is a type of fast patrol boat owned by the government in Karimun area. This ship is made and submitted by one of the shipyard company in Indonesia in 2010. Every year the ship is doing repair in the place of it manufactured. So, as shipyard must provide the best service in the result and customer satisfaction. To get that goal, the most important thing is to make good planning. Schedule planning is one important element for the shipyard company can get more profit. In this stage many things must be planned such as the required funds, material to be used, schedule from start to finish (Soeharto, 1995). Today there are many methods used in project scheduling. In order to schedule the project the most frequently used analysis is using Critical Path Method (CPM). CPM is a project scheduling method by determining the total duration of the longest chain of event to complete a project (PMI., 2013). But in reality, using the CPM and other traditional methods is considered to be inefficient because it does not consider the productivity of each work in it and problems that caused by human behavior resulting in additional time to completion of the project (Goldratt, 1997). The problem of that behavior such as student's syndrome, Parkinson's Law, multitasking and overestimated activity durations (Leach, 2000). According to that problem, there is a new method to create a project schedule, Critical Chain Project Management (CCPM). CCPM was first introduced in 1997 by Goldratt (1997). CCPM is a project planning method that emphasizes the resource that required performing tasks in the project. The purpose of using CCPM is to increase completion rates by eliminating human behavior as in the example above. So, the completion of the project will be faster and more efficient. It is hoped that the use of this method can improve the completion of the future projects and save cost that incurred and can raise the quality of the company without making great sacrifices. In order to conduct the best maintenance of the system it has been elaborated by Shafiq (2010). In this study, it will

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use the critical chain project management to plan a schedule for ship repair project in shipyard company to determine the total duration. The result will be compared with the traditional method of Critical Path Method (CPM).

MATERIALS AND METHODS

The flow and procedure of the study is conducted by the stages as follow. Firstly, a literature review is performed by referring to the materials as contained in text books, journals, codes and standards, rules and regulations and so on. This study uses CPM and CCPM method to identify the project schedule. CPM has been used widely in many areas as elaborated by Firmansyah *et al.* (2018), Silvianita *et al.* (2018) and Arinto (2010). CCPM also has been used widely in many areas as well (Leach, 2000; Shurrab, 2015). This study is trying to elaborate both method CPM and CCPM in order to schedule the repair ship.

Data collection: The data collection is carried out through a field study, comprises the direct observation to the object to be evaluated and also acquiring a number of data related to the study. The primary data which are required includes:

- Ship repair schedule data in which accordance with initial work contract
- Data on daily working hours in the shipyard
- Data on the number of workers involved

Project planning using critical path method: This step began with making the network plan which accordance with the work breakdown structure from the data that has been acquired before. Next to determine, the critical path with forward and backward calculation and then calculate the total float to identify the critical path and the total duration can be obtained.

Project planning using critical chain project management: Same as CPM method, this step began with making the network plan accordance with project data. Next to identify the critical path. The next step is to eliminate safety times by 50% from the initial duration that aims to increase the productivity of the work. Next to eliminated multitasking by exploiting the network plan that has been created using CPM. The process is done by changing the starting time of the identified activity that experienced multitasking. The last step in this method is to add buffer time into the network plan. The method which in used to calculate the buffer time is Root Mean Square Error Method (RSEM).

Direct labor cost analysis: After all analyzes have been done in the CCPM and CPM, it can be seen the total duration from the duration of the critical path. Then proceed with calculating labor cost based on working hours and total man power.

Comparison of the result of both methods: At this stage the results of each method will be compared the total duration of the project. This is faster than both methods.

RESULTS AND DISCUSSION

Project overview: The ship repair project A is a project undertaken by one of the shipyard company in Indonesia. This project runs from October 2016 through December 2016 as described in Fig 1. The principal dimension of a ship understudy is tabulated in Table 1. Grouping of project activities must be done and determined using the WBS system. WBS shows the overall project activities that contain the volume of work, activity duration and project cost. Table 2 of activities on the ship repair project.

Project planning using critical path method: This stage begins with modeling the schedule based on WBS data. The network planning based on CPM can be seen in Fig. 2.

