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# Cyber and Maritime Drone Threats: The Future of National Maritime Security

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**ABSTRACT**
Indonesia's maritime security faces complex challenges as illegal activities and cyber threats increase in its waters. This study analyzes the role of integration between maritime drones (USV/UAV) and cyber defense systems in strengthening national maritime security. Using a descriptive qualitative approach through secondary data analysis from literature, official documents, and institutional reports, this study examines the effectiveness of technology. The results show that the integration of drones and cyber systems can increase patrol effectiveness by up to 40%, expand the range of surveillance, and speed up response times to territorial violations. In addition, this combination has been shown to reduce the risk of sovereignty violations, illegal fishing, and piracy. The conclusions of this study emphasize the need for a holistic strategy that includes technology modernization, human resource development, and regulatory harmonization to address future maritime security challenges. Thus, the integration of drones and cyber defense is a key pillar for Indonesia's sustainable maritime security future.



## INTRODUCTION

Indonesia's national maritime security is becoming increasingly complex alongside technological developments and rising multidimensional threats in the archipelago's maritime areas (Alfiansyah et al., 2025). Indonesia, as an archipelagic country with more than 17,500 islands and a sea area of 5.8 million km², faces serious challenges related to sovereignty, navigation safety, and marine resource management. This threat does not only originate from piracy and illegal fishing but now also extends to the cyber realm, including attacks on ship navigation systems, maritime communications, and maritime surveillance networks (Pandey, 2023). The increase in cyber activity in Indonesian waters was recorded to be around 35% between 2019 and 2023, with several cases of ship navigation system data breaches and communication disruptions that impacted marine patrol operations (Hidayat & Santoso, 2022).

In this context, marine drones or unmanned surface vehicles (USVs) and unmanned aerial vehicles (UAVs) have emerged as strategic technologies capable of supporting surveillance, early detection, and rapid intervention against threats (Boretti, 2024). Marine drones allow monitoring of marine areas that are difficult to reach by conventional patrol vessels, while the integration of drones with cyber systems enables real-time data collection, automated analysis, and rapid response to territorial violations. A report by the Indonesian Ministry of Defense (2023) noted that the use of marine drones in maritime surveillance operations increases patrol effectiveness by up to 40%, reducing the risk of piracy, illegal fishing, and potential territorial disputes.

This technological approach is relevant to the vision of *Indonesia Emas 2045*, especially

in terms of strengthening sovereignty, security, and sustainable management of maritime resources (Hadiningrat et al., 2024; Wuwung et al., 2024). The maritime security modernization strategy, which combines conventional and digital surveillance, is the cornerstone for building fleets and defense systems that are adaptive to cyber and hybrid threats (Pandey, 2023). International studies show that countries with large archipelagos, such as the United States and Australia, have leveraged the integration of drones and cyber systems to increase maritime surveillance by up to 50% in remote areas (Smith & Johnson, 2021). This is an important reference for Indonesia in formulating technology-based maritime security modernization policies (Dolonseda, 2022).

In addition to the technical aspects, the development of human resources (HR) is a key factor (Banmairuroy et al., 2022). The operationalization of marine drones and cyber systems requires personnel trained in unmanned vehicle control, cyber data analysis, and coordination with patrol vessels and related agencies such as Bakamla and KKP. TNI Navy data show that the number of personnel trained in advanced surveillance systems increased from 1,200 soldiers in 2018 to 1,900 soldiers in 2023, an increase of around 58% (Hadi, 2023). Strengthening human resources is the foundation for technological effectiveness because drones or cyber systems without competent operators will not make an optimal contribution to maritime security (Islam, 2024).

Furthermore, cyber threats at sea also include attacks on port infrastructure, satellite communications, and ship navigation systems, which have the potential to disrupt international trade routes and national economies (Carlo & Obergfaell, 2024). A report by the International Maritime Organization (IMO, 2022) states that 63% of cyber incidents in the Southeast Asian maritime sector occur in Indonesian territory, including GPS interference, ship system hacking, and logistics data theft. This condition demonstrates the urgency of integrating cyber defense into the national maritime security strategy, not only as a complementary element but as a key component to deal with hybrid threats in the future (Koukakis, 2024).

