Journal of Maritime Policy Science
e-ISSN: 3063-4245 p-ISSN: 3063-5705
VOL 1 NO 1 APRIL 2024
https://ojs.umrah.ac.id/index.php/jmps

Digital Transformation in the Maritime Industry; Opportunities and Challenges for Indonesia

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https://doi.org/10.31629/jmps.v1i1.6872

Received: February 27, 2024 | Revised: March 20, 2024 | Accepted: April 28, 2024

ABSTRACT

Digital transformation is reshaping industries worldwide, including the maritime sector, by integrating advanced technologies to improve efficiency, safety, and sustainability. In the context of Indonesia, a country with a vast archipelago and significant maritime activities, digital transformation offers substantial opportunities but also presents distinct challenges. This paper explores the multifaceted impacts of digital transformation on Indonesia's maritime industry, examining both the opportunities and challenges that arise from this technological shift. Opportunities in the maritime sector include enhanced operational efficiency, improved safety, and better environmental management. Technologies such as the Internet of Things (IoT), big data analytics, artificial intelligence (AI), and blockchain are pivotal in optimizing logistics, predictive maintenance, and real-time monitoring of vessels and cargo. These advancements can lead to reduced operational costs, minimized human errors, and lower environmental footprints. For Indonesia, leveraging these technologies could significantly boost its competitiveness in global shipping, enhance port operations, and support the sustainable management of its extensive marine resources. However, the journey towards digital transformation in Indonesia’s maritime industry is fraught with challenges. Key issues include inadequate digital infrastructure, limited technological expertise, and regulatory hurdles. The uneven distribution of digital infrastructure across Indonesia's archipelago hampers the consistent application of advanced technologies. Additionally, the maritime workforce requires upskilling to handle new digital tools effectively, necessitating substantial investment in education and training. Regulatory frameworks also need to evolve to address data security, privacy concerns, and the integration of international standards, ensuring a seamless transition to digital operations.

Keyword: Digital Transformation; Maritime Industry; Opportunities

INTRODUCTION

The maritime industry is a cornerstone of global trade and economic activity, encompassing a wide range of sectors and operations related to the transportation of goods and passengers across the world's oceans and waterways (Mière, 2014). It plays a pivotal role in the international supply chain, facilitating the movement of approximately 90% of global trade by volume. This industry includes various segments such as shipping companies, port operators, shipbuilders, and maritime logistics providers (Yang et al., 2013). Shipping companies are responsible for the operation of fleets that transport cargoes such as raw materials, finished goods, and energy resources. Ports and terminals act as critical hubs where

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e-ISSN: 3063-4245 p-ISSN: 3063-5705
VOL 1 NO 1 MAY 2024
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goods are loaded, unloaded, stored, and transshipped, making them vital nodes in global logistics networks (Djalal, 2013).

In addition to cargo transport, the maritime industry also covers passenger services, including cruise lines and ferries, which contribute significantly to tourism and regional connectivity. The industry is characterized by a high degree of international collaboration and regulation, governed by organizations such as the International Maritime Organization (IMO), which sets global standards for safety, security, and environmental performance (Jousselme et al., 2021). Technological advancements and innovations, such as automated and smart ports, autonomous vessels, and digitalization, are increasingly shaping the industry's future, aiming to enhance efficiency, safety, and sustainability (Saha, 2016).

The maritime industry is undergoing a significant transformation with the advent of digital technologies. This paper examines the opportunities and challenges that digital transformation presents for the maritime industry in Indonesia. The urgency of addressing this issue stems from Indonesia's strategic position as the world's largest archipelagic state and its dependency on maritime transport for economic growth and development (Roe, 2013). The paper will explore the core issues of digital transformation in the maritime sector, analyze existing literature, and present original insights into the unique challenges and opportunities for Indonesia. This analysis is critical to ensure that Indonesia can leverage these technological advancements to enhance its maritime capabilities and maintain its competitive edge (Kurth et al., 2019; Roe, 2020).

Maritime industry is integral to global trade and the economy, with over 90% of the world's goods being transported by sea. Digital transformation in this sector promises increased efficiency, safety, and sustainability. However, it also presents significant challenges, especially for developing countries like Indonesia (Laksmana, 2022; Sivaramaganesh et al., 2014). The main issues addressed in this paper include the potential benefits of digital technologies for the maritime sector, the barriers to their adoption, and the specific challenges faced by Indonesia in implementing these technologies (Panayides, 2006; Shimoyama et al., 2013).

