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Effectiveness of the Marine Terminal Safety Inspector (MTSI) in Improving Ship Safety During Berthing (A Case Study at Pertamina Integrated Terminal Tanjung Uban Jetty)

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Abstract.
Indonesia, as an archipelagic country, relies heavily on maritime distribution, especially for oil and gas, making ship safety during anchorage critical. PT Pertamina Integrated Terminal Tanjung Uban has implemented the Marine Terminal Safety Inspector (MTSI) program to enhance safety supervision based on international standards. However, the program's effectiveness has not been thoroughly evaluated. This study investigates the effectiveness of the MTSI program in improving ship safety during berthing at the terminal. The MTSI program aligns with standards such as ISGOTT and IMO, replacing previous inspections by non-specialist personnel often marked by suboptimal supervision. It aims to ensure stricter, more professional inspections conducted by experienced inspectors. Using a qualitative descriptive approach, data were gathered from in-depth interviews with six key informants, each having over ten years of experience in terminal operations and safety inspections. Thematic analysis supported by the Fishbone diagram identified root causes of existing challenges. Findings reveal that while MTSI has increased regulatory compliance and risk awareness, issues persist, including inefficient resource allocation, limited digital innovation, poor inter-unit communication, and a lack of adaptive performance evaluation. To address these challenges, the study recommends improving competency-based training, digitizing inspections, creating cross-functional safety teams, and implementing adaptive performance indicators. These measures aim to enhance the sustainability and overall effectiveness of the MTSI program, contributing to safer berthing operations at Pertamina Integrated Terminal Tanjung Uban.

Keywords: *Inspection Effectiveness, Maritime Safety, MTSI*

INTRODUCTION

The maritime industry plays a strategic role in Indonesia's economy, serving as the backbone of commodity distribution, particularly oil and gas (Samsudin et al., 2022; Zhang et al., 2021). With more than 17,000 islands, Indonesia is highly dependent on sea transportation to sustain both domestic and international trade (Hidayat & Wibowo, 2020; Liu et al., 2018). In the petroleum sector, tankers are a vital component to ensure efficient and safe fuel distribution, making safety in maritime operations a critical priority to prevent potential accidents with far-reaching impacts (Rahman et al., 2021; Santos et al., 2019; Putra et al., 2020). The importance of safe distribution lies not only in maintaining industrial continuity but also in ensuring public energy security, as energy supply disruptions can directly affect society's daily needs (Abdullah et al., 2023).

As the state-owned enterprise mandated to manage the national energy supply chain, PT Pertamina bears significant responsibility for ensuring that all oil and fuel distribution via sea routes adheres to high safety standards. This responsibility extends beyond securing supply continuity to protecting the marine environment from pollution risks. Pertamina's operational principle is aligned with the "Zero Accident" campaign, aiming to eliminate workplace accidents across all business lines, including ship berthing and cargo-handling activities at oil terminals. To strengthen safety supervision, Pertamina introduced the Marine Terminal Safety Inspector (MTSI) program, which emphasizes more professional and structured inspections by experienced inspectors, moving beyond the earlier system managed by Loading Masters and Mooring Masters in accordance with international guidelines such as ISGOTT and IMO.

Previous studies have underlined the importance of safety management in the oil and gas shipping sector. Riaz et al (2023) state that vessels play a vital role in ensuring efficient and safe fuel distribution. Similarly, de Vos et al (2021) emphasize that tanker safety systems are essential in preventing incidents such as oil spills, fires, and explosions, which could cause severe environmental and economic harm. Amanuel (2023) further demonstrates that safety monitoring technologies, crew training, and comprehensive safety management contribute significantly to operational safety in oil terminals. Chaal et al. (2023) also highlight that ship safety is fundamental for safeguarding human lives, corporate assets, and the environment, with berthing operations representing a particularly critical stage due to the risks associated with cargo transfer and ship-terminal interactions (Chaal et al., 2023).

