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Network Planning Analysis Using CPM And PERT Methods For Time And Cost Optimization In Ship Repair Projects

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Abstract: Delays in ship repair projects can significantly impact operational timelines and increase costs. This study applies the Critical Path Method (CPM) and Project Evaluation and Review Technique (PERT) to analyze and optimize the planning and scheduling of a ship repair project at PT DNC. Using secondary data on task sequences, durations, and cost budgets, the project was modeled to identify critical activities and estimate time completion probabilities. The analysis showed a critical path with a duration of 98 days. A crashing method was then implemented to reduce the project duration to 72 days, achieving cost savings of Rp. 16,351,708. Without this intervention, delays would result in a penalty of over Rp. 3 billion. This demonstrates the effectiveness of integrated network planning and crashing in optimizing project timelines and budgets.

***Index Terms* - Network Planning, CPM, PERT, Crashing Method, Time Optimization, Cost Efficiency**

SIGNIFICANT STATEMENT

In the dynamic and high-stakes environment of ship maintenance, delays can lead to severe economic consequences and operational risks. This study provides a practical and quantitative approach to mitigating such delays using mathematical modeling. The combined use of CPM, PERT, and crashing methods offers a framework that project managers in the maritime sector can adopt to improve efficiency, reduce penalties, and ensure timely project delivery.

RESEARCH GAP

Although CPM and PERT are widely recognized in project management, there remains a gap in applying these methods specifically to ship repair projects in Indonesia, especially in the context of cost optimization through crashing techniques. Limited literature addresses the integration of probability-based time estimation and cost trade-off analysis in real-world shipyard scenarios. This study fills that gap by applying these methods to a specific case and quantifying both time and financial impacts.

METHOD

Planning and scheduling activities requires a method called network planning. Network Planning is a process analysis by describing a work diagram, which can estimate and determine the path of activity that requires precise control (Meflinda & Mahyarni, 2011). The CPM and PERT are methods used to design network planning.

SCHEDULING CPM METHOD

CPM or critical path method is a method that can be used to plan and manage a project using a time activity flowchart diagram in completing a project and the connectedness between its resources has been determined with certainty (Anenda, 2020). The critical path on the CPM method can be calculated by the total duration of the project. A critical path is a sequence of critical activities that determines the timeframe for project completion. The calculation model of the CPM method is:

FORWARD PASS CALCULATION

Advanced calculation is a method the one in use to determining the critical path starting from Node first on a diagram Activity pipeline project.

$$ES = \max\left(EF\ previously\right) \quad (1)$$

$$EF = ES + duration \quad (2)$$

BACKWARD PASS

Countdown is a method which can be used to Define the critical path of the endpoint deep Diagram Activity pipeline project