Indonesia's maritime industry is vital to its economy, given its extensive coastline and strategic location along major shipping routes. However, the sector faces numerous challenges, including outdated infrastructure, limited technological adoption, regulatory hurdles, and a shortage of skilled labor. By examining the digital transformation within this context, this paper positions itself within the broader discourse on maritime modernization and economic development. It builds on existing research by highlighting Indonesia's unique position and the specific hurdles it must overcome to benefit from digital advancements (Abdullah & Zaki Ahmad, 2019; Rusli, 2012).

Tabel 1. Outlining the impact of digital transformation technologies on the maritime industry

Technology	Description	Impact on Maritime Industry
Artificial Intelligence (AI)	Utilizes algorithms to perform tasks traditionally requiring human intelligence, such as route optimization and predictive maintenance.	Enhances operational efficiency, improves safety through predictive analytics.
Internet of Things (IoT)	Network of interconnected devices that collect and exchange data.	Enables real-time monitoring of vessel conditions, enhances fleet management.

Journal of Maritime Policy Science
e-ISSN: 3063-4245 p-ISSN: 3063-5705
VOL 1 NO 1 APRIL 2024
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Technology	Description	Impact on Maritime Industry
Big Data Analytics	Analyzes large datasets to uncover patterns and insights, aiding in decision-making.	Optimizes logistics, improves fuel efficiency, enhances supply chain visibility.
Blockchain	Decentralized digital ledger technology ensuring transparency and security in transactions.	Streamlines documentation processes, enhances supply chain traceability.
Automation	Integration of robotics and automated systems to perform tasks with minimal human intervention.	Reduces labor costs, enhances operational efficiency in port operations and on vessels.

Source: Author, 2024

Digital transformation in the maritime industry refers to the fundamental shift driven by digital technologies across various facets of maritime operations and management. This transformation encompasses the integration of advanced technologies such as artificial intelligence (AI), the Internet of Things (IoT), big data analytics, blockchain, and automation into traditional maritime practices. These technologies are revolutionizing how shipping companies, ports, logistics providers, and related stakeholders operate, communicate, and manage resources.

At the heart of this transformation is the quest for increased efficiency, safety, sustainability, and competitiveness in an industry that forms the backbone of global trade. AI, for example, enables predictive maintenance of vessels and optimization of shipping routes, thereby reducing operational costs and downtime while enhancing safety. IoT devices are deployed to monitor vessel performance in real-time, track cargo conditions, and manage fleet logistics efficiently. Meanwhile, blockchain technology ensures transparent and secure transactions within maritime supply chains, preventing fraud and improving accountability. The urgency of digital transformation in the maritime sector is underscored by the industry's inherent complexities and challenges.

These include navigating through stringent regulatory frameworks, adapting to environmental sustainability goals, and addressing the rising demands for faster and more reliable supply chain operations. Indonesia, as a prominent maritime nation with a vast archipelago and a strategic position in global shipping routes, stands to benefit significantly from embracing digital transformation (Hammervoll et al., 2014; Wicaksana, 2017). The country's maritime industry, pivotal for its economic growth and development, faces both opportunities and challenges in adopting these technologies. While digitalization promises enhanced efficiency, reduced costs, and improved competitiveness, it also requires substantial investments in infrastructure, digital literacy among the workforce, and regulatory adaptations to ensure seamless integration.

The maritime industry is a critical component of Indonesia's economy, given the nation's status as the largest archipelago in the world with over 17,000 islands. This geographic expanse necessitates a robust and efficient maritime sector to ensure the seamless movement of goods and people, thereby driving economic growth and regional development (Kurnianingsih et al., 2022; Muhammad et al., 2021). The digital transformation of this sector represents a pivotal opportunity to enhance operational efficiencies, reduce costs, and improve safety and sustainability(Afriansyah et al., 2022; Octavian & Jatmiko, 2020). By integrating advanced technologies such as the Internet of Things (IoT), big data analytics, blockchain, and artificial intelligence, maritime operations can achieve unprecedented levels

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e-ISSN: 3063-4245 p-ISSN: 3063-5705
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of automation, predictive maintenance, and real-time decision-making. This not only boosts competitiveness but also aligns with global trends towards smarter, more connected industries.