Internal reports from PT Pertamina Integrated Terminal Tanjung Uban show that since the implementation of MTSI in mid-2024, inspections have become stricter and more effective. For instance, in 2022 and 2023, no vessels received negative feedback due to the less stringent procedures conducted by Loading and Mooring Masters. However, after MTSI was introduced, 79 vessels were recorded with negative feedback in 2024 out of 1,484 inspections, reflecting more rigorous evaluations. By early 2025, the number of vessels receiving negative feedback had decreased significantly, indicating increased compliance and safety awareness. Despite these positive outcomes, the effectiveness of MTSI has not yet been comprehensively evaluated. As Murphy (2020), Tran et al (2020), and Duan et al (2023) stress, systematic evaluation is necessary to identify performance gaps and ensure continuous improvement. Therefore, this study seeks to analyze the effectiveness of MTSI in improving ship safety during berthing, identify the root causes of suboptimal performance, and propose strategies to strengthen its contribution to maritime safety governance (Murphy, 2020).

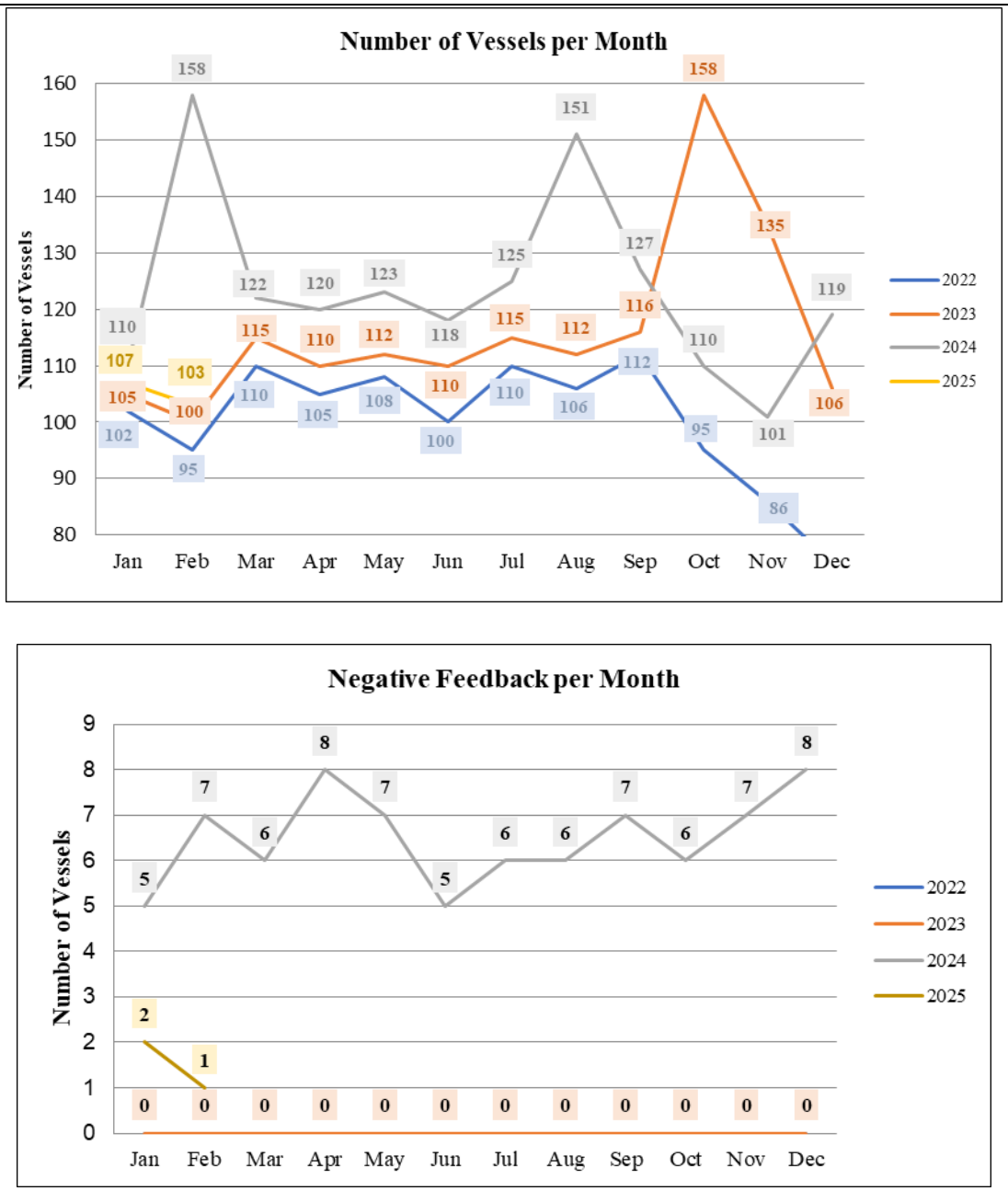

Figure 1. Vessel Inspection Checklist at Tanjung Uban

Source: Internal Documents of PT Pertamina Integrated Terminal Tanjung Uban, 2025

Previous research has extensively examined aspects of maritime safety and terminal operations with various approaches and focuses. Joubert and Pretorius (2020) explored design and construction risks in ports and container terminals through structured interviews and workshops, resulting in a list of 215 managed risks. Hervas-Peralta et al. (2020) used Delphi and AHP methods to design the layout of dangerous goods terminals to improve safety and economic efficiency. In the Indonesian context, Setiyantara et al. (2022) analyzed the role of the Marine Inspector in ensuring the feasibility of ships through a qualitative approach at KSOP Probolinggo. Meanwhile, Goksu and Arslan (2023) conducted a quantitative risk assessment using Fuzzy FMEA for berthing/unberthing operations, highlighting human fatigue factors and environmental conditions. Sahara and Putri (2023) examine occupational safety risk factors during loading and unloading at port terminals, emphasizing the importance of worker awareness and equipment conditions. Liou and Tseng (2024) identified the safety indicators of

