

# EVALUATING THE CURRENT CONDITION OF THE MAINTENANCE AND REPAIR FACILITIES (FASHARKAN) OF THE INDONESIAN NAVY (TNI AL) USING NVIVO (NON-VERBAL INTERACTIVE VISUALIZATION ORGANIZER)

## AVALIAÇÃO DA SITUAÇÃO ATUAL DAS INSTALAÇÕES DE MANUTENÇÃO E REPARO (FASHARKAN) DA MARINHA INDONÉSIA (TNI AL) UTILIZANDO O NVIVO (ORGANIZADOR DE VISUALIZAÇÃO INTERATIVA NÃO VERBAL)

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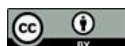
The authors declare that there is no conflict of interest

### Abstract

The operational readiness of warships is greatly influenced by the effectiveness of maintenance and repair systems supported by adequate maintenance facilities. This study aims to evaluate the condition of the Indonesian Navy's ship maintenance and repair facilities (Fasharkan) in supporting the readiness of the naval fleet. The study used an exploratory qualitative approach with system analysis through the integration of the 5M framework (Man, Machine, Method, Material, Money) to examine internal factors and PESTLE (Political, Economic, Social, Technological, Legal, Environmental) to analyze external factors that affect the performance of maintenance facilities. Data analysis was performed using NVivo software through coding, thematic analysis, and visualization of the relationships between research variables. The results showed that structurally, Fasharkan TNI AL is still capable of performing ship maintenance functions, but its capacity is not yet optimal and is not evenly distributed nationwide. The main problems include limited technical human resources, delays in equipment modernization, limited availability of spare parts, and budget support

### Resumo

*A prontidão operacional dos navios de guerra é fortemente influenciada pela eficácia dos sistemas de manutenção e reparo, apoiados por instalações de manutenção adequadas. Este estudo tem como objetivo avaliar as condições das instalações de manutenção e reparo de navios (Fasharkan) da Marinha da Indonésia no apoio à prontidão da frota naval. O estudo utilizou uma abordagem qualitativa exploratória com análise de sistemas, por meio da integração da estrutura 5M (Homem, Máquina, Método, Material, Dinheiro) para examinar fatores internos e PESTLE (Político, Econômico, Social, Tecnológico, Legal, Ambiental) para analisar fatores externos que afetam o desempenho das instalações de manutenção. A análise dos dados foi realizada utilizando o software NVivo por meio de codificação, análise temática e visualização das relações entre as variáveis da pesquisa. Os resultados mostraram que, estruturalmente, o Fasharkan da Marinha da Indonésia ainda é capaz de desempenhar funções de manutenção de navios, mas sua capacidade ainda não é ideal e não está distribuída uniformemente em todo o país. Os principais problemas incluem recursos*



that is not commensurate with the increasing complexity of ship technology. In addition, external factors such as developments in maritime technology and defense policy dynamics also affect the effectiveness of the maintenance system. This study recommends strengthening technical human resource capacity, modernizing maintenance facilities, strengthening the spare parts logistics system, and optimizing defense industry cooperation to improve the operational readiness of Indonesian Navy ships in a sustainable manner.

**Keywords:** Indonesian Navy Fleet Command. Warship Maintenance. 5M Analysis. PESTLE Analysis. Nvivo. Fleet Operational Readiness.

*humanos técnicos limitados, atrasos na modernização de equipamentos, disponibilidade limitada de peças de reposição e apoio orçamentário que não é compatível com a crescente complexidade da tecnologia naval. Além disso, fatores externos, como os avanços na tecnologia marítima e a dinâmica da política de defesa, também afetam a eficácia do sistema de manutenção. Este estudo recomenda o fortalecimento da capacidade de recursos humanos técnicos, a modernização das instalações de manutenção, o fortalecimento do sistema de logística de peças de reposição e a otimização da cooperação com a indústria de defesa para melhorar a prontidão operacional dos navios da Marinha da Indonésia de maneira sustentável.*

**Palavras-chave:** Comando da Frota da Marinha da Indonésia. Manutenção de Navios de Guerra. Análise 5M. Análise PESTLE. Nvivo. Prontidão Operacional da Frota.