Furthermore, digital transformation in the maritime industry can address several challenges that Indonesia currently faces. These include outdated infrastructure, regulatory inefficiencies, and security concerns. For instance, blockchain technology can streamline and secure shipping documentation processes, reducing the risk of fraud and enhancing transparency. Similarly, IoT-enabled sensors and big data analytics can provide predictive insights to prevent equipment failures and optimize maintenance schedules, thus minimizing downtime and operational disruptions. Moreover, digital platforms can facilitate better coordination between various stakeholders, including port authorities, shipping companies, and logistics providers, leading to more synchronized and efficient supply chain operations (Dwicahyono et al., 2021; Tran et al., 2018).

However, the transition to a digitally-driven maritime sector is not without its challenges. Significant investment in technology and infrastructure is required, alongside a concerted effort to upskill the workforce to handle new digital tools and systems. Regulatory frameworks need to be updated to accommodate technological advancements and ensure cybersecurity measures are robust enough to protect against emerging threats. Additionally, there is a need for international collaboration and standardization to ensure interoperability and seamless integration across global supply chains

METHODOLOGY

The methodology employed in this paper involves a qualitative analysis of secondary data, including academic articles, industry reports, and government publications (Bogdan & Taylor, 1975; Johnston, 2014). This approach allows for an in-depth understanding of the current state of digital transformation in the maritime industry and the specific challenges faced by Indonesia. The analysis is structured around three key areas: technological advancements, regulatory frameworks, and human capital. By examining these areas, the paper aims to provide a holistic view of the digital transformation process and its implications for the maritime sector in Indonesia.

This paper employs a qualitative analysis of secondary data sources to investigate the digital transformation in the maritime industry, focusing particularly on Indonesia. Structuring the analysis around these dimensions, the paper aims to offer a thorough perspective on the current landscape of digital transformation and its implications for Indonesia's maritime industry. This approach allows for a nuanced exploration of challenges, opportunities, and strategic recommendations to foster digital advancement in maritime operations.

RESULTS AND DISCUSSION

The digital transformation of the maritime industry in Indonesia represents a crucial evolution, addressing the pressing need for modernization in a sector characterized by traditional practices and limited technological integration. The global maritime industry is highly competitive, and Indonesia, with its strategic geographic location and extensive coastline, is uniquely positioned to leverage technological advancements to enhance its maritime operations. This comprehensive analysis explores the contextual background, the inputs driving transformation, the processes involved, the expected outputs, and the continuous feedback mechanisms necessary.

1. General Conditions of Digital Transformation in the Maritime Industry in Indonesia

Digital transformation in the maritime industry in Indonesia presents a unique set of challenges and opportunities influenced by the nation's geographic, economic, and regulatory

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e-ISSN: 3063-4245 p-ISSN: 3063-5705
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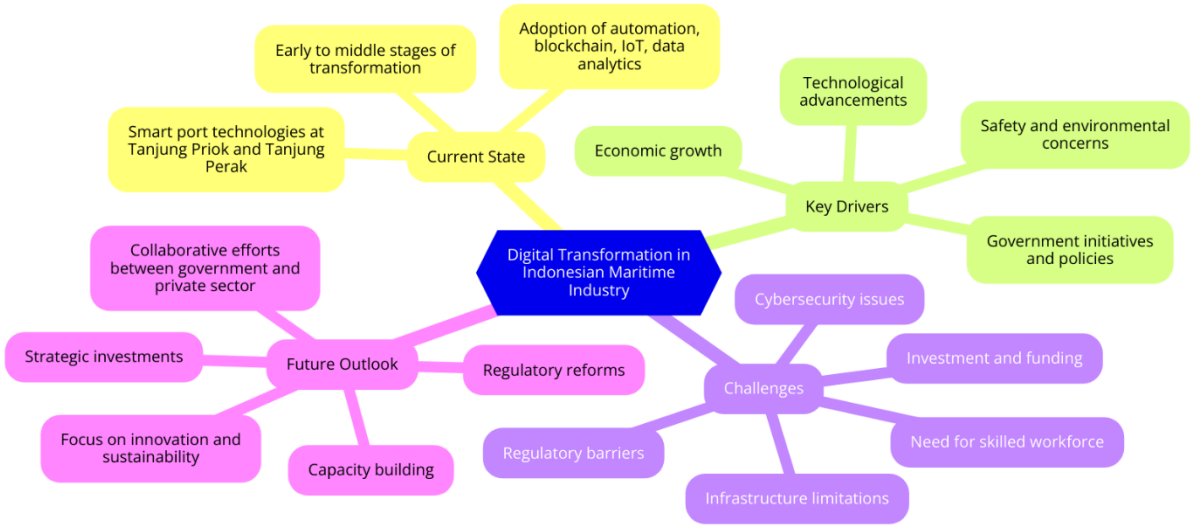
landscape. As the largest archipelagic country in the world, Indonesia's maritime industry plays a critical role in its economy, supporting trade, transportation, and national security. The drive towards digital transformation is motivated by the need to enhance operational efficiency, ensure safety, and maintain competitiveness in a rapidly evolving global maritime sector. This essay will explore the general conditions of digital transformation in Indonesia's maritime industry, focusing on the current state, key drivers, challenges, and the future outlook.

