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Strategic Optimization to Enhance Effective Jetty Operations at Kertapati Port

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Abstract

This study addresses operational challenges at Kertapati Port, where barge delays, poor stakeholder coordination, and lengthy administrative processes hinder efficiency. Using the Current Reality Tree (CRT) analysis, the research identifies root causes that reduce jetty throughput and extend vessel waiting times, leading to higher operational costs. To overcome these issues, three solutions were proposed: (1) developing integrated Standard Operating Procedures (SOPs) for berthing/unberthing and administration, (2) adding standby tugboats to ensure smoother berthing operations, and (3) decentralizing administration through an operational office at the jetty. The Analytical Hierarchy Process (AHP) was applied to prioritize these alternatives, while financial feasibility was evaluated using Net Present Value (NPV) and Internal Rate of Return (IRR). Results indicate that implementing integrated SOPs is the most effective solution, significantly reducing idle time and enhancing loading and unloading processes. A 2025 field trial of draft SOPs improved coal loading efficiency to an average of 500 MT/hour, with potential for notable annual throughput growth. Cost simulations suggest savings of thousands of USD per month, mainly by lowering demurrage costs. Furthermore, a real-time digital monitoring system has improved coordination, administrative speed, and schedule accuracy. The study recommends continuous evaluation using Key Performance Indicators (KPIs) and the Theory of Constraints (TOC) to sustain improvements and foster future innovations.

Keywords: Idle Time, Jetty Operations, Integrated SOP, Throughput Efficiency, Analytic Hierarchy Process (AHP), Risk Management, Project Management.

1. Introduction

In literature, various expert opinions have emerged to explain and define competitive advantage. Michael Porter, one of the leading figures in this field, argues that competitive advantage can be achieved through differentiation and low-cost strategies. In the transportation and logistics sector, particularly in the mining industry, effective management of freight schedules and operational monitoring is crucial. PT Bukit Asam Tbk, as one of the leading coal mining companies in Indonesia, faces significant challenges in optimizing jetty operations.

These issues are not only local but also reflect global issues in the logistics industry. With increasing demand for energy and commodities, as well as pressure to minimize costs and environmental impacts, companies around the world are striving to improve their operational efficiency. More production clean has contributed to the separation between economic growth and environmental impact in developed countries and is now being accelerated in developing and transitional countries (Huang, Zhong, & Zhang, 2023). In the context of PT Bukit Asam Tbk, this challenge becomes more complex due to the need to integrate various aspects of operations, from scheduling deliveries to supervision in the field.

At PT Bukit Asam Tbk, barge delivery schedules were often sub-optimal, leading to delays in delivery. With uncertainty in arrival and departure times, as well as a lack of effective monitoring, the company risks losing market opportunities and incurring financial losses. This problem occurs on an ongoing basis and can be seen at various locations of the company's operations, especially at the jetties used to load coal onto barges. According to Ida Hidayah & Nugroho (2021), sales volume is a measure that shows the number or magnitude of the number of goods or services sold. With the increase in production volumes and market demand, this situation is becoming increasingly urgent to overcome. The impact of this issue is not only felt by PT Bukit Asam Tbk, but also impacts the entire supply chain, including customers and business partners. The inability to manage schedules well can result in decreased customer satisfaction, which in turn can affect the company's reputation and its position in the market.

Thus, this thesis will discuss an optimization and monitoring strategy that can improve jetty operations at PT Bukit Asam Tbk. Through in-depth analysis of the existing problems, it is expected that an effective solution can be found to improve the operational efficiency and competitiveness of the company in this increasingly competitive industry.

PT Bukit Asam Tbk, abbreviated PTBA below, is a member of the SOE holding company for the mining industry. which shall henceforth be referred to as MIND ID. PTBA was founded in 1981 and is engaged in mining, with Tanjung Enim serving as the mining hub. **MIND ID** (Mining Industry Indonesia) is a strategic holding company established by the Indonesian government to manage state-owned enterprises in the mining sector.

Figure 1. The organizational structure of the Mining Industry Indonesia (Source: internal company data)

PTBA is a state-owned coal mining company in Indonesia that relies heavily on the efficiency of Jetty operations, particularly at Kertapati Port, Palembang, to transport coal via barges. According to The Council of Logistics Management (2013), logistics management is the process of the supply chain that functions to plan, execute, and control the flow of goods, services, and information effectively and efficiently to meet customer needs. However, suboptimal barge scheduling and insufficient monitoring have led to operational inefficiencies at the Jetty, which are characterized by delays, congestion, and resource underutilization.

PTBA's coal distribution performance for 2020–2024, reviewed from the aspects of Logistics & Distribution Performance, Financial Value Held Up (in USD and Rupiah), and Operational Efficiency:

1. Logistics & Distribution Performance
   In 2020 distribution was very good and nearly optimal. Production and distribution realization exceeded the target (101%). This indicates that logistics and loading/unloading systems functioned in sync. The time cycle from stockpile to

buyer was fast, indicating highly efficient logistics performance. In 2021, distribution exceeded actual production. This indicates pressure on remaining stock from the previous year. However, the discrepancy between the RKAP and actual production indicates an imbalance in logistics and production capacity planning. In 2022, distribution performance slowed. Realization was only 81% of the target. Ship queues, low jetty utilization, and potential high idle time indicate bottlenecks in the distribution system. This discrepancy caused coal to pile up in the stockpile. In 2023, distribution performance declined significantly despite near-perfect production (99.89%). With a production-distribution gap of 214.864 tons. In 2024, with a production-distribution gap of 463.950 tons. a large backlog became a logistical burden and added pressure at the port. This is a key indicator of the disruption of logistics activities at the port.