ship operations at Taiwan international ports using the BWM method, placing the human factor and ship facilities as priorities. Rachman (2024) examines the influence of the quality of human resources, infrastructure, and technology on domestic shipping safety through a literature review. Finally, Unal (2024) evaluated the hazardous cargo operating system at Turkish container terminals using AHP, focusing on fire risk and cargo dispersion.

Although diverse, these studies have some limitations in the context of the implementation of MTSI in oil terminals. Methodologically, most studies use quantitative or mixed approaches such as risk workshops, Delphi-AHP, or BWM, while these studies adopt a descriptive qualitative approach through in-depth interviews and document reviews. In terms of data sources, previous research relied heavily on expert surveys, layout simulations, or literature reviews, while this study used primary data from key informants directly involved in terminal operations and tanker safety inspections. More importantly, the focus of previous research has tended to be risk identification, layout optimization, or operational safety indicators, while this study specifically evaluates the organizational effectiveness of the implementation of the MTSI program in improving tanker safety in the context of corporate operations at PT Pertamina Integrated Terminal Tanjung Uban. Thus, this study not only fills the gap in the literature regarding the evaluation of specific maritime safety inspection programs, but also provides contextual and applicable strategic recommendations for the development of safety systems at Indonesian oil terminals.

The purpose of this study is threefold. First, it aims to analyze the effectiveness of the Marine Terminal Safety Inspector (MTSI) in optimizing ship safety during berthing operations at the Jetty of PT Pertamina Integrated Terminal Tanjung Uban. Second, it seeks to identify the root causes of suboptimal performance indicators in the implementation of MTSI at the terminal. Third, this research intends to formulate practical improvement strategies that can be applied to enhance the overall effectiveness of MTSI, thereby strengthening the ship safety management system during berthing activities at Pertamina's terminal. The benefits of this research are expected to make a practical contribution to terminal managers in improving the effectiveness of the MTSI program, as well as becoming an academic reference for the development of a more adaptive and sustainable maritime safety inspection system. In addition, the resulting findings and recommendations can be adopted by regulators and other port operators in Indonesia to strengthen operational safety governance in the energy sector.