Indonesia's maritime industry is in the early to middle stages of digital transformation. While there have been significant strides in adopting digital technologies, many areas still rely heavily on traditional methods. Ports, shipping companies, and other maritime stakeholders have begun implementing technologies such as automation, blockchain, Internet of Things (IoT), and data analytics to streamline operations, reduce costs, and enhance safety. For instance, major ports like Tanjung Priok in Jakarta and Tanjung Perak in Surabaya are investing in smart port technologies to improve efficiency and cargo handling capabilities.

Figure 1. Mindmap general conditions of digital transformation in the maritime industry in Indonesia



Source: Author, 2024

The Indonesian government has also played a pivotal role in driving digital transformation through various initiatives and policies. The Ministry of Transportation has launched the Indonesia National Single Window (INSW) system to facilitate smoother and faster customs processes. Additionally, the Indonesian Sea Toll Road program aims to enhance connectivity between islands, supported by digital solutions to optimize logistics and supply chain management. Digital transformation in Indonesia's maritime industry is an ongoing process characterized by significant opportunities and considerable challenges.

The current state of digital adoption reflects a mix of advanced initiatives and areas needing improvement. Key drivers such as economic growth, government initiatives, technological advancements, safety concerns, and environmental sustainability underscore the importance of digitalization. However, challenges related to infrastructure, skilled workforce, regulatory barriers, investment, and cybersecurity must be addressed to realize the full potential of digital transformation. The future of Indonesia's maritime industry hinges on collaborative efforts between the government and private sector, strategic investments, regulatory reforms, capacity building, and a focus on innovation and sustainability. By

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e-ISSN: 3063-4245 p-ISSN: 3063-5705
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embracing these strategies, Indonesia can enhance its maritime operations, bolster economic growth, and secure a competitive edge in the global maritime industry.

2. Thingking Framework Digital Transformation In The Maritime Industry In Indonesia

a. Context: Current State and Need for Transformation

The maritime industry in Indonesia has historically relied on conventional methods, with limited adoption of modern technology. This has resulted in inefficiencies, higher operational costs, and reduced competitiveness on the global stage. The industry's reliance on outdated systems has also made it challenging to meet the stringent safety and environmental standards increasingly demanded by international regulatory bodies. The need for transformation is further underscored by the rapid technological advancements occurring globally, which offer unprecedented opportunities for enhancing operational efficiency, safety, and overall productivity.

Digital transformation is not merely an option but a necessity for Indonesia to maintain and enhance its position in the global maritime industry. The adoption of advanced technologies can streamline operations, reduce costs, and improve service delivery, thereby attracting more business and fostering economic growth. The transformation journey begins with understanding the current state of the industry and recognizing the need for change, which is driven by the desire to remain competitive, meet regulatory requirements, and harness the potential of digital technologies.

b. Inputs: Technological Innovations and Stakeholder Perspectives

The digital transformation of the maritime industry is fueled by several key technological innovations. These include the Internet of Things (IoT), Big Data and Analytics, Blockchain, and Artificial Intelligence (AI). IoT enables real-time monitoring and control of maritime operations, improving efficiency and safety. Sensors placed on ships and port infrastructure can collect data on various parameters, such as equipment performance, fuel consumption, and environmental conditions. This data can be analyzed to optimize operations, predict maintenance needs, and enhance decision-making processes.

Big Data and Analytics play a critical role in extracting actionable insights from the vast amounts of data generated by maritime activities. By analyzing historical and real-time data, maritime companies can identify patterns, trends, and anomalies, leading to improved operational efficiency, reduced downtime, and enhanced safety. Predictive analytics can also be used to forecast demand, optimize routes, and manage inventory more effectively. Blockchain technology offers a secure and transparent way to manage transactions and track assets in the maritime industry. It can be used to streamline processes such as cargo tracking, documentation, and payments, reducing the risk of fraud and errors. Blockchain can also enhance supply chain visibility, enabling better coordination and collaboration among stakeholders.