2. Financial Value Held Up (USD and IDR)
   2024 was the year with the highest value of coal held up. Calculated from a backlog of 463,950 tons and using an average coal price assumption of USD 70/ton (conservative):
   Total value held up = 463,950 tons × USD 70/ton = USD 32,476,500
   At an exchange rate of IDR 15,500/USD, then:
   IDR 32,476,500 × 15,500 = Rp 503,385,750,000
   This means there is a potential revenue of approximately Rp 503 billion held up due to suboptimal distribution. This figure does not include additional costs such as demurrage, storage costs, or opportunity costs from buyer payment delays.
3. Operational Efficiency
   The years 2020 and 2024 show very high operational throughput with a nearly balanced Production–Distribution ratio. This indicates that there is no excess inventory in the stockpile, and the logistics flow is optimal. Conversely, 2022 and especially 2023 are examples of inefficiency. Produced coal is not immediately distributed, idle equipment costs increase, the jetty experiences congestion due to barge queues, and the potential for coal damage (quality degradation) increases.
   Over the past five years, PTBA has shown significant dynamics between coal production and distribution. In 2020, the company managed to produce 5,571,503 tons of coal, slightly exceeding the RKAP target of 5,500,000 tons. Distribution in the same year also reached 5,565,699 tons, resulting in a small surplus of 5,804 tons. This reflects good efficiency in that year, where nearly all production was distributed optimally.

However, the situation changed in the following three years. In 2021, production fell to 5,365,858 tons compared to the RKAP target of 6,370,000 tons. Distribution also only reached 5,381,036 tons, resulting in a deficit of 15,178 tons. The situation worsened in 2022 and 2023. In 2022, although the production and distribution targets were both set at 6,600,000 tons, the actual production was only 5,402,049 tons, and distribution was 5,350,655 tons. The deficit of 51,394 tons indicates operational obstacles that disrupted coal distribution. In 2023, although production almost matched the target (6,992,232 tons out of a target of 7 million tons), distribution only reached 6,777,368 tons, resulting in a negative difference of 214,864 tons.

The peak occurred in 2024, with production reaching 7,966,608 tons and distribution at 7,502,658 tons, resulting in a negative difference of 463,950 tons. This figure is significant and reflects serious challenges in the distribution system, including transportation delays, barge queues, adverse weather conditions, and low loading efficiency at the jetty.

In conclusion, the 2020–2024 period demonstrates the potential for stock accumulation, as distribution is slower than production. This could be the primary cause of high idle time at the jetty, due to delays in loading and barge queues.

Illustrates the main stages in the operational activities of loading coal at the jetty, starting from stockpiling and inventory checking, through the arrival of barges at the jetty, the loading process onto barges, and the departure of barges. All of these stages are interconnected, so that if an obstacle arises in one stage, it will have a direct impact on the next stage. For example, if the coal stock in the stockpile is not available as needed, even if the barge has arrived at the jetty, the loading process will be delayed. Conversely, if the barge is delayed in docking, the coal that is ready in the stockpile will have to wait longer.

Upon arrival at the unloading port, the discharging process at the destination (coal unloading) takes 10-12 hours. Once completed, the barge makes a return voyage, which takes approximately the same amount of time, namely 1-2 days. Upon arrival in Palembang waters, the barges enter the anchorage area to wait for their turn to enter the jetty.

Based on available data, docking and undocking or changing barges at the jetty causes an average idle time of around 90 minutes per barge. This idle time is the main bottleneck that can be directly controlled in jetty operations.

In the management of PTBA's jetty operations, several prominent symptoms can be identified quantitatively. First, the berthing and departure processes of barges are not properly monitored, resulting in jetty waiting times, with an average waiting time of approximately 5000 hours in 2024. Second, there is a problem of underutilization of jetty capacity, as idle waiting time during the transition from one barge to the next still averages 90 minutes per barge in 2024. This condition causes the jetty to be underutilized during certain periods. Third, the impact is an increase in operational costs, mainly due to demurrage, with a waiting cost of USD 416.67 per hour, which, when accumulated, can reach a potential loss of around USD 450,000 per year. Finally, these coal delivery delays also affect customers, reducing satisfaction and decreasing supply chain reliability. Therefore, these figures emphasize the need to optimize the jetty schedule and operation management to improve efficiency and minimize losses.