MATERIALS AND METHOD

This research adopted a qualitative approach to examine organizational practices within the oil terminal context, enabling the capture of experiences and perceptions of individuals involved in maritime safety inspection and performance management. The study was descriptive-evaluative, allowing both systematic description and assessment of the Marine Terminal Safety Inspector (MTSI) system's effectiveness in enhancing ship safety during berthing operations. The evaluation focused on key dimensions including goal clarity, resource efficiency, organizational characteristics, internal communication, and adaptability to change.

Data were collected through in-depth interviews, document analysis, and literature review. Primary data came from five purposively selected informants directly involved in maritime safety operations, each with at least three years of experience in terminal or vessel inspection and knowledge of safety standards. Secondary data included company reports, inspection records, regulatory guidelines, and organizational policies to triangulate and validate findings.

Data analysis was descriptive, based on one round of interviews with six key informants covering 14 core questions related to overall MTSI effectiveness, root causes of inefficiencies based on six indicators from Omelchuk et al. (2020), and strategic recommendations. Two additional questions

captured broader barriers and suggested improvements. Responses were systematically reduced to identify recurring themes and critical factors affecting MTSI effectiveness.

The Fishbone Diagram method categorized causal factors into six domains: Man (competence, training), Method (procedures, policies), Machine (equipment reliability), Material (quality of tools), Environment (external conditions), and Measurement (standards, evaluation), which helped identify systemic weaknesses.

Triangulation of interviews, observations, and documents ensured validity and reliability. Reflective analysis during data collection helped interpret findings within social and operational contexts. Fieldwork was conducted at PT Pertamina Integrated Terminal Tanjung Uban between March and May 2025, providing robust and empirically grounded results to inform maritime safety policy and inspection system improvements.

RESULTS AND DISCUSSION

Overview of Operational Activities at Tanjung Uban Terminal

PT Pertamina Integrated Terminal Tanjung Uban is a national strategic asset managed by PT Pertamina Energy Terminal (PET), a subsidiary of PT Pertamina International Shipping (PIS). Located in the Riau Islands, directly adjacent to Singapore, the terminal occupies a geographically strategic position that supports both domestic and international energy logistics. Covering an area of 247 hectares, it is equipped with seven jetties capable of accommodating vessels up to 100,000 DWT, making it a critical node in the regional energy supply chain. The terminal has a storage capacity of 400,000 kiloliters for petroleum products and 93,500 metric tons for LPG, complemented by blending facilities that allow for the management of multiple fuel components within a single tank. In addition, the terminal plays an essential role in distributing biodiesel to nearby terminals and local fuel stations, as well as supplying gasoline and kerosene to northern and southern Sumatra and West Kalimantan.

The facility is further supported by a 205-hectare buffer zone consisting of forest and swamp areas, along with a lightning protection system installed across 18 operational points. These features are designed to enhance efficiency and ensure comprehensive operational safety. Such measures underscore PET's commitment to global standards of Health, Safety, Security, and Environment (HSSE), a commitment reflected in its achievement of zero fatalities and 40.5 million safe working hours recorded up to 2023. With robust infrastructure and a strong emphasis on sustainability, PT Pertamina Integrated Terminal Tanjung Uban is positioned to become a major energy trading hub in Southeast Asia. The terminal not only strengthens Indonesia's national energy security but also creates opportunities for global suppliers to store their cargo in Indonesia, aligning with Pertamina's vision of supporting energy transition and advancing the national target of Net Zero Emissions by 2060.

The jetty at the Integrated Terminal Tanjung Uban serves as a primary facility supporting the loading and unloading of energy cargo, including petroleum products (BBM), LPG, and other derivatives. Designed to accommodate large tanker vessels of up to 100,000 DWT, the jetty is equipped with seven berthing points strategically positioned to ensure smooth energy distribution to and from various domestic and international destinations. Operational activities at the jetty include vessel berthing, cargo transfer via dedicated pipelines, and technical monitoring through an integrated control system. Each stage is supervised by trained personnel operating under stringent safety standards to minimize the risk of workplace accidents and environmental pollution. These activities are conducted continuously to maintain the stability of national energy supply flows. The application of digital monitoring technologies and HSSE-based operational procedures forms an integral part of the jetty management system. This approach ensures operational reliability and efficiency in handling energy cargo. Beyond functioning as a transit point, the Tanjung Uban jetty also represents a symbol of modern, competitive, and integrated energy logistics in Southeast Asia.