AI can be leveraged to automate various tasks, such as navigation, cargo handling, and administrative processes. AI-powered systems can analyze data, recognize patterns, and make decisions in real time, improving efficiency and reducing human error. Additionally, AI can be used for predictive maintenance, identifying potential issues before they become critical, thereby reducing downtime and repair costs. Stakeholder perspectives are crucial in driving digital transformation. Government policies and regulations play a significant role in creating an enabling environment for technological adoption. Industry leaders and maritime workers provide valuable insights into the practical challenges and opportunities associated with implementing new technologies. Technology providers offer the tools and expertise needed to integrate and manage these innovations effectively.

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e-ISSN: 3063-4245 p-ISSN: 3063-5705
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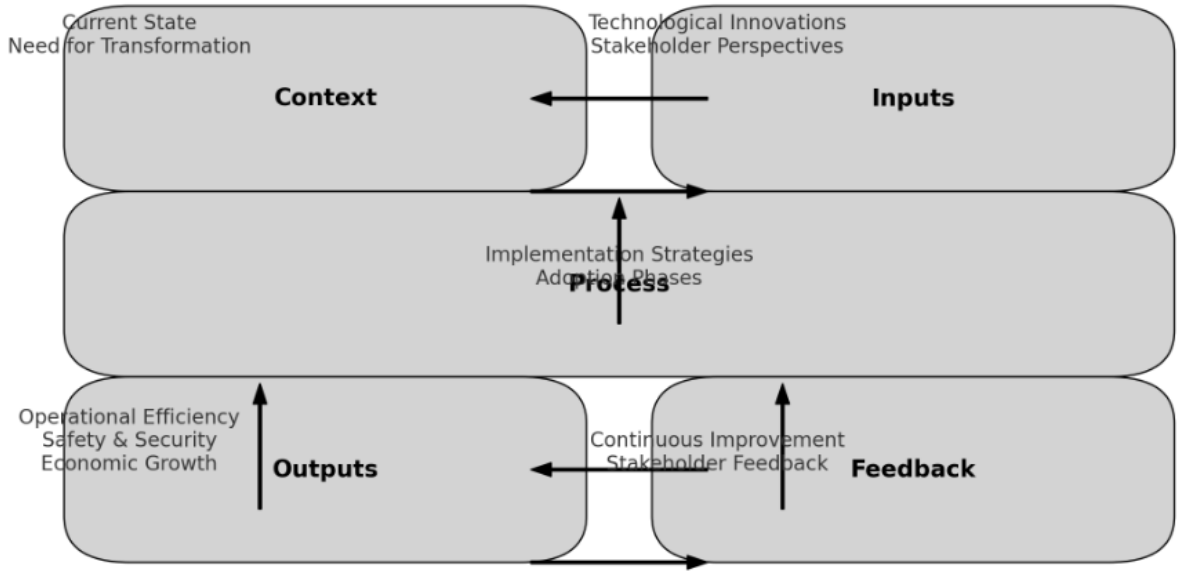
c. Process: Implementation Strategies and Adoption Phases

Digital transformation is a multifaceted process that necessitates strategic planning and phased implementation to be effective. A key strategy for implementation is ensuring policy and regulatory support from the government. This involves creating and enforcing policies that encourage technological innovation and provide incentives for adopting digital technologies. Updating regulations to accommodate new technologies, ensuring cybersecurity, and promoting data sharing and collaboration among stakeholders are essential components of this strategy. Another critical aspect is investing in infrastructure. Significant investments are needed to modernize maritime infrastructure, including upgrading port facilities, deploying IoT sensors, and implementing advanced data analytics platforms. The integration of blockchain and AI systems is also vital.

Figure 1. Thingking Framework Digital Transformation in the Maritime Industry in Indonesia



Source: Analysis Author, 2024

Public-private partnerships can be instrumental in mobilizing the necessary resources for these upgrades. Additionally, training and capacity building are crucial. The workforce must be trained to operate and maintain new technologies, which requires the development of training programs and educational initiatives focused on digital literacy, data analysis, and technical proficiency. Continuous learning and professional development are essential to stay updated with technological advancements.

The adoption of digital transformation can be broken down into several phases. The first phase involves an initial assessment of the current state of the industry. This assessment helps identify gaps, understand the specific needs of various stakeholders, and set clear objectives for digital transformation. Following this, pilot projects are implemented. These projects allow for the testing of new technologies and processes on a smaller scale, helping to identify potential challenges, refine strategies, and demonstrate the benefits of digital transformation. Successful pilot projects can then serve as models for broader implementation. The final phase is full-scale implementation, which involves deploying technologies across the entire maritime infrastructure, integrating systems, and ensuring interoperability. Continuous monitoring and evaluation are necessary to ensure that the digital transformation achieves the desired outcomes.