## 1 INTRODUCTION

A country's defense strength is not only determined by the number and capability of its defense equipment, but also by the readiness of its logistics and maintenance support systems. In the context of naval power, the operational readiness of warships is a crucial factor in ensuring the Navy's ability to carry out national defense tasks, maritime security, and military operations other than war. The maintenance and repair of warships are an important part of the defense logistics system, which aims to maintain *the availability, reliability*, and optimal service life of warships. Ship maintenance infrastructure, such as maintenance and repair facilities (Fasharkan), plays a strategic role in supporting the operational readiness of a country's naval fleet (Tinga *et al.*, 2020; Sipos *et al.*, 2022).

The Indonesian Navy (TNI AL) has several ship maintenance and repair facilities spread across various strategic regions in Indonesia, including Fasharkan Tanjung Uban, Fasharkan Jakarta, Fasharkan Surabaya, Fasharkan Makassar, and Fasharkan Manokwari. These facilities are responsible for routine maintenance, damage repairs, and overhauls of TNI AL warships. However, with the development of increasingly complex warship technology and increasing demands for operational readiness, the condition of these

maintenance facilities needs to be comprehensively evaluated to ensure that their capacity, technology, and management systems are capable of supporting the maintenance needs of the naval fleet effectively and efficiently (Boulougouris *et al.*, 2019; Scurati *et al.*, 2021).

Evaluation of ship maintenance facilities can be carried out through a systematic approach that considers various internal organizational factors. One approach that is widely used in operational analysis and maintenance management is the 5M approach (*Man, Machine, Method, Material, Money*). This approach allows researchers to identify the factors that cause system performance through five main elements that affect the effectiveness of an organizational or industrial process. Human resources, equipment technology, work methods, material availability, and financial support are important components in determining the success of a facility's maintenance system (Singh *et al.*, 2020). The 5M approach is also often used in quality analysis, operations management, and maintenance systems because it provides a comprehensive overview of the internal factors that influence the performance of an operational system.

In addition to internal factors, the performance of an organization is also greatly influenced by external environmental factors. Therefore, this study also uses the PESTLE (*Political, Economic, Social, Technological, Legal, Environmental*) approach to analyze the influence of the strategic environment on the development and sustainability of the Indonesian Navy's ship maintenance facilities. The PESTLE framework is widely used in strategic management research to understand how political factors, economic conditions, technological developments, legal regulations, social conditions, and environmental issues can affect organizational performance and policies. This analysis helps organizations identify opportunities and threats from the external environment so that they can formulate more adaptive and sustainable development strategies.

This study provides a clear theoretical contribution by advancing the analysis of maintenance systems in defense organizations through the integration of internal and external perspectives. Unlike prior studies that tend to apply the 5M (*Man, Machine, Method, Material, Money*) or PESTLE (*Political, Economic, Social, Technological, Legal, Environmental*) frameworks separately, this research develops a more comprehensive analytical approach by combining both into a unified system framework. This integration allows for a deeper understanding of how internal operational capacity

interacts with external structural pressures in shaping maintenance effectiveness. Furthermore, by employing NVivo-based qualitative system analysis, this study extends existing maintenance management literature—traditionally dominated by quantitative and engineering approaches—toward a more interpretive and systemic perspective. In doing so, it contributes to bridging the gap between maintenance management theory, strategic environmental analysis, and defense logistics studies, particularly in the context of resource-constrained and geographically dispersed maritime defense systems.

This study aims to systematically evaluate the current condition of the Indonesian Navy's ship maintenance and repair facilities (Fasharkan) in supporting fleet operational readiness by integrating internal and external analytical perspectives. Specifically, this research seeks to (1) identify and analyze internal factors affecting maintenance performance using the 5M framework, (2) examine the influence of external strategic environments through the PESTLE approach, and (3) explore the interrelationships between these factors using NVivo-based qualitative system analysis to reveal key patterns, constraints, and systemic challenges. Ultimately, this study aims to generate a comprehensive and evidence-based understanding of maintenance system performance and to formulate strategic recommendations for strengthening the effectiveness, adaptability, and sustainability of naval maintenance facilities in a dynamic defense environment.