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SCHEDULING PERT METHOD

$$LS = LF - duration \quad (3)$$

$$LF = \min\left(LS\ next\ activity\right) (4)$$

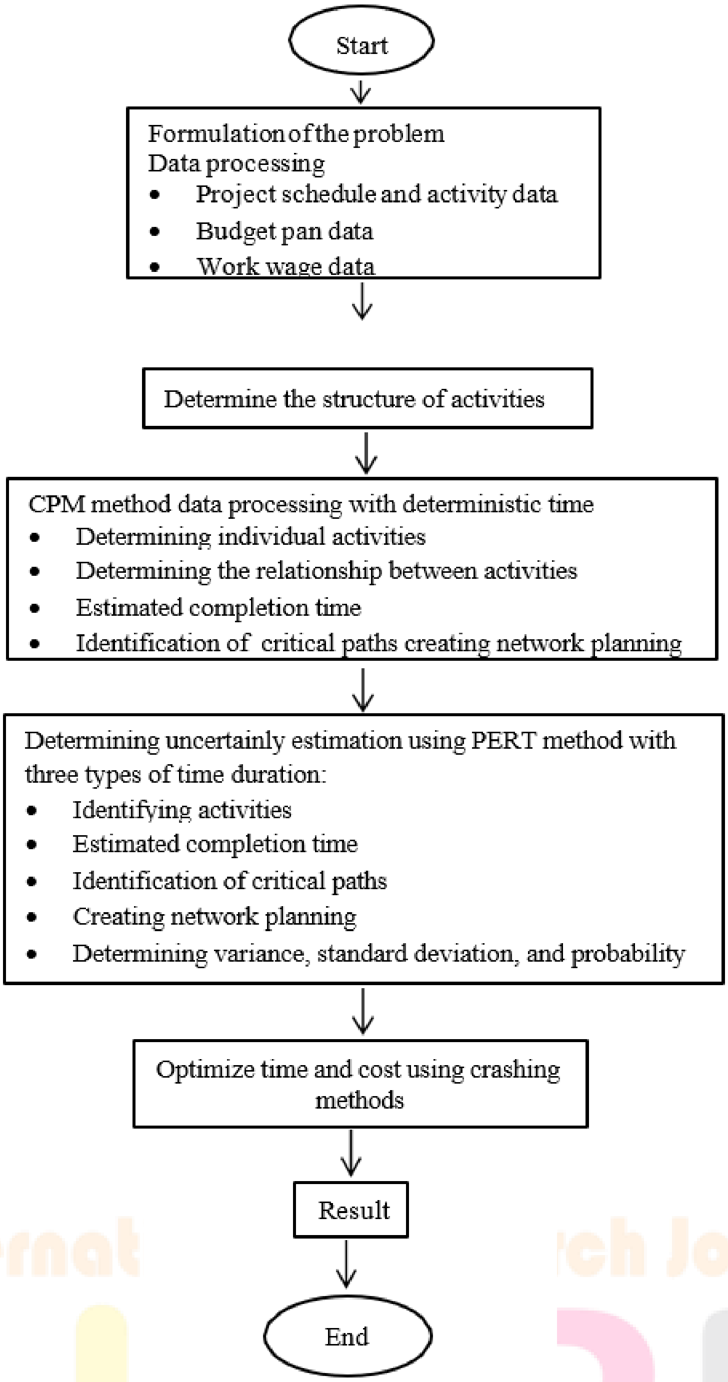


Fig 1. Design of Research

PERT or Project Evaluation and Review Technique is a management science to plan and manage a project in calculating the estimated time needed (Yuliarty et al., 2021). In analyzing PERT also serves to negotiate fellow customers with parties related to the implementation of the (John M. Nicholas, 2008). Estimates on PERT use time ranges that indicate uncertainty related to estimated activity times. This estimate can calculate the expected time (te) in completing project work (Soeharno, 1999).

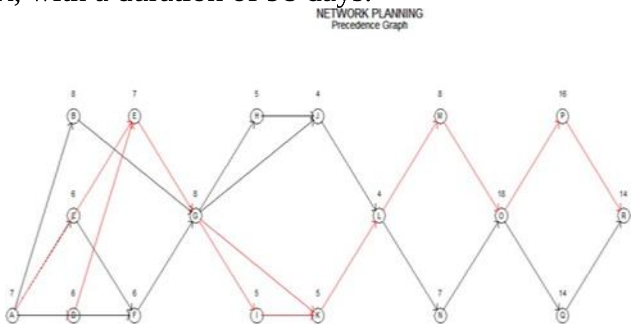
No	Code	Activities	Duration (Days)	Prodecessor	Successor
		Start		-	-
1	A	Preparatory work - socialization - lighting and water - mobilization and demobilization - work equipment and materials	7 days	-	B,C,D
2	B	High bow repair	8 days	A	G
3	C	Bottom improvements	6 days	A	F
3	D	Bulkhead repair	6 days	A	E
4	E	Right & left hull repair	7 days	D	G
5	F	Deck repair	6 days	C	G
6	G	Repair of the US propeller / stream tube	8 days	B,E,F	H,I
7	H	Wheelhouse repair	5 days	G	J
8	I	Bathroom repair	5 days	G	K
9	J	Steering skek repair	4 days	H	L
10	K	Daily tank plate installation	5 days	I	L
11	L	Installation of machine bench plate	4 days	J,K	M,N
12	M	Bullwark improvements	8 days	L	O
13	N	Ramp door repair	7 days	L	O
14	O	Power steering installation	18 days	M,N	P,Q
15	P	Auxiliary engine installation	16 days	O	R
16	Q	Electrical installation	14 days	O	R
17	R	Painting	14 days	P,Q	*End*
		End	-	-	-