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The Marine Terminal Safety Inspector (MTSI) is a newly established structure designed to enhance safety oversight at oil terminals, particularly during vessel berthing and cargo transfer activities. Previously, safety supervision was carried out by the Loading Master and Mooring Master, whose roles were largely limited to technical operational functions. MTSI now serves as an independent supervisory unit responsible for conducting comprehensive inspections using a negative feedback approach—an in-depth verification process aligned with international standards such as ISGOTT, SOLAS, and MARPOL. As an integral part of the terminal safety system, MTSI oversees ship documentation, readiness of safety equipment, risk management practices, and communication protocols between vessels and terminals.

At Tanjung Uban Terminal, the safety framework is highly structured and supported by multiple elements, including buffer zones, environmental protection systems, and both land- and sea-based emergency response facilities. Within this framework, MTSI acts as the primary supervisor ensuring that all safety protocols are implemented according to established standards, covering equipment inspection, personnel training, communication systems, and the adoption of real-time safety monitoring technologies. Inspections are carried out from pre-arrival to pre-transfer and post-transfer stages, with results evaluated through a rigorous assessment system. Findings reported by MTSI, such as vessels receiving negative feedback, serve as key indicators of improved awareness and compliance with safety requirements among all operational stakeholders at the terminal.

Effectiveness of SIRE Implementation

In evaluating the effectiveness of the implementation of the Marine Terminal Safety Inspector (MTSI) at the Jetty of PT Pertamina Integrated Terminal Tanjung Uban, this study conducted in-depth interviews with six informants who had direct experience in the application of terminal safety systems. The interviews were designed to capture the respondents' perceptions regarding the extent to which MTSI has contributed to enhancing vessel safety during berthing and cargo transfer operations, as well as to identify the root causes of challenges encountered in practice. One of the key questions posed was: *"What is your view on the effectiveness of the role of the Marine Terminal Safety Inspector (MTSI) in ensuring vessel safety during berthing operations at Tanjung Uban Jetty?"* To complement qualitative insights with measurable indicators, respondents were also asked to provide a quantitative rating of MTSI effectiveness on a scale from 1 to 100 percent. The results of these assessments are presented in Figure 2.