Fig. 1: Repair ship (Butler, 2000)

Table 1: Principal dimension of ship

Principal dimension	Mesurements
Length Over All (LOA)	42 (m)
Length Perpendicular (LPP)	38 (m)
Breadth (B)	7.3 (m)
Hight (H)	4.47 (m)
Draft (T)	1.85 (m)
Speed (V max)	30 (Knot)

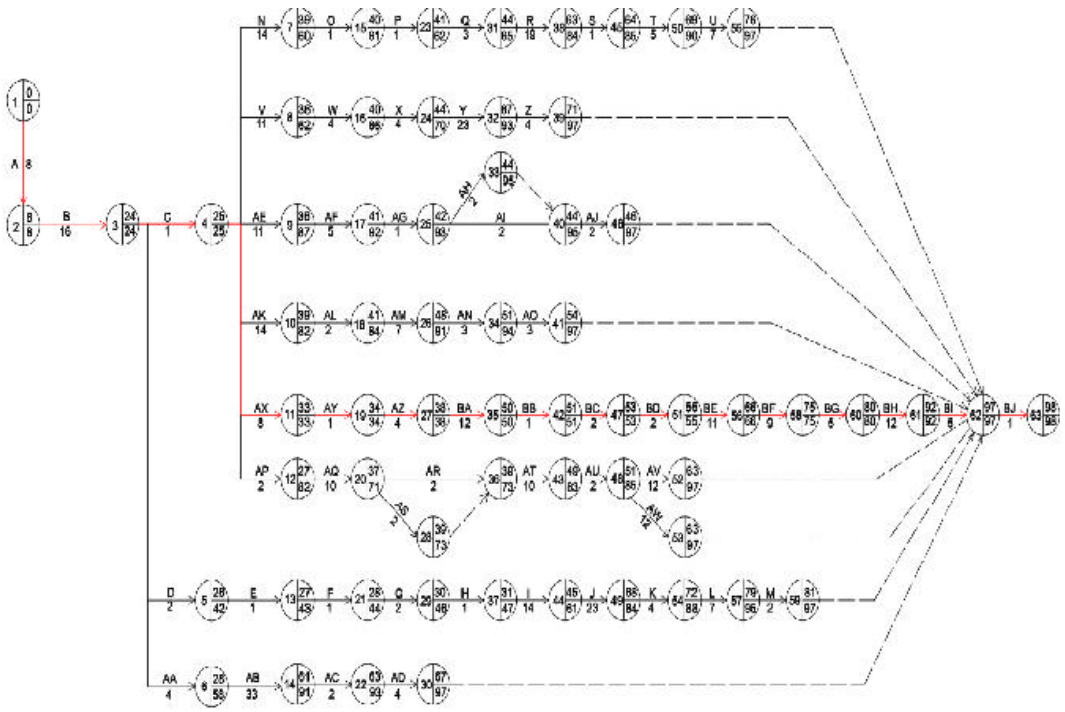

Fig. 2: Network planning using CPM

Table 2: Summary task of a ship repair project

A ship repair

Summary tasks	Duration (h)
General service	144
Storage tank	464
Propulsion	1168
Main engine	208
Hull	344
Sea chest value auxiliary generator room	176

Table 3: Direct cost of a ship repair project

Summary tasks	Labour cost (Rp.)
General service	53,040,000.00
Storage tank	231,880,000.00
Propulsion	573,240,000.00
Main engine	282,880,000.00
Hull	184,960,000.00
Sea chest value auxiliary generator room	435,520,000.00
Total	1,369,520,000.00

From CPM scheduling, it was found that the duration required to complete the project was 98 days. Based on the image above the bar that has a red color is including critical activities. The following is the direct labor costs of the ship repair project A can be seen in Table 3.

Project planning using critical chain project management: Scheduling using the CCPM method is divided into the following steps:

Reducing the duration of activities: In this first step, the activity duration will be reduced by 50% because the CPM method stillhas problem as follows by Aulady and Orleans (2016) and Valikoniene (2015).

Student's syndrome: Behavior that procrastinating because the deadline is still far away.

Parkinson's Law: Human behavior that do not want to finish work faster because it does not get a reward afterwards.

Overestimated activity durations: Estimate the longer project duration because wants to make more profit. From the reduction of the duration of the activity then obtained a new duration for 56.5 days.