## 2 METHOD

This study uses an exploratory qualitative approach with a systems analysis of the condition of the Indonesian Navy's ship maintenance and repair facilities (Fasharkan). This method aims to evaluate internal and external factors that affect the performance of ship maintenance facilities through a combination of the 5M (*Man, Machine, Method, Material, Money*) and PESTLE (*Political, Economic, Social, Technological, Legal, Environmental*) approaches. Data analysis was carried out using NVivo software to organize, code, and visualize the relationships between research themes.

## 2.1 5M analysis approach

The 5M approach was used to analyze internal factors that influence the effectiveness of the ship maintenance facility system. The five main elements analyzed include:

- 1) Man: the competence, number, and qualifications of human resources, namely maintenance technicians and operators.
- 2) Machine: availability and condition of maintenance equipment, docking systems, and ship repair technology.
- 3) Method: work procedures, maintenance management systems, and ship maintenance operational standards.
- 4) Material: availability of spare parts, repair materials, and supporting logistics systems.
- 5) Money: maintenance budget *allocation*, cost efficiency, and maintenance facility financing.

This approach is widely used in operational analysis and maintenance management to identify factors that affect the performance of an organization's production or maintenance system (Tsang, 2002; Macchi & Fumagalli, 2013).

## 2.2 PESTLE analysis approach

In addition to internal factors, this study also analyzes external factors that influence the development of ship maintenance facilities through the PESTLE framework. This approach identifies six strategic environmental factors:

- 1) Political – defense policy and maritime industry development.
- 2) Economic – defense budgets and ship maintenance cost efficiency.
- 3) Social – availability of labor and human resource competencies.
- 4) Technological – developments in ship maintenance technology and maintenance digitization.
- 5) Legal – defense regulations and maritime safety standards.
- 6) Environmental – environmental issues in docking and ship repair activities.

PESTLE is widely used in organizational strategy analysis to understand opportunities and threats from the external environment that may affect organizational operations and policies.

### **2.3 Data analysis with nvivo**

Data analysis was conducted using NVivo, qualitative data analysis software that allows researchers to systematically code, classify themes, and analyze relationships between variables. The steps of analysis with NVivo include:

- 1) Data collection – collecting data from interviews, organizational documents, facility observations, and maintenance reports.
- 2) Coding process – coding data based on the 5M and PESTLE categories.
- 3) Thematic analysis – identification of patterns, relationships, and dominant factors that influence maintenance facility performance.
- 4) Visualization – use of models, diagrams, and network analysis to visualize the results of the analysis.

This data-based analysis method allows for a more comprehensive and evidence-based evaluation of the maintenance system.

### **2.4 Maintenance system context**

In modern maintenance systems, the analysis of maintenance facility conditions is usually carried out using a condition-based maintenance and predictive maintenance approach that utilizes operational data to improve system reliability. This maintenance program involves the process of collecting condition data, analyzing data, and making maintenance decisions to reduce downtime and improve system availability.

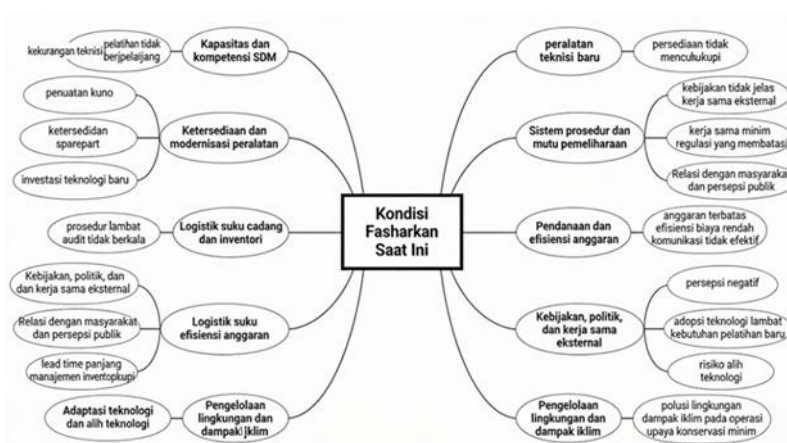
This approach is particularly relevant in warship maintenance systems, which require a high level of operational readiness and an efficient logistics support system.