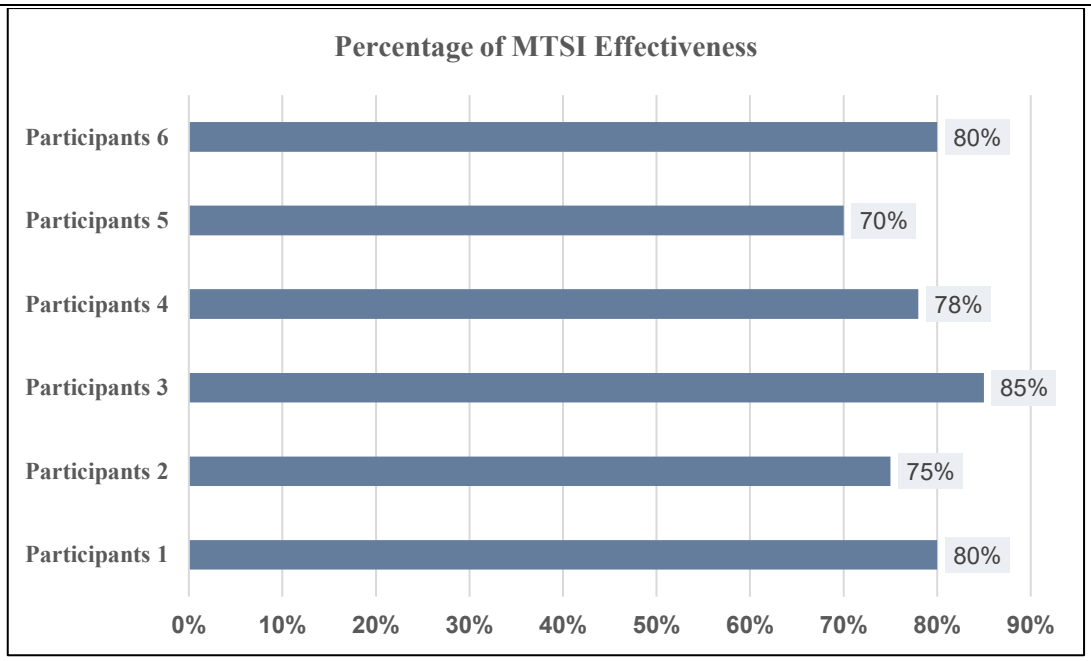

Figure 2. Percentage of The Effectiveness of SIRE Implementation
Source: Primary Data Analysis Results, Interviews with Six Key Informants, 2025

Figure 2 illustrates that the six informants rated MTSI effectiveness between 70% and 85%. Specifically, Informant 1 gave a score of 80%, Informant 2 rated it at 75%, Informant 3 at 85%, Informant 4 at 78%, Informant 5 at 70%, and Informant 6 at 80%. The average effectiveness score across all informants was therefore 78%, reflecting a general consensus that the role of MTSI is perceived as reasonably effective by practitioners. Nevertheless, the variation in ratings indicates that there remains scope for improvement, particularly with regard to inspection practices in the field, follow-up mechanisms on identified findings, and the utilization of digital technologies in reporting and monitoring safety performance. Internal company reports further reveal that in the first year of active MTSI involvement (2024), 79 out of 1,484 inspected vessels received negative feedback. By early 2025, this figure had dropped significantly to only 3 out of 210 vessels. While this demonstrates a positive impact from enhanced oversight, it also raises questions regarding the sustainability of systemic safety improvements over the longer term.

The study further explored how the role of MTSI should be developed moving forward. Informants emphasized that MTSI should not be limited to functioning as a reactive technical inspector addressing operational nonconformities. Instead, they envisioned MTSI as a strategic driver of predictive safety, capable of identifying potential risks prior to incidents. In their view, MTSI should be positioned as an integral component of long-term operational governance, including involvement in policy formulation, cross-functional procedure development, and continuous evaluation of operational standards. Such a proactive role is considered essential to ensure that MTSI is not merely an extension of regulatory enforcement, but also a transformative agent fostering a strong, collaborative, and adaptive safety culture within oil terminals and port operations.

Respondents also underscored the importance of digital transformation to support MTSI performance, particularly through the development of risk-based safety monitoring dashboards. Such systems would enable real-time monitoring of incident trends by terminal management and strengthen the capacity of MTSI to deliver accurate, measurable, and responsive feedback in dynamic operational contexts. The adoption of digital solutions was viewed as critical for elevating inspection outcomes from compliance-oriented documentation to actionable insights capable of driving organizational learning and continuous improvement.

This study applies the effectiveness theory of Omelchuk et al (2020), which emphasizes six key indicators: goal achievement, quality of service, quantity of service, resource capability, transparency and accountability, and innovation and digitalization capacity. The findings reveal that resource efficiency and digital innovation remain the most critical challenges for MTSI effectiveness. Informants highlighted that MTSI findings should not be treated solely as compliance records but should form the basis for designing periodic training programs for vessel crews. Such training should prioritize recurring areas of concern, including safety equipment management, emergency preparedness, and adherence to standard operating procedures. Additionally, the post-inspection follow-up system should be strengthened and integrated with the broader performance evaluation mechanisms of both terminals and vessels. By doing so, MTSI can evolve into a strategic actor in shaping a sustainable safety culture. The analysis, grounded in Omelchuk et al (2020), indicates that while progress has been made, certain dimensions—particularly resource efficiency and digital innovation—remain underdeveloped. These gaps suggest the presence of structural and operational barriers that must be systematically addressed through continuous improvement efforts. Ultimately, positioning MTSI as both a compliance enforcer and a proactive change agent is critical to advancing maritime safety performance in an increasingly complex operational environment.