Eliminating multitasking: In addition, to the above three problems, the next step is to eliminate multitasking or do two or more jobs at the same time (Aulady and Orleans, 2016). In the case of this project, multitasking can occur when workers exceed the quota that can be provided by the shipyard every day. Quotas provided by the shipyard can be seen in Table 4.

From the scheduling results using the CPM method then obtained the maximum number of workers in one day as follows Table 4 based on Table 5 can be seen an error

Table 4: Resources sheet of each workers quota

Resource name	Max units
Tugboat	30
Dock assist	30
Dock operator	30
Ship superintendent	4
Production superintendent	30
Cleaning	30
Pipe worker	30
Mechaincal shaft worker	30
Blasting/Painting	30
Fitter	30
Mechanical shaft worker	30
Welder	30
Material buyer	30
PT. Air	30

Table 5: Resources sheet result using the CMP method

Resource name	Max units
Tugboat	1
Dock assist	15
Dock operator	15
Ship superintendent	1
Production superintendent	8
Cleaning	3
Pipe worker	10
Mechaincal shaft worker	4
Blasting / Painting	8
Fitter	11
Mechanical shaft worker	34
Welder	6
Material buyer	2
PT. Air	4

Table 6: Resources sheet after eliminates multitasking

Resource name	Max units
Tugboat	1
Dock assist	15
Dock operator	15
Ship superintendent	1
Production superintendent	8
Cleaning	3
Pipe worker	10
Mechaincal shaft worker	4
Blasting/Painting	8
Fitter	11
Mechanical shaft worker	17
Welder	6
Material buyer	2
PT. Air	4

in the type of mechanical shaft worker because it exceeds the quota. Therefore, multitasking occurs in work that uses that type of workers and must be removed. How to overcome it is to move the starting time each activity that use that type of worker (Shurrab, 2015) and the results can be seen in Table 6.

Adding buffer to the CCPM schedule: The buffer or reserve time is entered at the end of the activity due to a reduced activity duration of 50% resulting in the risk of being late getting bigger. The amount of buffer obtained by using the equation Root Square Method (RSEM) by new bold (1998):

$$\text{Buffer size} - 2\times\sqrt{\frac{(S_1 - A_1)^2}{2} + , \ldots , + \frac{(S_{72} - A_{72})^2}{2}} \quad (1)$$

This equation is equivalent to calculating two standard deviations by entering the duration of CPM (S) and the duration of CCPM (A) which is 50% of the estimated safe. In this method there are two types of buffers used are project buffers that are placed at the end of critical activities and feeding buffer that is placed at the end of non-critical activities (Leach, 2000). Results of buffer calculations can be seen in Table 7.

Table 7: Result of feeding buffer calculation

Non-critical chain	Feeding buffer (days)
A-B-C-N-O-P-Q-R-S-T-U	13.70
A-B-C-V-W-X-Y-Z	9.18
A-B-C-AE-AF-AG-AH-AI-AJ	8.72
A-B-C-AK-AL-AM-AN-AN-AO	10.30
A-B-D-E-F-G-H-I-J-K-L-M	16.51
A-B-AA-AB-AC-AD	16.40
A-B-C-AP-AQ-AR-AS-AT-AU-AV-AW	9.45

Table 8: Result of project buffer calculation

Critical chain	Project buffer (days)
A-B-C-AX-AY-AZ-BA-BB-BC-BD-E=BE-BF-BG-BH-BI-BJ	14.36

Table 9: Labor cost ship repair project using CCPM

Summary tasks	Labour cost (Rp.)
General service	39,780,000.00
Storage tank	173,910,000.00
Propulsion	429,930,000.00
Main engine	212,160,000.00
Hull	138,720,000.00
Sea chest value auxiliary generator room	32,640,000.00
Total	1,027,140,000.00

Based on the calculation of Table 8, obtained project buffer are 14.36 days. Then the result is placed into the scheduling method of CCPM, so that, the total duration becomes 70.86 or 71 days. After that, it can be modeled as network diagram as in Fig. 4 as follows: the following is direct labor cost from ship repair project a can be seen in Table 9.

Comparison of the result from both methods: Based on the overall results of analysis that has been done, the duration of schedule that use CPM is 98 days and cost as much of Rp.1.369.520.000,00 and CCPM method with duration of 71 days and cost as much of Rp.1.027.140.000,00. From these results the CCPM method is 27 days faster than CPM and saves cost as much of Rp.342.380.000,00.