### 3 RESEARCH RESULTS AND DISCUSSION

#### 3.1 Research results

**Figure 1**

*Semantic Analysis Using Queries*



The semantic analysis image provides a comprehensive overview of the current state of Fasharkan by grouping all queries/coding into related major themes.

##### a) Main structure of the image

In the center is the "Current Fasharkan Conditions" box as the central node that summarizes the overall situation of the organization.

From the central node, several major theme branches emerge from the initial coding and focused coding: human resource capacity, equipment, procedures and quality, spare parts logistics, funding, external policies/cooperation, community relations, technology adaptation, and environment/climate.

##### b) Meaning of each major theme

Human resource capacity and competence: describes the problems of technician shortages, aging human resources, loss of competence, non-tiered training and post-training transfers, resulting in weak human support for ship maintenance.

Availability and modernization of equipment: includes the condition of docks, cranes, and old/legacy workshop machinery, corroded dock rails, minimal equipment and manual labor, as well as modernization that lags behind the technology of the Indonesian

Navy's ships, including modern machinery that is idle because there are no trained operators.

c) Procedures, quality, and logistics

Maintenance procedures and quality systems: indicate that SOPs, regulatory references, and QA procedures are actually available, but their implementation is hampered by budget constraints, infrastructure limitations, lack of quality personnel, dependence on the central Dislaik, and uneven maintenance quality across regions.

Spare parts and inventory logistics: explains that stocks are minimal or even non-existent, critical items are unavailable, procurement is reactive after damage occurs, suppliers outside the region cause delays, and the inventory system is still administrative and does not truly guarantee readiness and docking preparedness.

d) Funding and external context

Funding and budget efficiency: describes insufficient maintenance budgets, rising work backlogs, increasing defense equipment, rising spare parts prices, and reduced preventive maintenance, despite high budget absorption; fixed ceilings are small and insufficient for real needs, so the focus is only on critical components.

Policy, politics, and external cooperation: indicates political and defense industry support and opportunities for maritime cooperation, but strengthening is uneven, some units are lagging behind, and the utilization of cooperation is hampered by military regulations and a lack of proactive communication.

e) Social relations, technology, and environment

Relations with the community and public perception: explains that Fasharkan is viewed positively in areas where it frequently interacts (student/vocational school internships, PHL, employment sources, learning centers), but in other areas, Fasharkan's role is less known and its contributions are not yet understood.

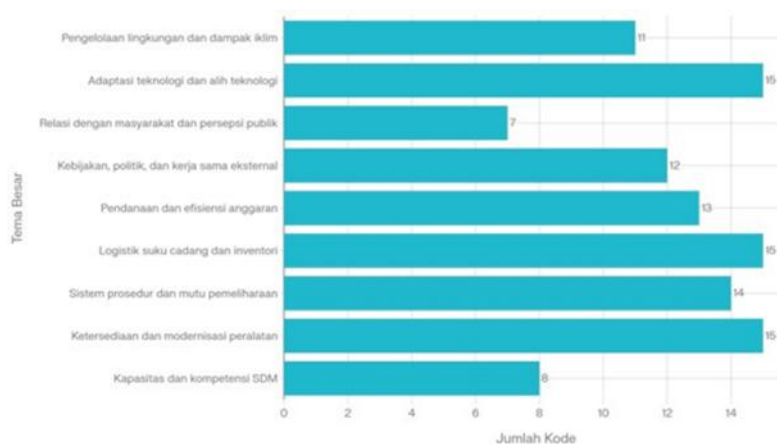
Technology adaptation and transfer: describes developments in maritime technology, IMO standards, navigation, and Sewaco that require improvements in human resources and equipment, but adaptation is slow, access to TOT is limited, technology transfer from foreign ship projects is still minimal, and is even constrained by central government policy.

