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Scheduling Analysis Docking of the Leo Mariner Tug Boat Vessel at PT Using the Critical Path Method

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Abstract

So far, ship docking work at the shipyard facility in XYZ has so far not implemented a project scheduling method to optimize performance. Determining the time and scheduling of ship docking work is done based on experience. As a result, there is time and cost inefficiency that impacts low performance, so that the docking and shipping industry is difficult to develop and contribute to the development of the maritime sector. This study aims to optimize the docking schedule of the Leo Mariner Tugboat. The method used is the Critical Path Method (CPM) to determine critical path. Research result shows that the Docking process under existing conditions has 24 activities and 21 paths that require a working time of 100.50 hours. Optimization using CPM produces a critical path with 10 activities and 9 paths that require a working time of 100.50 hours. work for 22.5 hours, or an efficiency of 4.8 % From the base This demonstrates that CPM successfully optimizes ship docking times This finding is beneficial for PT. XYZ in optimizing performance and supporting the development of Indonesia's maritime sector.

Introduction

The world of shipping Currently, becoming the World Maritime Axis (PMD) is one of the strategic policies of the Indonesian government in advancing the maritime-based economy (Manurung, 2014; Sitanggang et al., 2023; Anggoro & Amrullah, 2023). The main orientation is through the development of the maritime sector by emphasizing five main pillars, namely: (1) maritime culture; (2) maritime economy; (3) maritime connectivity; (4) maritime diplomacy; and (5) maritime security (Yani & Montratama, 2015; Pangemanan, 2019; Hanggarini et al., 2022; Gonggong, 2020). The PMD policy needs to be supported by the development of maritime infrastructure, including the dock and shipping industry.

Research and development of dock infrastructure in shipping industry needs to emphasize quality aspects to be able to compete (Panayides & Cullinane, 2002; Peters, 2001). One aspect of quality that needs attention is the optimization of performance or productivity. The measure of productivity of the dock and shipping industry is the ability to produce finished products through the effective and efficient use of resources, as well as the appropriate application of technology (Hutapea et al., 2020; Wu & Lin, 2015; Jebbor et al., 2023; Xiao et al., 2024). Performance optimization can be achieved through effective and efficient work planning and

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scheduling to avoid delays that can result in increased costs, decreased consumer confidence and chaotic *timelines* (Howick et al., 2009; Shobrys, D. E., & White, 2002; Iqbal et al., 2022)

Method (CPM) is a work (project) scheduling method that presents a series of work items for a project and reveals the critical parts of the project's overall completion (Lock, 1987). *CPM* uses a fixed time estimate for each activity (Napitupulu & Lubis, 2022; Ammar, 2013). The critical path in *CPM* is the optimal project completion path required if all work on other previous paths has been completed. Therefore, if there is a resource path that has not completed the planned work, then the time obtained cannot be optimized for other activities aimed at accelerating the project unless it is at the critical path level.

Therefore, the use of *CPM* is intended as a work monitoring tool by determining the amount of slack time *for* each job and which jobs are on the critical path that must be completed on time (Istiqomah et al., 2021) . *CPM* can be used in planning and scheduling ship repair work at a shipyard, because its advantages are that it can estimate project completion time by finding the critical path and identifying the start and end times of the project (Muhammad, 2020).

XYZ Shipyard Company is a shipyard facility equipped with a number of supporting equipment for docking operations, such as *airbags,* lathes, drills, *electric compressors, oxygen tanks,* hydraulic jacks, *forklifts, winches, welding machines, painting equipment, water jet equipment,* and welding machines. In addition, there is *a slipway* measuring 1.92 x 1.96 m meters suitable for docking small and medium- sized vessels The availability of this equipment is intended to ensure optimal ship docking operations

However, to date, determining the duration and scheduling of ship repair work is still based solely on experience. As a result, it is often There were delays in completing the work. Based on this, this study aims to apply the *CPM* method in planning and scheduling the docking work of the Leo Mariner tugboat which is utilized at PT XYZ The ship docking work previously required a duration of 100 50 hours. Therefore, this study aims to evaluate the time and schedule repair work using the *CPM device.*