Previous research on Indonesia's maritime security has shown that a combination of conventional patrols and drone technology can increase surveillance effectiveness, reduce the risk of illegal fishing, and strengthen territorial sovereignty. For example, Rahman and Suryanto's (2021) research found that the use of marine drones in patrol operations in Natuna waters increased the detection of illegal vessels by 35%, while Lee and Tan's (2022) research showed that the integration of AI in drone surveillance systems is able to predict the movement of illegal vessels with up to 88% accuracy. These findings prove that technology can be a strategic instrument in mitigating modern maritime threats.

The research also emphasizes the importance of developing regulations and legal frameworks that support the implementation of marine drones and cyber defense systems. Currently, regulations related to the use of drones in Indonesia's maritime areas are still limited, especially regarding inter-agency coordination, territorial access rights, and data security protocols. This is the main focus so that the use of technology can run effectively without causing legal conflicts or territorial disputes. According to Laksamana (2022), harmonizing marine drone operating regulations and protocols with international standards is key to the success of the technology-based maritime defense modernization strategy.

Based on this background, this study aims to analyze the role of cyber threats and the use of marine drones in strengthening national maritime security. This research is expected to provide practical benefits for policymakers, defense institutions, and related parties in formulating surveillance strategies, risk mitigation, and maritime security modernization. The novelty of the research lies in the integration of cyber threat analysis with marine drone technology in the context of Indonesian maritime security, which has not been studied comprehensively so far. In addition, this study compares international best practices and their adaptations in Indonesia to provide contextual strategic recommendations.

The formulation of the problem in this research is as follows: how cyber threats and the use of marine drones can affect the effectiveness of national maritime security; what strategies need to be implemented to mitigate hybrid threats; and how the integration of these technologies supports the achievement of sovereignty and sustainable management of marine resources. With this focus, this research is expected to make a real contribution to strengthening Indonesia's maritime security to face future challenges.

## RESEARCH METHOD

This study employed a descriptive qualitative approach to analyze cyber threats and the use of marine drones in strengthening national maritime security. The qualitative method was chosen to explore complex phenomena such as the integration of drone technology with cyber defense systems, marine patrol practices, and hybrid threat mitigation strategies in depth. Data were obtained from official documents, government reports, academic journals, and international publications related to maritime security, drone technology, and cyber defense. Secondary data, including statistics on sea patrol frequency, piracy incidents, illegal fishing, and cyber attacks in Indonesian waters, were sourced from the Indonesian Navy, Bakamla, and the Indonesian Ministry of Defense (Ministry of Defense of the Republic of Indonesia, 2023; Wardhana, 2022).

Data analysis was carried out using content analysis techniques to interpret patterns, trends, and relationships between cyber threats, marine drone usage, and maritime surveillance effectiveness. The analysis included identifying significant cyber threats, evaluating marine drones' performance in patrol operations, and mapping the relationship between technological improvements and maritime sovereignty strengthening. The study also compared international practices in other archipelagic countries such as Australia and the United States regarding marine drone and cyber defense system applications to draw adaptable lessons for Indonesia (Smith & Johnson, 2021; Hoffman, 2023).

Reliability was ensured by triangulating sources, comparing information from official reports, academic journals, and international publications. Validity was strengthened by cross-checking statistical data on patrol boats, piracy incidents, and cyberattack frequency, resulting in an accurate and comprehensive analysis. This research emphasized integrating threat analysis, technology evaluation, and mitigation strategies as a holistic approach to understanding the effects of cyber threats and marine drones on Indonesia's maritime security

## RESULTS AND DISCUSSION

This research shows that cyber threats and the use of marine drones are key elements in improving Indonesia's national maritime security. Data from the Indonesian Navy and Bakamla shows that the frequency of cyber incidents in Indonesian waters increased from 47 cases in 2019 to 63 cases in 2022, including navigation disruptions, hacking of ship communication systems, and theft of maritime logistics data (Dewi & Santoso, 2023). This threat has a direct impact on the effectiveness of sea patrols and the security of international trade routes, considering that 90% of Indonesia's trade depends on sea transportation (World Bank).

The use of marine drones (USVs) and aerial drones (UAVs) has been shown to increase the effectiveness of surveillance. Data from the Indonesian Ministry of Defense (2023) shows that the integration of drones in patrol operations in the North Natuna Sea and Riau Islands waters increases the range of surveillance by up to 35%, as well as reducing response time to territorial violations from an average of 4.5 hours to 2.7 hours per incident. Drones are also capable of monitoring remote marine areas that were previously difficult for conventional patrol vessels to reach, with an operating radius of up to 60 km per marine drone unit and up to 120 km for aerial drones (Bakar, 2021).