Environmental management and climate impact: shows that there are fairly good waste management practices and locations that are far from residential areas, but

environmental facilities are lacking and the environment is not yet a priority; climate change (tides, rain, and high waves) has disrupted docking and outdoor work, posing health risks to personnel, although the impact is smaller in sheltered locations.

## Figure 2

Bar chart showing the amount of data obtained from respondents



### a) Themes with the most issues

The availability and modernization of equipment, spare parts logistics and inventory, as well as technology adaptation and transfer were in the highest frequency group (around 15 codes).

This indicates that the main problems faced by Fasharkan are concentrated on: outdated and uneven equipment, spare parts that are often unavailable or arrive late, and lagging adaptation and technology transfer capabilities.

### b) Themes with medium-level issues

Maintenance procedures and quality systems, funding and budget efficiency, as well as policy, politics, and external cooperation are at a medium level (around 11–14 codes).

This means that, in addition to technical equipment and logistics, there are quite a number of findings regarding obstacles to the implementation of SOPs and quality, budget constraints that cause backlogs, and the suboptimal utilization of policy support and maritime cooperation.

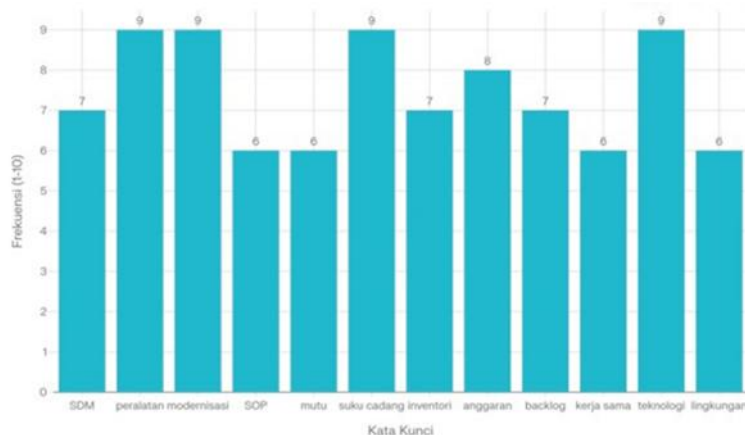
c) Themes with relatively fewer issues

Human resource capacity and competence, as well as relations with the community and public perception, had the lowest frequency (around 7–8 codes). This does not mean that human resources and social relations are unimportant, but in the coded data, the greatest pressure in the respondents' narratives was directed more towards equipment, logistics, technological adaptation, and funding, while issues of human resources and public image appeared more briefly.

Overall, the bar chart confirms that Fasharkan's current problems are most severe in terms of infrastructure, supply chains, and technology, which are then exacerbated by budget constraints and suboptimal policy frameworks and external cooperation.