In managing jetty operations at PTBA, there are several real problems that affect the smooth distribution of coal. First, delays often occur in the berthing and departure processes of barges, with an average waiting time of 1–2 hours per ship due to overlapping schedules and a lack of coordination between stakeholders. This condition makes the distribution flow unstable and adds to operational uncertainty. Second, the jetty capacity in Kertapati currently only has 2 active jetties, so bottlenecks often occur, especially during peak season when the number of barges served can reach 90 per month. As a result, there are periods when the jetty cannot be utilized optimally due to inefficient scheduling. Third, the impact of this inefficiency is an increase in operational costs, particularly demurrage costs. Based on average contract data, demurrage costs for barges in Indonesia range from USD 8,000 to 15,000 per day. With the idle time that occurs in Kertapati, the potential annual loss is estimated at ± USD 450,000. In addition, delays in coal delivery not only have an impact on costs but also reduce customer satisfaction. Clients often experience delays in supply, which can ultimately disrupt the reliability of the company's supply chain. Therefore, this data further emphasizes the urgent need for improvements in the scheduling and management of jetty operations, in order to increase efficiency and reduce unnecessary costs.

In the context of this study, the importance of operational efficiency cannot be overlooked, especially in relation to effective scheduling and monitoring at the jetty. High operational efficiency contributes directly to throughput at the jetty, which is critical to meeting business demands and client needs. By minimizing delays and demurrage costs, companies can reduce operational costs, which in turn will increase profitability. Moreover, on-time delivery not only strengthens client confidence but also enhances the company's competitive position in the market. Kertapati jetty, as the main logistics hub for PTBA, plays a crucial role; inefficiencies at this location can have a detrimental impact that extends to the entire supply chain. Therefore, addressing the current issues will build a strong foundation for increasing capacity in the future, so that the company can accommodate higher volumes as the business grows.

2. Literature Review

Standard Operating Procedure

In a company, rules are established in a more formal manner, known as Standard Operating Procedures (SOPs). Every company has a vision and mission it aims to achieve, whether in the short or long term. Every vision and mission that a company aims to achieve does not involve just a few people within the company. Instead, all members of the company must work together to ensure that these visions and missions are achieved.

Addition of Standby Tugboats

According to Stopford (2009) in his book Maritime Economics, tugboats are one of the vital assets in port operations because they serve to speed up and ensure the safety of ship berthing and unberthing processes. Adequate tugboat capacity can reduce the risk of delays, increase port throughput, and reduce indirect costs such as demurrage.

Decentralization of Jetty Administration (Build Office at Jetty)

According to Mintzberg (1979) in The Structuring of Organizations, decentralization is a strategy to accelerate the decision-making process by bringing administrative units closer to the point of operational activity. In the context of ports, transferring administrative functions to the jetty location will reduce physical distance and time lost due to document processing being carried out far from the operational area.

Delays and Obstacles

To identify delays and obstacles in ship movements related to waiting times, ship movement durations, and cargo loading rates or throughput (tons/hour), systematic calculations are needed to optimize ship cycle times, which in turn improve port operational efficiency by calculating KPIs (Key Performance Indicators).

Theory of Constraint (TOC)

Theory of Constraint, or constraint theory, is a system management philosophy developed by Eliyahu M. Goldratt since the early 1980s. TOC states that the performance the company is constrained. Every company must face the resources and limited demand for their products. These limitations are called constraints (Hansen and Mowen, 2013: 231).

AHP (Analytical Hierarchy Process)

The use of AHP is not limited to government or private institutions but can also be applied for individual purposes, especially for research related to policy or priority strategy formulation. AHP is reliable because in AHP, priorities are established from various options that can be criteria that have been decomposed (structured) beforehand, so that priority setting is based on a structured (hierarchical) and logical process.

Risk Management

Risk management is a systematic approach to identifying, analyzing, and addressing potential risks that could hinder the achievement of business objectives. This includes assessing the likelihood of various risks and their impact, taking proactive steps to minimize their negative effects, and maximizing existing opportunities.

3. Method

Research Design

The research design for this study adopts the Theory of Constraints approach to problem solving, which requires consideration of several aspects. This design was chosen to ensure a balanced understanding of operational inefficiencies and barge monitoring at the Kertapati port of PT Bukit Asam Tbk, as well as to develop practical solutions supported by existing internal company data.

Data Collection Method

Data collection in this study uses a method designed to collect data systematically and in detail. Data on the performance of each stage in the strategy optimization process and barge loading monitoring to improve dock operations to be more effective. The main objective of this data collection is to obtain quantitative data on the obstacles or constraints that affect overall throughput. This approach combines real-time data, historical data, and data verification to ensure the accuracy and consistency of relevant data. This data will serve as the basis for applying the Theory of Constraints (TOC) and strategic optimization monitoring to improve the effectiveness and efficiency of port operations.

Data Collection Techniques

1. Operational team data recording:
   Data recording plays a key role in collecting real-time data with precision. The monitoring system records KPIs based on ship reports, records throughput, barge downtime/availability, and jetty vacancy rates on an ongoing basis. This data collection method provides a reliable stream of data that can be analyzed at different time intervals. This recording also allows for more detailed analysis, as data can be monitored hourly, identifying changes in performance during peak and non-peak periods.