No	Activity Code	Duration (days)	ES *(earlliest start)*	EF *(earliest finish)*	LS *(Latest start)*	LF *(latest finish)*	*Slack* / TF	Critical Path
1	A	7	0	7	0	7	0	Yes
2	B	8	7	15	12	20	5	No
3	C	6	7	13	8	14	1	No
4	D	6	7	14	7	13	0	Yes
5	E	7	13	19	13	20	0	Yes
6	F	6	13	20	14	20	1	Not
7	G	8	20	28	20	28	0	Yes
8	H	5	28	33	29	34	1	No
9	I	5	28	33	28	33	0	Yes
10	J	4	33	37	34	38	1	Not
11	K	5	33	38	33	38	0	Yes
12	L	4	38	42	38	42	0	Yes
13	M	8	42	50	42	50	0	Yes
14	N	7	42	50	43	50	1	Not
15	O	18	50	68	50	68	0	Yes
16	P	16	68	84	68	84	0	Yes
17	Q	14	68	84	70	84	2	Not
18	R	14	98	98	84	98	0	Yes

OBSERVATION AND FINDINGS

1. PROJECT MODELING AND CRITICAL PATH IDENTIFICATION

The ship repair project was analyzed using CPM, revealing a critical path comprising activities: A – D – E – G – I – K – L – M – O – P – R, with a duration of 98 days.



2. PROBABILITY OF ON-TIME COMPLETION (PERT ANALYSIS)

Using PERT, the estimated completion time (Te) was also 98 days. However, with a contract duration of 96 days, the calculated Z-value was -1.343, corresponding to a completion probability of only 9.18%. This low probability indicates a high risk of project delay.

Kode	Activity	Duration				
		ta	*tm*	*tb*	*te*	σ^2
A	Preparatory work	6	7	8	7	0,111
B	High bow repair	7	8	9	8	0,111
C	Bottom improvements	5	6	7	6	0,111
D	Bulkhead repair	5	6	7	6	0,111
E	Right & left hull repair	6	7	8	7	0,111
F	Deck repair	5	6	7	6	0,111
G	Repair of the US Propeller / stream tube	7	8	9	8	0,111
H	Wheel house repair	4	5	6	5	0,111
I	Bathroom repair	4	5	6	5	0,111
J	Steering skek repair	3	4	5	4	0,111
K	Daily tank plat installation	4	5	6	5	0,111
L	Installation of machine bench plat	3	4	5	4	0,111
M	Bullwark improvements	7	8	9	8	0,111
N	Ramp door repair	6	7	8	7	0,111
O	Power steering installation	16	18	20	18	0,444
P	Auxiliary engine installation	14	16	18	16	0,444
Q	Electrical installation	12	14	16	14	0,444
R	*Painting*	12	14	16	14	0,444

3. CRASHING ANALYSIS FOR TIME-COST OPTIMIZATION

Crashing involved increasing labour resources at a cost of Rp. 100,000/day per person. Through crashing, the project duration was reduced from 98 to 72 days, incurring an additional cost of Rp. 11 million, but avoiding a potential penalty of Rp. 3.07 billion.

No	Activity Code	*Normal Duration*	*Normal cost*	*Crash duration*	*Crash Cost*	*Cost Slope*
1	A	7	5.000.000	4	5.800.000	266.666,66
2	B	8	7.231.500	6	7.831.500	300.000
3	C	6	81.936.000	5	82.436.000	500.000
4	D	6	40.946.500	5	41.446.500	950.000
5	E	7	31.246.000	5	31.746.000	250.000
6	F	6	68.315.000	5	68.815.000	500.000
7	G	8	21.756.000	6	22.356.000	300.000
8	H	5	4.905.000	3	5.505.000	300.000
9	I	5	9.418.000	3	9.418.000	300.000
10	J	4	16.900.000	3	17.200.000	300.000
11	K	5	1.772.000	4	2.172.000	400.000
12	L	4	7.087.000	3	7.387.000	300.000
13	M	8	11.077.000	6	11.677.000	300.000
14	N	7	42.102.800	6	42.702.800	600.000
15	O	18	32.241.824	14	33.641.824	350.000
16	P	16	47.357.000	11	48.457.000	220.000
17	Q	14	30.611.706	12	31.511.706	180.000
18	R	14	25.100.000	9	26.300.000	600.000
	Sum		485.403.330		496.403.330	