Scheduling of ship docking work for optimization purposes has been widely used and uses various methods, including *Project Evaluation and Review Technique (PERT), Precedence Diagram Method (PDM), Critical Chain Project Management (CCPM), Network Diagram, Fuzzy Logic Application for Scheduling (FLASH)* and *CPM. The PERT* method has been implemented in the repair work of the KMP. Prisma Mariner ship (Armela et al., 2022) and the KN. RB *309* Temate 01 ship (Oktafiana & Baroroh, 2022), *Network Diagram* is used on the MV. Awu ship (Hutapea et al., 2020), *PDM* is used on the *Tug Boat type ship* (Nudin, 2023), *CCPM* is used on the BG. KFT 8005 ship (Suyuti & Basuki, 2022), and *FLASH* is used on ferry 1483 GT (Firstdhitama et al., 2018). Meanwhile, *CPM* was implemented in the repair of the TB. Patra Tunda 3001 ship (Istiqomah et al., 2021), also on the ship MV. Awu (Hutapea et al., (2020), ship BG. KFT 8005 (Muhammad et al., 2022), and *Tug Boat* (Nudin, 2023).

Application of *the CPM* method to the repair of the TB. Patra Tunda 3001 ship found that by adding working hours and manpower, the work time was 25% more efficient than the normal time of 16 days (Istiqomah et al., 2021). On the MV. *Awu ship,* after *crashing,* the work duration was 32 days. days from the original schedule 36 days (Hutapea et al., 2020). Meanwhile, on the BG. KFT 8005 ship the work duration was 152 days. Apart from being used in ship repair scheduling, *CPM* is also generally used in scheduling other work or projects such as road construction (Farida & Anenda, 2022; Santosa et al., 2023; Shahri, 2022), building construction (Soni et al., 2022), as well as for various project scales, both

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large and small scale (Simion et al., 2019; Bakken et al., 2014; Rodney et al., 2009; Turner, R., & Zolin, 2012; Campos et al., 2023).

The aim of this research is to optimize the docking time of the Leo Mariner Tugboat Ship through rescheduling using the method device. *CPM.* The results of this study are expected to provide input for shipyard managers, so that they can increase *income* as a shipyard industry. boat to support government policies in supporting the development of the maritime sector in Indonesia.

Methods

This research was conducted in October - December 2025 located at the shipyard facility located at PT.XYZ in Balikpapan the object of the research is the Tug Boat Leo Mariner owned by the oil and gas company Transportasion Figure 1 is a picture of the research object with the main dimensions listed in Table 1.

Figure 1. Tug Boat Leo

Table 1. Main Dimensions of Leo Mariner Ships

No.	Dimensions	Size
1	Overall length of the ship	40.6 4 m
2	Overall hull length	30.8 1 m
3	Heavy boat	112,701 tons
4	Operational speed	9 knot
5	Maximum speed	13 knot
6	Fuel capacity	4025 3 liters
7	Water capacity	2 2.0 00 liters
8	Crew capacity	12 people

The data required in this study include: (1) ship docking process data ; and (2) ship repair work time data, consisting of: (a) start time, namely the length of time needed to prepare the ship until the ship is lifted into the *slipway area; (b)* docking work time namely the length of time for the docking work ; and (c) end time, namely the length of time in the process of lowering the ship from *the slipway* to the sea. These data were obtained from interviews and direct observations at the research location. The method used for ship repair scheduling is *the Critical Path Method (CPM)* The research data were processed using *LINGO software*.

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Results and Discussion

Determining the Sequence of Activities

Procedure The arrangement of activities in the ship repair process is based on *predecessors.* This is intended to ensure the project schedule runs according to the planning process. *Predecessors* are activities carried out before the activity in question begins. *Successors* are activities carried out after the activity. The sequence of activities or work activities for the Leo Mariner Tugboat repair is shown in Table 2.

Table 2. Sequence of Docking Activities for the Leo Mariner Ship

No	Task Name	Code	Duration (hours)	Predecessors
1	Enter the dock area boat	A	3	
2	Air bag setup process	B	1	A
3	Tie winch sling to the ship	C	1	B
4	Air bag filling process	D	3	B
5	Towing the ship using a winch	E	3	C,D
6	Ship up to the slipway area	F	4	E
7	Installation of the block on the hull of the ship	G	1	F
8	Air bag deflation	H	1	G
9	Electrical wiring	THAT	0.4	G,H
10	Hull oyster scrap	J	3	THAT
11	General over hull repairs machine	K	25	I
12	Water jet hull	L	6	J
13	Waiting for drying	M	4	L
14	Welding freeboard	N	5	M
15	Welding ash cleaning	0	2	N
16	Embossed hull painting	P	5	0
17	Waiting for drying	Q	16	P
18	Anti-fouling painting on ship draft	R	6	Q
19	Waiting for drying	S	2	R
20	Air bag settings	T	0.50	K,S
21	Inflating the airbag	U	3	T
22	Installation of the winch sling to the ship	V	0.50	T,U
23	Bilge block release	W	1	U,V
24	The ship is down	x	3	W
	Total Time		**96.40**	