2. Frequency and Duration of Sampling:
   To build a comprehensive picture of the operational effectiveness of the jetty, data is collected annually over a specific period, such as a month. This duration covers a wide range of operational conditions, helping the study detect cyclical patterns or variations in system performance. Hourly sampling is detailed enough to show subtle changes but broad enough to provide a clear picture of overall trends, ensuring that both typical and atypical operational conditions are covered. The focus of this study is on the updated time calculation for the year 2024, with the sample period being January to December 2024.
   - Berth Time: The duration of time a ship is at the dock for loading and unloading.
   - Loading and Unloading Productivity: The number of tons loaded/unloaded per unit of time.
   - Frequency and duration of sampling: To develop optimization strategies and monitoring, data is collected monthly over a specific period, such as a year. This duration covers various operating conditions, helping this study to detect cyclical patterns in system performance.
3. Data Verification: Verification is a crucial step to ensure the authenticity and accuracy of the data used in this study. Cross-verification helps identify any inconsistencies, confirming that the data presented is accurate and reflects system performance. Verification is necessary to ensure that the analysis and conclusions drawn from the data are based on reliable and consistent information.

Data Analysis Method

The research design used in this study is structured quantitatively, with a focus on numerical data and statistical analysis by integrating the data through the theory of constraints (TOC) framework to determine the conclusions about the optimization strategy and operational efficiency monitoring of PTBA Kertapati Port

4. Result and Discussion

AHP (Analytical Hierarchy Process)

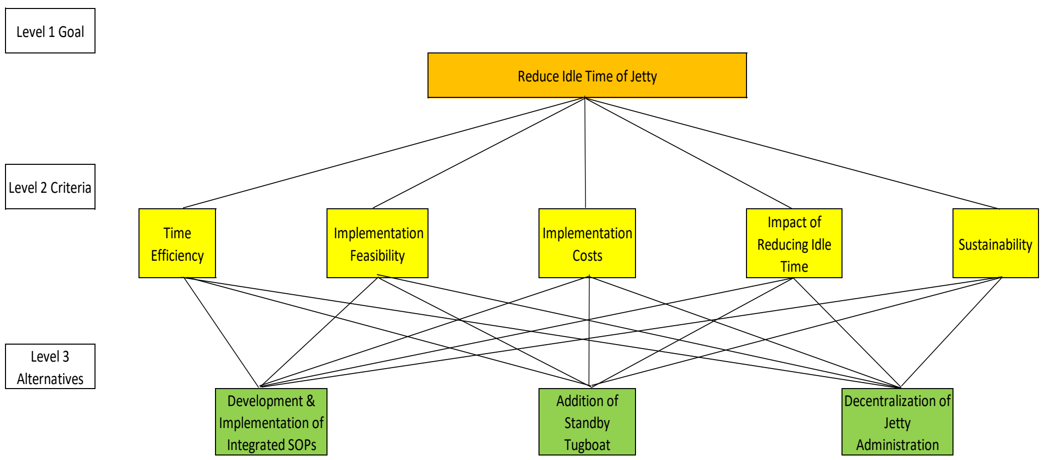

Figure 2. AHP framework

Based on the AHP framework, Figure 2 above, the main objective is to reduce idle time at the jetty. To achieve this objective, there are five criteria that form the basis for consideration, namely time efficiency, implementation feasibility, implementation costs, impact of reducing idle time, and sustainability. Each of these criteria is then used to evaluate the three proposed alternative solutions.

The first alternative is the Development & Implementation of Integrated SOPs, which focuses on developing and implementing integrated SOPs to ensure that workflow at the jetty becomes more efficient and minimizes obstacles. The second alternative is the Addition of Standby Tugboats, which involves adding standby tugboats to accelerate vessel maneuvering processes, thereby reducing waiting times. The third alternative is Decentralization of Jetty Administration, which aims to accelerate operational decision-making by granting greater authority at the jetty level.

This AHP framework helps prioritize the best alternative by considering all criteria in a balanced manner, ensuring that the decision made is not only time-effective but also realistic in implementation, cost-effective, significantly impactful, and sustainable in the long term.

Questionnaire Design

To obtain valid and credible data during the alternative identification process, respondents who completed the questionnaire consisted of employees from various operational units who played important roles in the implementation of operations at the coal port. These respondents included personnel from the port's operational work units, port business entities, and coal transporters, each of whom had expertise in their respective domains, making them reliable sources for responding to the managed questionnaire. Below is a list of the names of the employees mentioned above, along with their respective positions and length of professional experience.

Table 1. List of Respondents for AHP Questionnaire

No	Name	Position	Work Experience	Alias
1	ICA	General Manager of Kertapati Port	> 15 years	Z1
2	WMS	Kertapati Port Operation Dept Head	> 15 years	Z2
3	EDF	Coal Loading Sub Section Head	> 10 years	Z3
4	IPP	Ops Manager of PIT	> 9 years	Z4
5	IGN	Mooring Coordinator of PIT	> 9 years	Z5
6	IKW	Vice President of BPB	> 10 years	Z6
7	MUA	Tug Coordinator of BPB	> 10 years	Z7

Table 1 contains a list of names of respondents who participated in completing the questionnaire, who came from various positions and played an important role in the questionnaire completion process.

Pairwise comparison between criteria

The five decision criteria were compared in pairs by respondents, as illustrated in the figure below. This analytical approach facilitates the prioritization of variables that influence the selection process, thereby minimizing idle time at the port.