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e-ISSN: 3063-4245 p-ISSN: 3063-5705
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d. Outputs: Enhanced Operational Efficiency, Safety, and Economic Growth

The digital transformation of the maritime industry is set to bring about substantial benefits across several key areas. One major advantage is enhanced operational efficiency. Automated processes, such as automated cargo handling, navigation, and administrative tasks, reduce the need for manual intervention, minimizing errors and accelerating operations. Furthermore, real-time data monitoring, enabled by IoT sensors and data analytics, allows for continuous oversight of equipment, environmental conditions, and operational performance. This facilitates proactive decision-making and swift responses to arising issues. Additionally, predictive maintenance, which leverages data from IoT sensors, can foresee potential equipment failures, allowing for timely maintenance and thus minimizing downtime.

Another critical benefit is improved safety and security. Advanced tracking systems using GPS and IoT technologies enable precise tracking of ships and cargo, enhancing situational awareness and improving safety. This capability is crucial for preventing accidents and ensuring rapid response during emergencies. Moreover, as the industry increasingly relies on digital systems, implementing robust cybersecurity measures becomes essential to protect sensitive data and maintain the integrity of maritime operations.

Economic growth is also a significant benefit of digital transformation in the maritime industry. By streamlining operations, reducing costs, and improving efficiency, digital technologies can increase productivity, making the industry more attractive and competitive. This, in turn, can draw in more business and bolster the industry's overall economic impact. Additionally, digital transformation fosters the emergence of new business models. For instance, blockchain technology can revolutionize the management and financing of maritime logistics, while artificial intelligence can support the development of autonomous ships and smart ports, further driving innovation and growth within the sector.

e. Feedback: Continuous Improvement and Stakeholder Feedback

The process of digital transformation is an ongoing journey that necessitates continuous improvement and adaptation. Regular performance evaluations and stakeholder feedback are crucial for identifying areas needing enhancement and ensuring that the transformation aligns with industry needs and technological advancements. Continuous improvement involves several key aspects. Firstly, regular performance evaluations, including assessments of operational performance, efficiency, and safety, are essential. These evaluations typically involve data analysis, audits, and benchmarking against industry standards to pinpoint areas for further enhancement.

Secondly, adaptation to new technologies is vital. The maritime industry must remain flexible and continuously integrate emerging technologies, necessitating ongoing investment in research and development and a willingness to experiment and innovate. Finally, stakeholder feedback is invaluable. Engaging with a broad range of stakeholders, such as government bodies, industry leaders, maritime workers, and technology providers, offers critical insights into the effectiveness of digital transformation initiatives. This feedback helps identify challenges, highlight successes, and inform future strategies.

CONCLUSION

The digital transformation of Indonesia's maritime industry is an imperative, driven by the necessity to modernize and remain competitive in a global landscape that is increasingly technology-driven. The current state of the industry, characterized by a reliance on traditional methods and limited technological integration, underscores the urgent need for change. By adopting advanced technologies such as the Internet of Things (IoT), Big Data and Analytics, Blockchain, and Artificial Intelligence (AI), Indonesia can enhance operational efficiency, safety, and service delivery. This transformation is essential not only to meet international

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safety and environmental standards but also to capitalize on the economic opportunities presented by Indonesia's strategic geographic position. The journey towards digital transformation in Indonesia's maritime sector involves a comprehensive framework that begins with recognizing the need for change and understanding the current state of the industry. Technological innovations, supported by robust government policies and active stakeholder engagement, are key inputs driving this transformation. Strategic implementation through public-private partnerships, significant investment in modern infrastructure, and extensive training and capacity building are crucial for a successful transition. The phased adoption of these technologies, starting with pilot projects and culminating in full-scale implementation, ensures that the transformation is well-managed and effective.

The expected outputs of this digital transformation are multifaceted, encompassing enhanced operational efficiency, improved safety and security, and significant economic growth. Automated processes and real-time data monitoring will streamline operations, reduce costs, and enable proactive decision-making. Advanced tracking systems and robust cybersecurity measures will enhance safety and security, while the overall modernization of the maritime industry will boost productivity and competitiveness, attracting more business and fostering economic development. Continuous improvement and stakeholder feedback will ensure that the transformation remains aligned with technological advancements and industry needs, securing Indonesia's position as a key player in the global maritime industry.

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