4. TIME-COST TRADE-OFF CALCULATION

Normal Cost: Rp. 485,403,330
Crashing Cost: Rp. 496,403,330
Total Optimized Cost: Rp. 556,080,027.34
Savings from Crashing: Rp. 16,351,708 compared to penalty costs if delayed

CONCLUSION

Some of the problems faced by the implementers of the ship repair project TK Ake Sigala gala is a delay in completion activities, with the postponement of project activities, the project experiences delays in project completion which is influenced by several factors. Therefore, to minimize the occurrence of delays in completion, the right planning, scheduling, and control process is carried out. With the CPM and PERT methods used by researchers, there are several activities that are on the critical path, where on that path the project implementer strives to ensure that there is no time allowance in implementation, namely A – D – E – G – I – K – L – M – O – P – R activities with an optimal duration of 98 days. From the agreed duration of the work contract, which is 96 days, there has been an opportunity to complete the project by 9.18%. It can be seen that the project has the possibility of experiencing delays in completing the project. In this case, it is certainly necessary to do an appropriate way so as not to miss too far from the agreed employment contract agreement. With the crashing method, an alternative is obtained, namely by crashing is 72 days, which is able to shorten the time by 26 days from the duration of 98 days. This reduction saves costs of Rp. 16,351,708 with an additional workforce of 22 people. If the project implementer does not use the crashing method, it seen from the completion time of 101 days, the delay is 4 days from the agreed contract. The implementers can pay a penalty of Rp. 3,072,963. When compared, project implementers can choose crashing with savings of Rp. 16,351,708 and saving time by 26 days, provided that implementers add manpower and do not give time leeway on critical path than having to pay a penalty of Rp. Rp. 3,072,963,905.

REFERENCES

1. D. Simchi-Lewi, Ph. Kaminski, E. Simchi Lewi, Designing & Managing the Supply Chain. Concepts, strategies and case studies. McGraw-Hill, 2003

2.Oksana Soshko, Riga Technical University, Vilmars Vjakse, Modelling Inventory Management System at Distribution Company: Case Study

3.Inventory Theory Book http://www.ime.unicamp.br/~andreani/MS515/capitulo12.pdf

4. Bhavithra HA, Sindu Devi S. Feasibility and Stability Analysis for Basic Measles Model Using Fuzzy Parameter. Contemp.Math. 2024 Feb. 20. https://doi.org/10.37256/cm.5120242428.

5 Bhavithra, H.A., Sindu Devi, S. Sensitivity stability and feasibility analysis of epidemic measles using mathematical SEIR model. OPSEARCH (2024). https://doi.org/10.1007/s12597-024-00848-z.

6. Bhavithra, H.A., Sindu Devi, S. (in press) Bifurcation Analysis and Effective Approache to Control for Measles using SEIR Mathematical Model. International Journal of Mathematics in Operational Research DOI: 10.1504/IJMOR.2024.10066815

7. Bhavithra, H.A., Kiruthika, N., Sindu Devi, S. (2025). Mathematical Modelling to Control the Spread of Water Contamination of Uppanar River in Cuddalore District. In: Jeyaseelan, A., Murugasen, K. (eds) Sustainable Environmental Remediation: Avenues in Nano and Biotechnology. Environmental Science and Engineering. Springer, Cham. https://doi.org/10.1007/978-3-031-78483-5_25

8. Gowthami, V., Bhavithra, H.A. (2025). A Review on AI Technologies for Air Toxic Waste and Human Health Prediction. In: Jeyaseelan, A., Murugasen, K. (eds) Sustainable Environmental Remediation: Avenues in Nano and Biotechnology. Environmental Science and Engineering. Springer, Cham. https://doi.org/10.1007/978-3-031-78483-5_26erapeutic approaches targeting disease-associated condensates.