Table 2. Pairwise comparison between criteria

Criteria A	Rating Scale																	Criteria B
(C1) Time Efficiency	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Implementation Feasibility (C2)
(C1) Time Efficiency	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Implementation Costs (C3)
(C1) Time Efficiency	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Impact of Reducing Idle Time (C4)
(C1) Time Efficiency	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Sustainability (C5)
(C2) Implementation Feasibility	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Implementation Costs (C3)
(C2) Implementation Feasibility	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Impact of Reducing Idle Time (C4)
(C2) Implementation Feasibility	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Sustainability (C5)
(C3) Implementation Costs	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Impact of Reducing Idle Time (C4)
(C3) Implementation Costs	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Sustainability (C5)
(C4) Impact of Reducing Idle Time	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Sustainability (C5)

Each row in table 2 shows a comparison between two criteria. Respondents chose values on a colored scale to increase clarity when they indicated which criteria they considered more important in each pair using the Saaty scale (1 to 9).

- If the criterion on the left is more important, respondents mark the value on the orange scale.
- If the criterion on the right is more important, they mark the value on the yellow scale.
- A score of "1" in the middle indicates equal importance.
- Respondents highlight their preferred score in red to indicate their judgment.

Pairwise comparison between alternatives

In the second part, respondents evaluated the three proposed alternatives based on each of the five criteria:

Alternatif 1: Development & Implementation of Integrated SOPs
Alternatif 2: Addition of Standby Tugboat Assistance
Alternatif 3: Decentralization of Jetty Administration

For each criterion, respondents indicated which option they preferred and how strong their preference was, again using the Saaty scale (1–9):

- If Alternative 1, 2, or 3 was chosen, the value was selected on the left or right.
- Equal preferences were indicated by selecting "1" in the middle.
- As in the previous section, the selection was marked in green.

In this research, the first step was to collect expert opinions through a paired comparison questionnaire. In this process, each expert was asked to compare the criteria based on their relative level of importance by using the Saaty scale. From these results, a 5x5 pairwise comparison matrix was prepared for each respondent, where the matrix shows the personal judgment of the respondent regarding how important one criterion is compared to the others. Following the AHP approach, the values on the upper side of the diagonal line in the matrix are the direct judgments from respondents, while the lower side contains the reciprocal (inverse) values of those judgments. The diagonal itself is filled with the value 1 because every criterion is considered equally important when compared to itself. As an illustration,

In this formula, xi is the score given by respondent i, and n=10. Through this process, an aggregated comparison matrix is generated, which reflects the combined perspective of all respondents.

Consistency Check

To verify that the aggregated judgments are logically sound, a Consistency Check was carried out following AHP principles. This process is important to ensure that expert comparisons are reliable for final decision-making. The consistency check involves several stages:

1. Calculation of Weighted Sum Vector
   Each eigenvector value is multiplied by the corresponding criteria values to produce the weighted sum vector.
2. Calculation of Consistency Vector
   The elements of the weighted sum vector are divided by their respective eigenvector values, resulting in the consistency vector.
3. Calculation of Maximum Eigenvalue (ƛ Max)
   The elements in the consistency vector are averaged to obtain the dominant eigenvalue of the matrix.
4. Calculation of Consistency Index (CI)
5. Consistency Ratio Calculation (CR)

The CR was obtained by dividing the CI by the Random Index (RI) for a matrix of equal dimensions (RI = 1.12, when n = 5)

The ensuing results are derived from these calculations:

ƛ Max = 5

CI = 0.01

CR = 0.016

Since the CR value is below 0.10, the assessments are considered acceptably consistent. This confirms the logical alignment and validity of the expert evaluations presented, ensuring they are suitable for the next stages of the AHP process.

Weighting the Alternatives

After determining the priority weights of each criterion using the AHP method and confirming the consistency of expert assessments, the following stage is to evaluate the performance of each alternative priority action against those criteria. This stage, known as Alternative Weighting, connects the global priorities obtained earlier with the local performance scores of each alternative to arrive at the final decision outcome.

In principle, this process links the level of importance of each criterion with the relative preference for each alternative, producing a combined score for every option. Similar to the computational approach used when calculating eigenvectors for the criteria—through matrix normalization and taking the average of each row—the local weights of alternatives under each criterion are determined.

These local weights are then multiplied by the global weights of their corresponding criteria, resulting in the overall priority score for each alternative. The results present a comparative summary of the alternatives and highlight the most prioritized actions to ensure consistency in Development & Implementation of Integrated SOPs.

The first priority action is the Development & Implementation of Integrated SOPs with a weight of 71%, followed by the Addition of Standby Tugboat Assistance at 17%, and Decentralization of Jetty Administration at 12%. From these results, it can be concluded that the implementation of integrated SOPs is the most critical step, contributing 71% toward reducing idle time at the jetty. This initiative is expected to standardize operations, enhance coordination among stakeholders, and minimize procedural delays. To ensure this SOP development and implementation are carried out effectively and efficiently, the process will be carefully planned using PERT (Program Evaluation and Review Technique), enabling precise scheduling, monitoring, and timely completion of each stage.