Root Cause Analysis of Problems in the Implementation of MTSI

The analysis revealed that the barriers and challenges in the implementation of the Marine Terminal Safety Inspector (MTSI) program can be systematically categorized according to the organizational effectiveness framework proposed by Omelchuk et al (2020). This framework consists of six dimensions which collectively provide a comprehensive basis for evaluating the effectiveness of MTSI in ensuring maritime safety. By mapping the empirical findings to these dimensions, the study is able to highlight not only the underlying structural and operational issues but also the targeted strategies required to improve MTSI performance in a holistic manner.

Based on an in-depth analysis using the Root Cause Analysis (RCA) approach, this study identified multiple underlying factors explaining why the role of the Marine Terminal Safety Inspector (MTSI) has not yet achieved optimal effectiveness. Six dimensions of effectiveness were examined: goal achievement, service quality, service quantity, resource efficiency, transparency and accountability, and innovation and digitalization. Within the goal achievement dimension, Informant 1 highlighted that near misses still occur due to weak cross-functional coordination and the absence of structured communication forums. Informant 2 added that pre-berthing inspections are inconsistently conducted, as standard operating procedures do not mandate them and inspection time is often limited. Informant 3 emphasized that limited staffing remains a major issue, with only one MTSI responsible for overseeing dozens of vessels per month, while Informant 4 noted that inspection decisions are sometimes compromised by operational pressures and the lack of standardized risk assessment systems.

In terms of service quality, Informant 5 observed that inspections are not evenly distributed across vessel types, particularly LPG and LNG carriers that require specialized expertise. Informant 6 further stressed the shortage of structured training in areas such as risk assessment and incident investigation, which weakens MTSI's capacity to enforce standards effectively. Respondents also pointed to the lack of post-inspection feedback systems, which results in findings not being consistently followed up. Moreover, variations in inspection quality across terminals remain evident due to insufficient continuous training and limited standardization of inspection procedures. The dimension of service quantity revealed a persistent mismatch between the number of MTSI personnel and the volume of vessels requiring supervision. Informant 2 underlined the limited number of inspectors, especially in terminals with high traffic, while Informant 4 explained that the absence of a digital scheduling system exacerbates workload imbalances. Resource efficiency also emerged as a challenge, as inspections are still predominantly manual. Informants noted that reporting remains paper-based, slow, and repetitive,

with insufficient allocation of digital tools and inspection equipment such as approved cameras. These inefficiencies hinder both documentation accuracy and timely follow-up. Transparency and accountability are further constrained by the lack of integrated digital reporting platforms, compounded by managerial or operational pressures that occasionally compromise the objectivity of MTSI decision-making.

Finally, in the dimension of innovation and digitalization, several informants stressed that many inspectors are not yet familiar with digital reporting systems due to inadequate training. Data integration between stakeholders remains weak, causing discrepancies between field conditions and system records. Respondents also highlighted the absence of a clear digital innovation roadmap for MTSI functions, limiting the use of advanced tools such as digital checklists, evaluation dashboards, or QR-based tracking systems. Taken together, these findings indicate that improving MTSI effectiveness requires not partial adjustments but a holistic, cross-functional transformation. The evidence underscores the need for systemic reforms encompassing policy enhancement, capacity building, provision of adequate tools, and the integration of digital solutions as the foundation for strengthening terminal safety governance.

Recommendations for Improving the Effectiveness of MTSI

The recommendations for improving the effectiveness of Marine Terminal Safety Inspector (MTSI) implementation are categorized based on the organizational effectiveness framework developed by Omelchuk et al. (2020). This framework encompasses six interrelated dimensions—goal achievement, service quality, service quantity, resource efficiency, transparency and accountability, and innovation and digitalization. By aligning the proposed improvements with these dimensions, the study ensures that the strategies are both comprehensive and targeted, directly addressing the structural and operational challenges previously identified. Such an approach provides not only a corrective pathway but also a sustainable roadmap for enhancing the role of MTSI in safeguarding maritime terminal operations.