**Figure 3**

*Word frequency bar chart using Query*

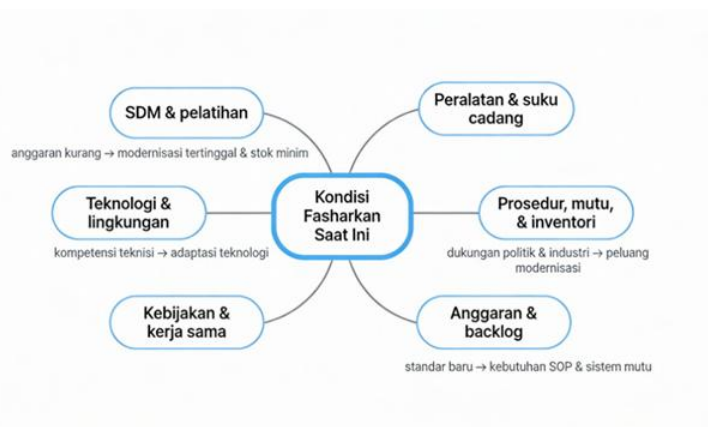


The word frequency analysis reveals that the dominant issues affecting Fasharkan are strongly concentrated in the areas of equipment, spare parts, modernization, and technology, all of which exhibit the highest frequency values (9), indicating that technical infrastructure limitations and slow technological adaptation are the most critical constraints in the maintenance system. These core issues are further reinforced by budget-related pressures (8), which play a central role in constraining modernization efforts, limiting spare parts availability, and contributing to the accumulation of maintenance backlogs (7). In parallel, human resource capacity (7) and inventory management (7) emerge as supporting but still significant challenges, particularly in terms of technician shortages, aging personnel, and administrative inventory systems that do not ensure

operational readiness. Meanwhile, procedural and governance aspects such as SOP implementation, maintenance quality, and collaboration (each scoring 6) suggest that formal systems and external cooperation mechanisms are already in place but have not yet been optimally implemented. Environmental factors (6), including tidal flooding and high waves, further add operational constraints, although their impact is relatively less dominant compared to technical and resource-related issues. Overall, this distribution of keywords highlights that Fasharkan's challenges are systemic, with technical, financial, and organizational factors interacting to shape maintenance performance and fleet readiness.

**Figure 4**

*Relationship Visualization using Mind Map*



The *mind map* illustrates how the main aspects are interconnected to form the current condition of Fasharkan, rather than standing alone.

At the center is the node "Current Fasharkan Conditions," which is the hub of all issues and potential improvements.

From this node, there are six branches: "Human Resources & Training," "Equipment & Spare Parts," "Procedures, Quality, & Inventory," "Budget & Backlog," "Policy & Cooperation," and "Technology & Environment," which represent the grouping of major themes resulting from coding.

a. Human Resources & Training

This branch summarizes the shortage of technicians, aging human resources, loss of competence, non-tiered training, and post-training transfers.

*The mind map* shows that the quality and quantity of human resources are prerequisites for being able to operate modern equipment and keep up with technological developments.

b. Equipment & Spare Parts

This section covers issues such as old docks, old cranes, old workshop machinery, minimal equipment, manual labor, minimal/zero spare parts stock, and reactive procurement.

This branch is linked to "Budget & *backlog*" and "Policy & cooperation," indicating that equipment modernization and spare parts availability are heavily influenced by the size of the budget and policy/defense industry support.

c. Procedures, quality, & inventory

Describes available SOPs, QA procedures, and certifications, but quality is inconsistent and the inventory system is still administrative, so readiness is not guaranteed.

In *the mind map*, this branch is connected to "Technology & Environment" because new technology standards and environmental demands drive the need to update SOPs, quality systems, and inventory management.

d. Budget & *backlog*

Includes insufficient budgets, high demand, rising spare part prices, small ceilings, and increasing maintenance *backlogs*.

The relationship to "Equipment & Spare Parts" is defined as "budget shortfall → delayed modernization & minimal stock," indicating that funding constraints directly hinder equipment upgrades and spare parts procurement.

e. Policy & cooperation

Includes political support, defense industry, defense equipment independence, potential for maritime cooperation, but strengthening is uneven and proactive communication is lacking.

The mind map shows the relationship to "Equipment & spare parts" as an opportunity: external policy and cooperation can be a source of equipment modernization and logistical strengthening if utilized optimally.

f. Technology & Environment

Combines issues of maritime technology development, IMO standards, modern navigation, Sewaco, slow adaptation, minimal technology transfer, as well as the impact of tidal waves, rain and high waves, and health risks.

This branch is linked to "Human Resources & Training" (technician competence → technology adaptation) and to "Procedures, Quality, & Inventory" (new standards → need for SOPs & quality systems), and emphasizes that climate change also affects maintenance work patterns.

Overall, *the mind map* shows that Fasharkan's condition is the result of a layered interaction between human resources, equipment and logistics, procedure and quality systems, budget capacity, policy support/cooperation, and technological and environmental demands, so improvements need to be made in an integrated manner, not sectorally.