Risk Management

Risk management is a process carried out to identify, analyze, and control potential problems that could hinder the achievement of a project or activity's objectives. In practice, risk management helps us map out possible risks that may arise, assess their impact levels, and prepare preventive measures or responses if those risks actually occur. With this approach, every decision made becomes more measured and focused, thereby minimizing losses and ensuring the project runs smoothly. In the world of work and operations, risk management is not merely a theory but an essential strategy for maintaining smooth operations, optimizing resources, and enhancing trust among all parties involved.

Table 3. Risk Identification

Risk ID	Risk Description	Risk Category
R1	Lack of stakeholder involvement in SOP development	Organizational
R2	Delays in SOP implementation	Operational
R3	SOPs that do not comply with regulations and industry standards	Legal
R4	Lack of training for SOP users	Project
R5	Delays in SOP updates	Legal

Table 3 explains the process of identifying risks that may occur in the development and implementation of SOPs. From the table, it can be seen that there are five main risks categorized by type. The first risk is the lack of stakeholder involvement in the SOP development process, which falls under the category of organizational risk. The second risk is delays in SOP implementation, which falls under the operational category. The third risk relates to SOPs that do not comply with regulations and industry standards, which is categorized as a legal risk. Next, the fourth risk is the lack of training for SOP users, which falls under the project risk category. Finally, the fifth risk is delays in updating SOPs, which also falls under the legal risk category. This identification is important so that any potential obstacles can be anticipated and managed from the outset.

Table 4. Causes and Impact

Risk ID	Causes	Impact
R1	Ineffective communication, lack of initial socialization	SOPs do not meet requirements, resistance during implementation
R2	Unrealistic time planning, limited resources	Project deadlines not met, disrupting jetty operations
R3	Lack of regulatory review, lack of expert consultation	Potential legal sanctions, decline in company reputation

R4	No formal training program, limited time, and budget	Operational errors, decline in work efficiency
R5	No mechanism for monitoring regulations and operational changes	SOPs become irrelevant, reducing operational quality and legal compliance

Table 4 outlines the causes and impacts of each risk identified previously. For example, for risk R1, the causes are ineffective communication and a lack of initial socialization, resulting in SOPs that do not meet requirements and cause resistance when implemented. Risk R2 is caused by unrealistic time planning and resource constraints, which result in project targets not being met and disrupting the smooth operation of the jetty. In R3, the lack of regulatory reviews and minimal expert consultation can trigger legal sanctions and damage the company's reputation. Risk R4 arises due to the absence of formal training programs, time constraints, and budget limitations, which result in operational errors and reduced work efficiency. Finally, R5 is caused by the absence of regulatory monitoring mechanisms and operational changes, resulting in outdated SOPs and reduced operational quality and legal compliance. This understanding is crucial for preparing appropriate mitigation measures.

Table 5. Risk Analysis

Risk ID	Likelihood (1-5)	Impact (1-5)	Risk Score	Risk Level
R1	3	4	12	Moderate to High
R2	4	4	16	High
R3	2	5	10	Moderate
R4	3	3	9	Moderate
R5	3	4	12	Moderate to High

Based on Table 5, the risk with code R2 (delay in SOP implementation) has the highest score of 16, which falls into the high-risk category. This value is obtained from a probability score of 4 and an impact score of 4. This risk is a top priority that must be addressed immediately, as delays in SOP implementation can disrupt the smooth operation of the jetty and potentially cause a chain reaction in the distribution process. Its management requires concrete steps such as schedule adjustments, resource optimization, and strengthened coordination among relevant parties.

Furthermore, risks R1 (lack of stakeholder involvement in SOP development) and R5 (delay in SOP updates) both have a score of 12, falling into the moderate to high category. These risks are significant as they can affect the quality and relevance of SOPs and trigger resistance during implementation. Proper handling includes improving communication, involving stakeholders from the early stages, and establishing clear SOP update mechanisms.

Meanwhile, risk R3 (SOPs not compliant with regulations) has a score of 10, and R4 (lack of SOP user training) has a score of 9, both falling under the moderate risk category. Although their impact is not as significant as high-scoring risks, consistent control measures are still necessary, such as conducting regular regulatory reviews, providing routine training, and ensuring compliance with industry standards.

Based on this analysis, risk mitigation efforts can prioritize R2, followed by R1 and R5, while R3 and R4 are managed using existing controls but remain under continuous monitoring. This approach helps ensure that resources are allocated according to the urgency and potential impact of each risk.

Table 6. Risk Mitigation

Risk ID	Controls / Mitigation Measures
R1	Conduct initial socialization, involving all relevant parties from the planning stage, and establish a regular discussion forum.
R2	Develop a realistic implementation schedule, add resources if necessary, and conduct weekly monitoring.
R3	Conduct periodic regulatory reviews, consult with legal and industry experts before finalizing SOPs.
R4	Provide formal training and training modules, and allocate specific time for training prior to implementation.
R5	Form a regulatory and operational change monitoring team, establish a schedule for periodic SOP reviews, use compliance checklists, and a digital reminder system.

After conducting a risk analysis, the next step is to develop a targeted mitigation plan to address the most important and urgent risks. This strategy can take the form of prevention, reduction, transfer, or acceptance of risk, depending on the type of risk and the project's capacity to manage it. Table 6 outlines clear steps to reduce each of the identified risks.