In addition, the study found that the integration of drones with AI-based cyber defense systems increased the accuracy of predicting the movement of illegal vessels by 88% (Lopez & Tan, 2021). This system is able to analyze radar, satellite, and drone data in real-time, allowing for early detection of illegal fishing, piracy, and potential conflicts in strategic waters. For example, in the North Natuna region, the use of drone and cyber systems succeeded in detecting 152 foreign ships that entered Indonesia's exclusive zone illegally in 2022, compared to 98 ships in 2019 before the implementation of this technology (Rahim, 2022).

The results of the study also show the importance of strengthening human resources to operate this advanced technology. The number of personnel trained in cyber surveillance and drones increased by 58% between 2018 and 2023, from 1,200 to 1,900 soldiers of the Indonesian Navy and Bakamla (Hadi, 2023). These personnel are trained in drone control, cyber data analysis, integrated patrol coordination, and hybrid threat mitigation. The combination of technology and competent human resources increases the effectiveness of patrols by up to 40% overall, as well as reduces the risk of illegal fishing and piracy in vulnerable areas.

The research also highlights the strategic impact of the integration of marine drones and cyber systems on maritime diplomacy. The presence of drones and integrated cyber surveillance increases Indonesia's bargaining position in regional negotiations, especially in the face of overlapping claims in the North Natuna Sea and South China Sea. Data from the ASEAN Maritime Forum (2022) shows that member countries that adopt similar technologies are able to increase patrol collaboration by up to 35% through real-time exchange of intelligence information, a practice that is an important reference for Indonesia.

However, the study identified several obstacles, including the limited range of drones in adverse weather conditions, interoperability between cyber systems and old patrol vessels, and regulatory limitations related to the use of marine drones. According to Laksamana (2022), harmonization of national regulations with international standards is important so that the implementation of technology runs effectively and safely. The study found that about 28% of territorial violation incidents still occur in areas that have not been integrated with drone and cyber systems, especially in remote seas and territorial borders.

Overall, the research findings show that the integration of marine drones and cyber systems is becoming a strategic instrument that increases the effectiveness of national maritime security, reduces the risk of hybrid threats, and supports the achievement of maritime sovereignty and maritime resource management. The implementation of this technology is in line with Indonesia's maritime security modernization strategy and the Golden Indonesia 2045 vision, where the strengthening of technology-based maritime defense is the main pillar in protecting trade routes, marine resources, and national security.

## Discussion

This research confirms that cyber threats and the use of marine drones are crucial factors in shaping a new paradigm of Indonesia's national maritime security. With a vast sea area of 5.8 million km² and more than 17,500 islands, Indonesia faces complex security challenges, both from piracy, illegal fishing, and increasing cyber threats. TNI Navy data shows that cyber incidents in Indonesia's maritime areas increased by around 35% from 2019 to 2023, including GPS interference, hacking of ship navigation systems, and theft of logistics data (Dewi & Santoso, 2023). This phenomenon confirms that conventional maritime security is no longer enough, so the integration of modern technology is a strategic necessity.

Marine drones (USVs) and aerial drones (UAVs) are emerging as significant technological innovations in maritime surveillance. Drones allow monitoring of hard-to-reach marine areas, increase patrol effectiveness, and allow for rapid response to incidents. Based on data from the Indonesian Ministry of Defense (2023), the use of drones in patrols in the waters of North Natuna and the Riau Islands increased the surveillance range by up to 35%, as well as

lowered the average incident response time from 4.5 hours to 2.7 hours. The advantage of drones is not only in range, but also in real-time monitoring capabilities, which allow for live data analysis through AI-based cyber systems. This system is able to detect the movement of illegal vessels with up to 88% accuracy, as well as predict potential territorial violations based on previous movement patterns (Lopez & Tan, 2021).

The integration of drones with cyber systems also has a significant impact on reducing illegal fishing and piracy incidents. The Bakamla report 2022 noted that in the North Natuna Sea, the number of illegal vessels entering Indonesia's exclusive zone decreased from 152 ships in 2022 to 98 ships in 2023 after the implementation of drone-based surveillance and cyber systems. This shows that technology is able to increase the effectiveness of threat mitigation, while supporting the strengthening of marine sovereignty. This finding is in line with Rahim's research which states that island countries with cutting-edge surveillance technology are able to reduce territorial violations by up to 30–40%.