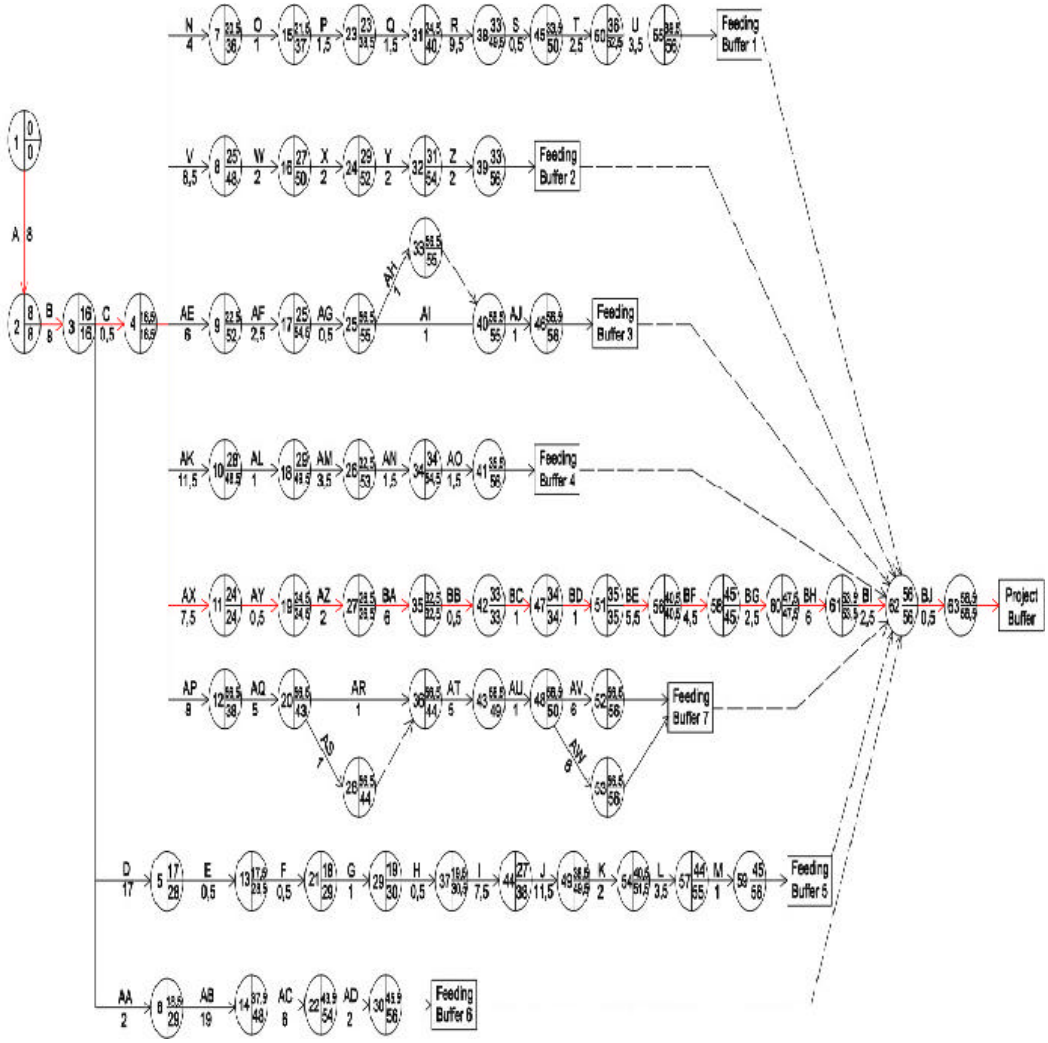

Fig. 3: Network planning using CCPM

CONCLUSION

Based on the overall result of the analysis that has been done can be concluded as follows: the total duration of project using the Critical Path Method (CPM) method is 98 days and direct labor costs Rp.1.369.520.000,00. The total project duration obtained using the Critical Chain Project Management (CCPM) method is 71 days and direct labor costs Rp. 684,760,000.00. From the results of both methods, the CCPM method will perform 27 days faster than CPM method.

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