For risk R1 (lack of stakeholder involvement), the solution adopted is to conduct initial outreach involving all relevant parties from the planning stage, as well as establishing a regular discussion forum to ensure smooth communication. Risk R2 (delay in SOP implementation) is addressed by creating a realistic implementation schedule, adding resources if necessary, and conducting weekly monitoring. Meanwhile, risk R3 (SOPs not in accordance with regulations) is handled by conducting periodic regulatory reviews and consulting with legal and industry experts before the SOPs are approved.

Risk R4 (lack of SOP user training) is anticipated by providing formal training programs, training modules, and special scheduling before SOPs are implemented. Meanwhile, risk R5 (delays in SOP updates) is minimized through the formation of a regulatory and operational change monitoring team, the establishment of a regular SOP review schedule, the use of compliance checklists, and the implementation of a digital reminder system.

This approach ensures that each risk is managed in the most effective manner, maintaining operational quality, legal compliance, and the smooth implementation of SOPs in the workplace.

Project Management

Estimating Activity Duration Using PERT, to address time uncertainty in project activities, activity duration estimates are made using the PERT (Program Evaluation and Review Technique) method. This method uses three time references—optimistic (O), most likely (M), and pessimistic (P)—and then calculates the duration as a weighted average.

Table 7. PERT

Code	Activity Description	O	M	P	PERT Estimate	Pre decessor	PIC
A	Identify integrated SOP requirements	3	5	7	5	-	Project Management & Operations Team
B	Collect work process data and supporting documents	5	7	9	7	A	Operations & Administration
C	Conduct a gap analysis of existing SOPs	4	6	8	6	B	HSE Team & Operations
D	Determine the structure and format of SOPs	3	4	6	4	C	Project Management Team
E	Prepare a preliminary draft of SOPs	5	7	10	7	D	Project Management & Operations Team
F	Internal review and revision of the SOP draft	4	6	9	6	E	All Related Departments
G	Pilot testing of SOP implementation in the field	7	10	14	10	F	Operations, HSE
H	Evaluation of pilot test results and final revision of SOP	5	7	10	7	G	Project Management
I	Final approval and validation of SOP	3	4	6	4	H	Top Management
J	Socialization and training on SOP for all users	7	10	14	10	I	HRD & Operations
K	Full implementation of integrated SOP	5	7	10	7	J	All Related Departments
L	Initial monitoring post-implementation	10	14	20	14	K	Project Management
M	Continuous evaluation and improvement of SOP	7	10	14	10	L	Project Management & Operations Team

Table 7 shows the estimated duration of PERT-based activities for the Development & Implementation of Integrated SOPs. The table includes time uncertainties represented by three estimation scenarios: optimistic (O), most likely (M), and pessimistic (P), which are then weighted averaged to obtain the PERT duration estimate. Some activities, such as SOP document preparation and SOP socialization, show a fairly wide range of time from optimistic to pessimistic, reflecting a higher level of variability and risk compared to other activities. For example, the SOP socialization activity has a range from a short optimistic estimate to a much longer pessimistic estimate, indicating potential obstacles in the implementation process. Meanwhile, other activities, such as preparing for coordination meetings, require a relatively short time with a low risk of delay. Overall, this PERT table serves as a strong foundation for project scheduling, helping to estimate time more accurately and facilitating the determination of buffer time to anticipate potential delays.

Based on the results of the analysis using the PERT/CPM network diagram, the entire series of activities for the preparation and implementation of integrated SOPs at Kertapati Port are interconnected in sequence, starting from the needs identification stage (A) to continuous evaluation (M). From the forward pass and backward pass calculations, the critical path is shown through the sequence A to M with a total duration of 97 calendar days. Since all activities are on the critical path without slack (time allowance), a delay in just one activity will have a direct impact on the overall project delay. This emphasizes the importance of strict supervision, coordination between teams, and appropriate resource allocation to ensure that the project schedule remains on track and the port's operational efficiency goals are achieved.

Business Solution

1. Development of Integrated and Standardized SOPs
   Developing integrated SOPs that involve all stakeholders from the planning stage, ensuring compliance with regulations and industry standards (including SNI 7932:2020), and conducting regular reviews to maintain relevance and legal compliance. This approach ensures that each stage of loading and unloading has clear, measurable, and easily monitored procedures.
2. Strengthening Capacity and Implementation Readiness
   Developing a realistic implementation schedule based on PERT calculations, adding resources when necessary, and conducting weekly monitoring to minimize the risk of delays. With good interdepartmental coordination, the implementation process is expected to run smoothly without disrupting jetty operations.
3. Structured Training and Socialization Program
   Provide formal training with clear modules to all SOP users before full implementation. This training is complemented by regular discussion forums so that obstacles in the field can be immediately identified and overcome. This way, the entire team will have a uniform understanding and skills in carrying out the new procedures.
4. Proactive Risk Management
   Implement mitigation measures such as forming a regulatory change monitoring team, using compliance checklists, and implementing a digital reminder system. This aims to reduce operational, legal, and reputational risks that may arise due to procedural non-compliance or regulatory changes.