Clarity of objectives in the MTSI program remains constrained by limited cross-functional communication and the absence of structured coordination mechanisms. Interview evidence showed that near misses were often linked to inconsistent pre-berthing inspections and the lack of mandatory risk-based procedures. Strengthening goal attainment therefore requires institutionalizing regular coordination forums between inspectors, terminal operators, and support units, as well as revising standard operating procedures to mandate pre-berthing inspections. In busier terminals, workload justification and a proportional ratio of inspectors to vessel calls are essential to ensure that oversight capacity keeps pace with operational demand.

Service quality is challenged by uneven inspection practices and insufficient technical competence, particularly for LPG and LNG vessels that demand specialized expertise. Inspectors reported gaps in training and certification, which weakened their ability to address specific vessel risks effectively. Targeted training programs tailored to vessel type, combined with mandatory technical certification, are recommended to enhance competence. Equally important is the creation of a digital post-inspection evaluation system that tracks the status of follow-up actions and ensures findings are systematically addressed rather than remaining as compliance records without resolution.

Quantity of service is also a recurring issue, with the number of inspectors falling short of operational requirements. High vessel call volumes often force inspectors to prioritize certain cases, leaving some vessels without adequate coverage. Recruiting additional inspectors on a shift basis and aligning staff levels to monthly vessel calls would reduce the gap between capacity and demand. Automating the inspection schedule and integrating it with ship scheduling systems such as VOS and OBIT would further ensure that inspections are distributed more evenly, documented consistently, and conducted in a transparent manner.

Resource efficiency suffers from the persistence of manual workflows and the limited availability of standardized tools. Reporting delays and repetitive data entry processes were identified as significant inefficiencies that undermine inspection effectiveness. Providing essential equipment such as approved gas-detection cameras, tablets, and mobile connectivity, alongside the development of a mobile inspection application, would streamline workflows. Direct digital input, integrated checklists, and real-time photo uploads would cut redundancy, increase accuracy, and accelerate reporting across all operational units.

Transparency and accountability remain fragile due to fragmented reporting systems and the potential for external intervention. Some findings are under-documented, while inspectors lack procedural safeguards to protect their independence. Developing an integrated reporting dashboard that consolidates all platforms into a single system would address fragmentation and enable real-time monitoring by all stakeholders. This needs to be complemented by a written policy framework that formalizes inspection independence, including escalation procedures for cases of interference, thereby reinforcing trust in the objectivity of the MTSI function.

Innovation and digitalization are progressing slowly, hindered by limited training and the absence of predictive technologies. Many inspectors struggle to adapt to digital platforms due to insufficient guidance, and data integration across stakeholders remains inconsistent. Institutionalizing regular digital training and embedding a predictive risk dashboard into the corporate HSSE roadmap would help shift MTSI's role from reactive to proactive. Incorporating dual confirmation features between inspectors and ship owners before closing inspection records would also ensure alignment between field realities and system documentation, strengthening data integrity and supporting adaptive, data-driven safety management.

CONCLUSION

This study evaluated the effectiveness of the Marine Terminal Safety Inspector (MTSI) system at the Jetty of PT Pertamina Integrated Terminal Tanjung Uban through interviews with six practitioners, revealing that MTSI has been effective in enhancing safety oversight, reflected in a 78% effectiveness score and fewer negative inspection outcomes. However, variations in stakeholder perceptions and Root Cause–Fishbone analysis identified critical gaps across six dimensions of organizational effectiveness—goal achievement, service quality, service quantity, resource efficiency, transparency and accountability, and innovation and digitalization—driven by challenges such as inconsistent pre-berthing inspections, manpower shortages, manual reporting, limited training, and weak digital adoption. While MTSI advances the safety agenda, its sustainability requires systemic reforms, including structured coordination, revised SOPs, additional inspectors, enhanced training, and digitalized reporting, enabling it to evolve from a technical inspector into a strategic driver of safety culture aligned with national and international standards. Limitations of this study include its reliance on a small number of qualitative interviews and a single case focus, suggesting future research should adopt mixed methods, broader stakeholder input, and longitudinal analysis to assess the long-term impacts of MTSI reforms, particularly in digitalization and predictive safety management.

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