The data in Table 2 shows that there are 24 activities/activities in the docking process of the Leo Mariner Tug Boat Ship which are coded A to X. Each activity/activity has a duration of work and predecessor activities It is known that the total duration of work time is 96.40 hours.

Network Diagram & Critical Path

A network diagram is a description of the relationship between activities in a project. This *network diagram* is arranged based on the sequence of activities of a project and has a time duration for each activity. Meanwhile, the critical path is a series of activities that become

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critical work from the beginning of the activity to the end of the activity in a project. Figure 2 (ac) presents *a network diagram* based on the activities/work activities of the Leo Mariner ship docking where there are 24 Docking activities Meanwhile, the critical path/trajectory formulated with *LINGO software* produces *the output* as shown in Figure 3.

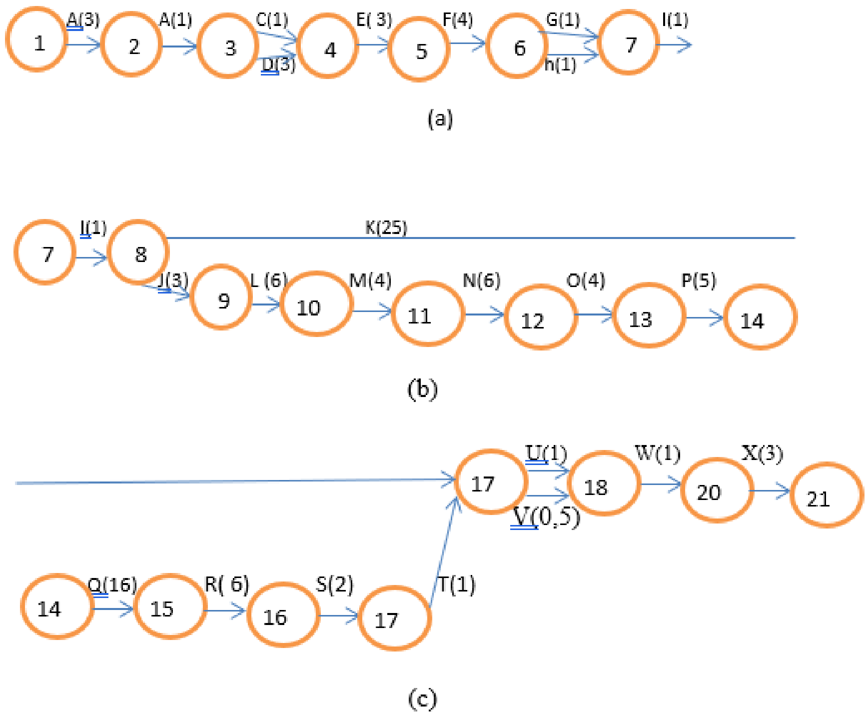

Figure 2. (a-c). Network Diagram of the Leo Mariner Ship Docking Work

Figure 3. LINGO output

The data in Figure 3 shows that x with a value of 1 indicates the optimal processing process. Based on these results, the sequence is known to be A. →B →D →E →F →H →K →I →U →W →X. The sequence shows the critical path, where the processing time is 24.0 hours. Table 3 presents the activities on the critical path. Figure 4 presents *the network diagram* of the critical path.