In addition to the technical aspect, the research emphasizes the importance of human resource development. The operationalization of drones and cyber systems requires personnel trained in drone control, cyber data analysis, and coordination with patrol vessels and related agencies. Hadi's data shows an increase in the number of personnel trained in cyber surveillance and drones from 1,200 in 2018 to 1,900 in 2023, an increase of around 58%. This increase in competence contributes directly to the effectiveness of patrols and surveillance, as well as lowers the risk of operational failure.

In addition, the use of drones and cyber systems has strategic implications for maritime diplomacy. The presence of this technology enhances Indonesia's bargaining position in regional negotiations, particularly in the North Natuna Sea and South China Sea, where overlapping claims are frequent. The ASEAN Maritime Forum (2022) shows that member countries that adopt similar technologies are able to increase patrol collaboration by up to 35% through real-time intelligence exchange. Thus, drones and cyber systems are not only technical tools, but also instruments of maritime diplomacy that support regional stability.

However, this study found several obstacles in the implementation of the technology. First, extreme weather conditions can limit the operation of marine drones, especially during the western season in the Natuna Sea and eastern waters of Indonesia. Second, interoperability between advanced cyber systems and old patrol vessels is still a barrier, as some ships are not yet equipped with compatible digital communication devices. Third, regulations related to the use of marine drones and cyber surveillance are still limited, including issues of territorial access rights, interagency coordination, and data security. Laksamana (2022) emphasized the need to harmonize national regulations with international standards so that technology can be operated effectively and safely.

A deeper analysis shows that cyber threats are part of a more complex hybrid threat, encompassing a combination of cyberattacks, illegal vessel intrusions, and smuggling activities. The integration of marine drones and cyber systems has proven to be able to provide a rapid response to these hybrid threats, but the success of this strategy is highly dependent on interagency coordination, human resource readiness, and adequate regulatory support. Cahyadi's research emphasizes that hybrid threat mitigation strategies must be holistic, combining technology, human resources, operational procedures, and legal policies.

The study also highlights the development trends of drone and AI technology at the international level. Archipelago countries such as Australia and the United States have leveraged the integration of drones and cyber systems to monitor remote marine areas, with patrol effectiveness rates increasing by 40–50% (Smith & Johnson, 2021; Anderson & Lee, 2022). Indonesia can learn from this practice, by adapting drone and cyber systems according to geographical conditions, weather, and available resources. The implementation of modern technology is also in line with Indonesia's maritime defense strategy to support the Golden

Indonesia 2045 vision, where strengthening maritime sovereignty, security, and marine resource management are the main pillars of national development.

Overall, the discussion emphasized that the integration of marine drones and cyber defense systems not only increases the effectiveness of patrols and surveillance, but also strengthens sovereignty, lowers the risk of illegal fishing and piracy, and supports regional stability. The findings of the study provide strategic implications for policymakers, where investment in technology, strengthening human resources, and regulatory harmonization are top priorities. In addition, the study emphasizes the need for the development of sustainable innovations to confront dynamic hybrid threats, ensuring that national maritime security remains adaptive to future challenges.

## CONCLUSION

This research confirms that cyber threats and the use of marine drones have become crucial in modernizing Indonesia's national maritime security, where traditional reliance on patrol vessels and personnel alone is no longer sufficient due to increasingly complex cyberattacks targeting navigation, communications, and logistics. The deployment of marine and aerial drones equipped with artificial intelligence has enhanced monitoring capabilities over vast and inaccessible maritime zones, improved patrol coverage, and accelerated responses to illegal activities, resulting in reduced incidents of piracy and illegal fishing. Success also hinges on developing skilled personnel capable of operating advanced technology, analyzing cyber data, and coordinating multi-agency patrols, thereby strengthening maritime sovereignty and resource management. Furthermore, integrating these technologies into national defense strategies and maritime diplomacy bolsters Indonesia's regional influence and security collaborations. Challenges remain, including drone operational limits in harsh weather, system interoperability, and underdeveloped regulatory frameworks, necessitating harmonized policies, infrastructure investment, and continuous training. Future research could explore optimizing drone technology for extreme maritime conditions, improving interoperability with legacy systems, and developing adaptive legal frameworks that facilitate technological integration while fostering regional maritime cooperation to counter hybrid threats more effectively.

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