#### **4 DISCUSSION OF RESEARCH**

The findings of this study indicate that the performance of Fasharkan is shaped by a complex interaction between internal capacity constraints and external structural pressures, rather than by isolated technical deficiencies. The dominance of issues related to equipment, spare parts, and technology reflects a structural gap between the rapid advancement of naval platform technology and the relatively slower development of maintenance infrastructure. This condition is consistent with the literature on modern maintenance systems, which emphasizes that maintenance effectiveness depends on the alignment between system complexity and supporting infrastructure (Boulougouris *et al.*, 2019; Karatuğ *et al.*, 2023). This imbalance indicates that the pressure of Indonesian Navy fleet modernization is progressing much faster than the development of Fasharkan facilities, creating a capacity gap that directly constrains maintenance effectiveness. As a result, maintenance systems tend to remain reactive rather than preventive, as also highlighted in studies on condition-based and predictive maintenance (Jardine *et al.*, 2006; Si *et al.*, 2011).

Furthermore, the analysis reveals that budget constraints function as a central limiting variable that influences multiple dimensions simultaneously. Insufficient and inflexible budget allocation not only delays equipment modernization but also restricts

spare parts procurement, reduces training intensity, and weakens the implementation of maintenance systems. This finding aligns with maintenance management theory, which identifies financial resources as a key determinant in maintenance policy selection and system performance (Tsang, 2002; Carnero, 2006). In this context, budget limitations directly contribute to increasing maintenance backlogs and reducing preventive maintenance practices, thereby reinforcing reactive maintenance patterns.

In terms of human resources, although the frequency of issues appears lower compared to technical factors, their impact is systemic and long-term. The shortage of skilled technicians, aging workforce, and weak regeneration and training systems affect the organization's ability to adopt modern maintenance technologies. This finding supports previous research emphasizing that human competence is a critical enabler in implementing technology-driven and data-based maintenance systems (Bokrantz *et al.*, 2020; Scurati *et al.*, 2021). This indicates that strengthening human resource capacity is a prerequisite for ensuring that equipment modernization translates into actual performance improvement.

The study also shows that formal systems such as SOPs and quality standards are already in place, but their implementation is not consistent across regions. This inconsistency reflects not only disparities in institutional capacity but also significant regional gaps, where Fasharkan facilities in the western region are relatively more developed compared to those in the eastern region, which still face limitations in infrastructure, resources, and operational support. In addition, although political will and regulatory frameworks appear supportive at the national level, their implementation and distribution are not evenly realized, resulting in unequal capacity development across regions. This suggests that the presence of policies alone is insufficient without effective implementation mechanisms and equitable resource distribution.

From an external perspective, the PESTLE analysis highlights that policy, technological developments, and environmental conditions significantly influence maintenance system performance. The role of external factors in shaping organizational strategy has been widely discussed in strategic management literature, particularly through environmental scanning frameworks such as PESTLE (Lau *et al.*, 2019; Dalirazar & Sabzi, 2023). In the case of Fasharkan, opportunities for cooperation with the defense industry and policy support are substantial but remain underutilized due to limited

coordination and regulatory rigidity. Meanwhile, environmental factors such as tidal flooding, high waves, and extreme weather conditions further increase operational complexity, which is often not yet systematically integrated into maintenance planning.

Overall, these findings confirm that the challenges faced by Fasharkan are structural, multidimensional, and interdependent, requiring an integrated rather than fragmented approach. This supports the broader perspective that maintenance systems in complex organizations should be understood as socio-technical systems, where technical, organizational, financial, and environmental factors interact dynamically (Van Horenbeek & Pintelon, 2013; Zhou *et al.*, 2023). Therefore, improving Fasharkan's performance requires not only technical interventions but also institutional reform, more equitable capacity distribution across regions, optimization of policy support, and adaptive strategies that align internal capabilities with external demands in a sustainable manner.