Table 3. Critical Path/Trajectory for Docking Work on the Leo Mariner Ship

No	Task Name	Code	Duration (hours)
1	Ship enters dock area	A	3
2	Air bag settings	B	1
3	Inflating the airbag	D	3

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4	Towing the ship using a winch	E	3
5	The ship ascends to the slipway area	F	4
6	Air bag deflation	H	1
7	General Over hull engine repair	K	25
8	Electricity distribution	I	1
9	Inflating the airbag	U	3
10	Bilge block release	W	1
11	The ship is down	X	3
	Total Time		**48 0**

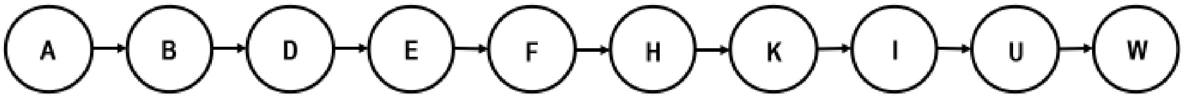

Figure 4. Critical Path Network Diagram

Analysis based on Table 2 (ac), there are 24 processes in the work on the Leo Mariner Ship Docking The work process generally consists of *the preparation* process, the core process and *the end* process. The *preparation* process consists of the ship entering the docking area, setting *the airbag,* installing the *winch rope* to the ship, filling *the airbag,* pulling the ship by *the winch,* the ship climbing onto *the slipway,* installing blocks on the ship's bilge, deflating *the airbag,* and distributing electricity. This process requires a work time of 16.15 hours process consists of oyster *scrap* on the ship's hull parallel to the engine *tune up work water jet* the ship's hull, drying, sanding the ship's embossed hull, cleaning sanding ash, painting the embossed hull, drying the paint, painting AF on the ship's draft, and waiting for the paint to dry. The time duration obtained in the core process of the Leo Mariner Ship Docking is 128 20 hours. In the *end* process section, it consists of *air bag arrangement,* air bag filling *installation of the winch* sling to the ship, release of the block on the ship's bilge, and lowering the ship.

The time duration obtained from the Leo Mariner Ship Docking is 16 hours. Process was implemented through rescheduling. Based on the actual data for the Leo Mariner ship docking project there were 24 activities, each requiring a total of 100.50 hours Rescheduling with *CPM* using *LINGO software* resulted in 10 activities requiring a total of 44.10 hours This means that the rescheduling using CPM resulted in a 48% reduction in project time % compared to existing conditions. Efficiency of the work indicates a disparity between the existing conditions and the research findings. In other words, the existing work process is not optimal in terms of work time. This condition has the potential to increase operational costs due to delays in completion times, reduce consumer confidence, and even disrupt the overall *timeline The implications are certainly far-reaching, especially for company revenue* Conversely, the research results show that ship repair work can be optimized through rescheduling based on research findings, potentially reducing operational costs due to shorter work durations, increasing consumer confidence, and supporting regular *timelines.*

The end result is increased *income,* enabling the dock and shipping industry to support the development of the maritime sector in Indonesia. The findings of this study prove the findings of previous studies, where the application of *CPM* can produce a work (project) schedule (time) with optimization in the time aspect, as well as describing the relationship between activities (Simion et al., 2019). This can be seen in the Docking work of the BG. KFT 8005 ship which resulted in a work time of 76 days (Muhammad, 2020). Meanwhile, the findings of work time optimization can be seen in TB. Patra Tunda 3001, where the application of

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CPM for re-scheduling repairs was able to reduce the work time from 16 days to 12 days, or an efficiency of 25% (Istiqomah et al., 2021). Similarly, on the MV. Awu ship, there was a reduction in work time from 18 days to 16 days or an efficiency of 11.11% (Hutapea et al., 2020). The existence of a relatively large difference in the duration of work time between the results of this study and previous studies is an indication of different types and sizes of ships. The use of the CPM method in the work (project) scheduling process provides benefits, including generating a critical path so that project execution can be accelerated (Nudin, 2023). The faster the project execution time, the better the company (industry) performance, which is indicated by increased *income,* increased public trust, and regular project *timelines* In this way, the dock and shipping industry will continue to grow to support the development and progress of the maritime sector in Indonesia.

Conclusion

The application of *CPM* as a project scheduling method on the Leo Mariner Ship Docking work successfully optimized the work time from 100.50 hours to 48.0 hours or an efficiency of 48% compared to the existing conditions. These results prove that the application of *CPM* on ship repair work can avoid delays in work that can result in increased costs, decreased consumer confidence and chaotic *timelines.* These findings can be a reference for shipyard business managers in preparing an optimal ship repair work schedule in order to increase *income* so that the shipyard business is able to play a role in supporting policies on the development of the Indonesian maritime sector. This study has not considered the flexibility of work time due to unavoidable technical factors, so it can be continued in subsequent research by applying other methods, such as *PERT, PDM* and *CCPM.*

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