5. Timely Project Implementation in Accordance with CPM and PERT
   Based on PERT calculations, the entire series of activities is planned to be completed within 102 calendar days. With strict supervision, cross-departmental coordination, and the addition of a time buffer to anticipate obstacles, the project is expected to be completed on time and ready for operation without significant disruptions.
6. Continuous Evaluation and Improvement
   Conduct post-implementation monitoring and periodic evaluations to ensure SOPs remain effective. Improvements will be made if there are changes in regulations, operational dynamics, or relevant technological developments.

Implementation Plan

A trial of the latest draft SOP has been conducted in the field as part of the company's efforts to reduce idle time and improve operational effectiveness at the Kertapati jetty. The results of this trial show that the implementation of the SOP has had a tangible impact on the berthing and unberthing processes for barges. Several stages that previously often caused delays have been streamlined, as the workflow is now clearer and more focused. In addition, coordination between the parties involved has also become easier because each step is outlined in standard procedures. This means that operators in the field no longer have to wait for repeated instructions, but can immediately execute their work according to the SOP guidelines. In this way, administrative processes that usually take a long time can also be streamlined, especially since some of the documents are prepared before the barge docks.

However, this trial also identified several challenges that require attention. For example, some personnel are still not accustomed to following the new procedures and require additional guidance. Additionally, external factors such as weather conditions and the readiness of the barge remain variables that must be anticipated in daily operations. Overall, the results of this trial implementation of the draft SOP show a positive trend. With improvements in certain areas and further training for the field team, this SOP has significant potential for full and sustainable implementation. If consistently implemented, not only can idle time be reduced, but jetty throughput will also increase, thereby supporting the achievement of the company's distribution targets.

From the first operational year (2026), the project will immediately generate positive EBITDA of IDR 22.56 billion, which will then increase consistently in subsequent years. The EBITDA margin reaches 100%, indicating that almost all revenue directly contributes to operational profits, without significant OPEX expenses. This indicates the high efficiency of the project being implemented.

From a cash flow perspective, the project will generate positive net cash flow starting in 2026, with accumulated cash flow exceeding IDR 87.93 billion by 2028. This financial performance yields very strong investment indicators, with an NPV of IDR 70.69 billion, an IRR of 45.150%, and a payback period of only 1 year. This means that the investment capital can be fully recovered within one year after implementation, and the project will subsequently generate pure profits.

After the draft is prepared, an internal review and revision (September–October 2025) will be conducted, involving all relevant departments. Field testing of the SOPs will take place from October 2025, followed by an evaluation of the test results and final revisions (October 2025), and final approval by top management (October 2025).

The socialization and training phase for all SOP users is the longest activity (October - November 2025), followed by the full implementation of the integrated SOP (November 2025).

Post-implementation, initial monitoring (November - December 2025) will be conducted by the Project Management team, followed by continuous evaluation for SOP improvements (November - December 2025). This workflow demonstrates the close interdependence between tasks, where a delay in one phase can impact the entire project schedule. With structured planning and clear assignment of responsibilities, this project is expected to proceed effectively, minimize the risk of delays, and ensure that the resulting SOP aligns with the company's operational needs and standards.

5. Conclusion

This study addresses key questions about how Kertapati Port can improve jetty operational time and cut down on idle time, which has been a major obstacle. Using a root cause analysis with the CRT, it can be explained that the main root cause of the problem at Kertapati Jetty is the absence of clear and detailed Standard Operating Procedures (SOPs) regarding time limits at each stage of operations. Existing internal documents are still general in nature, without any standard time limits that can be used as guidelines. This condition results in an inconsistent berthing schedule, poor coordination among stakeholders, and lengthy administrative procedures caused by the physical distance between the jetty and the office. This situation not only impacts the efficiency of loading and unloading activities but also increases demurrage costs and decreases port throughput.

To address this, this study proposes the implementation of an integrated solution encompassing the development and implementation of berthing/unberthing Standard Operating Procedures (SOPs), the addition of standby Tugboats, and the decentralization of Jetty Administration. Why was this solution chosen? Based on the results of the Analytical Hierarchy Process (AHP) calculation, these three solutions have a significant contribution weight in reducing idle time and smoothing the flow of loading and unloading, thereby directly impacting the improvement of port operational performance.

Additionally, the feasibility study indicates that the implementation of these integrated SOPs has the potential to save approximately USD 450,000 per year in demurrage costs, assuming a conservative reduction in idle time of 25% or equivalent to 1,080 hours per year. This cost-saving value reinforces the position of this solution as the most optimal choice, both operationally and financially.

To ensure effective implementation, this project is designed using the Critical Path Method (CPM) and Program Evaluation and Review Technique (PERT) to identify critical activities, determine stages that cannot be delayed, and ensure all work is completed on time. According to the schedule, the implementation of this SOP is planned to take 102 calendar days, starting on August 1, 2025, and targeted for completion on November 10, 2025. To ensure smooth progress, risk analysis and mitigation plans have also been developed, covering risks such as delays, technical challenges, regulatory changes, and coordination obstacles.

Thus, this study not only answers the question, "How can Kertapati Port reduce idle time and improve jetty operational effectiveness?" but also provides a structured, measurable implementation guide with direct impacts on cost efficiency, operational sustainability, and the achievement of the company's coal distribution targets.

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