#### 4.1 Synthesis of key findings

Based on the 5M and PESTLE analyses, it can be concluded that:

- a. The main obstacles are structural and multidimensional, especially in terms of human resources, equipment modernization, materials, and budget.
- b. The gap between regions is very apparent, especially between the western region (relatively more prepared) and the eastern region (very limited).
- c. Political will and regulations are relatively supportive, but implementation and distribution of support are not yet evenly distributed.
- d. The maintenance model is still predominantly reactive, not yet fully based on preventive maintenance and readiness strategy.
- e. The pressure for ship modernization is much faster than the modernization of Fasharkan facilities.

## 4.2 Theoretical implications

These findings reinforce and extend existing theory by demonstrating that the readiness of defense organizations is not determined by isolated variables, but by the dynamic integration of internal factors (5M) and external environmental conditions (PESTLE) within a systemic framework. The study shows that each element operates in an interdependent manner, where imbalances in one dimension such as budget constraints can trigger cascading effects across other components, including delayed equipment modernization, limited spare parts availability, reduced maintenance quality, and ultimately declining operational readiness. This confirms the relevance of systems theory in maintenance management, while also advancing it by empirically illustrating how internal operational capacity is structurally shaped and constrained by external policy, economic, and technological environments. Furthermore, the findings challenge the conventional assumption that maintenance effectiveness is primarily a technical issue, highlighting instead that it is a multi-dimensional organizational outcome influenced by institutional arrangements, resource allocation regimes, and external strategic pressures. By integrating 5M and PESTLE into a unified analytical lens, this study contributes to the development of a more holistic and context-sensitive theoretical framework for understanding maintenance systems in complex, high-reliability defense organizations, particularly in developing country settings characterized by resource limitations and uneven institutional capacity.

## 4.3 Practical implications

Strengthening Fasharkan requires an integrated strategic approach:

- a. Sustainable recruitment and training of technical human resources
- b. Priority-based modernization of equipment for new-generation ships
- c. Establishment of a minimum stock of critical items
- d. More flexible funding schemes
- e. Optimization of maritime industry cooperation and technology transfer

Overall, Fasharkan has a strong institutional foundation, SOPs, and regulatory support. However, its operational capacity is still limited by human resource constraints,

uneven facility modernization, a reactive material system, and a budget that is not commensurate with the maintenance burden.

Without planned and sustainable transformation, the gap between the demands of modern ship readiness and Fasharkan's capacity will widen. Conversely, with integrated strengthening, Fasharkan has the potential to become an independent and nationally competitive center for maritime defense maintenance.

## 5 CONCLUSION

An evaluation of the current condition of the Indonesian Navy's Fasharkan shows that:

- 1) Structurally, Fasharkan is still capable of performing ship maintenance and repair functions, particularly for emergency-level and organic-level repairs up to the harmen level.
- 2) However, its capacity is not yet optimal and is not evenly distributed nationally, particularly in:
  - a. The fulfillment and regeneration of technical human resources.
  - b. Modernization of shipyard equipment and facilities.
  - c. The provision of strategic spare parts.
  - d. Budgetary support proportional to the growth of defense equipment.
- 3) The biggest challenges are systemic and structural in nature, namely the imbalance between the increasing complexity of Indonesian Navy ship technology and the capabilities of Fasharkan's facilities, human resources, and budget.
- 4) From a governance perspective, procedures and management are relatively well-established, but are still constrained by limited resources, preventing the consistent application of ideal maintenance standards across all Fasharkan facilities.

Therefore, the current condition of the Indonesian Navy's ship maintenance facilities can be assessed as "functioning adequately but not optimally and not balanced nationally," with urgent needs in the following areas:

- a. Revitalization and modernization of facilities,
- b. Strengthening the cadre system and continuous training,

- c. Reformulation of budget support based on the real needs of the fleet,
- d. Strengthening the strategic inventory system,
- e. Acceleration of technology transfer and integration with the national defense industry.

Without strategic and planned intervention, there is a risk of increased maintenance backlog, dependence on external parties, and a decline in the operational readiness of the Indonesian Navy in the long term.

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### **Authors' Contribution**

All authors contributed equally to the development of this article.

### **Data availability**

All datasets relevant to this study's findings are fully available within the article.

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