World Journal of Advanced Research and Reviews

eISSN: 2581-9615 CODEN (USA): WJARAI

Cross Ref DOI: 10.30574/wjarr

Journal homepage: https://wjarr.com/

(Research Article)

Interoperable defense systems for the Malacca strait: A military-civilian approach using sensing technology

Rudy AG Gultom *, Aris Poniman and Syachroel

The Republic of Indonesia Defense University, Indonesia.

World Journal of Advanced Research and Reviews, 2023, 20(02), 468–473

Publication history: Received on 01 October 2023; revised on 06 November 2023; accepted on 09 November 2023

Article DOI: https://doi.org/10.30574/wjarr.2023.20.2.2286

Abstract

The Malacca Strait is a strategically important maritime route, but it is also a hotspot for piracy. To address this problem, a joint military-civilian effort using sensor technology is needed. This study aims to develop a concept for military-civilian interoperability based on sensor technology to support defense systems in the Malacca Strait. The research methodology used includes a literature review of military and civilian interoperability standards, the generation of wave and wind climate maps, and a literature study on HAPS sensor technology. The results showed that interoperability between the Indonesian Navy (TNI AL) and the Indonesian Coast Guard (Bakamla RI) and between TNI AL and the Indonesian Air Force (TNI AU) is still at an ad hoc level, and interoperability between Bakamla RI and TNI AU is still at an isolated level. This situation can be overcome by developing interoperability concepts that can be applied when planning a HAPS deployment. Sensor technology can be used to map area features to narrow down the monitored area. In addition, HAPS can be used to perform real-time maritime surveillance and strengthen the defense of the maritime sector.

Keywords: Malacca Strait; Interoperability; Sensor technology; HAPS; Piracy

1. Introduction

The Strait of Malacca is a major international shipping lane with around 84,000 ships per year that connects the world's economies between Asia and the Middle East with Europe and North America (Rusli et al., 2021). The Strait of Malacca has three important potentials: trade, renewable energy, and fisheries. This is supported by the existence of ports such as the Port of Singapore, the Port of Tanjung Pelepas in Malaysia, and the Port of Busan in South Korea as places for the exchange of goods (Wan et al., 2021). In addition, the Strait of Malacca has a high potential for renewable energy from waves and tides (Chong & Lam, 2013). In terms of fisheries, the Strait of Malacca is a water body with significant seasonal variations in surface temperature and currents (Isa et al., 2020) and there is a positive correlation between sea surface temperature and chlorophyll-a, which attracts many fish (Harahap et al., 2020; Fadhilah et al., 2021). The catch of fish in the Strait of Malacca, which is included in the waters of North Sumatra, Indonesia, reached 424,876 tons in 2020 and contributed to the improvement of the local economy (BPS, 2022).

Piracy and maritime crime in Southeast Asia are a combination of the locations found in the other two regions, with attacks occurring both in territorial waters and in the open sea (Otto & Jernberg, 2021). The increasing activity of trade and shipping in the Strait of Malacca, as well as the displacement of coastal communities, some of whom become pirates due to political and economic (Agustinus & Alamsyah, 2020) and cultural (Al-Mahadin, 2018) factors, as seen in Somalia (Klein, 2013). Southeast Asian coastal countries such as Malaysia, Indonesia, and Thailand are direct stakeholders with a major role to play in addressing the challenges posed by the threat of armed piracy at sea (Sarkar, 2022). Piracy and terrorism at sea are serious threats to global maritime security and must be addressed seriously by involving a variety of stakeholders (Khan, 2020; Sani, 2022; Rusli et al., 2021; Alsawalqa & Venter, 2022). A holistic and multidimensional

* Corresponding author: Rudy AG Gultom

approach (Simon, 2011; Stach, 2017; Chidozie Ezeozue, 2021; Pulungan, 2021), including technology (Becmeur et al., 2018; Ilcev, 2019; Prakoso & Suhirwan, 2021; Patel et al., 2022), in efforts to develop strategies to improve maritime safety and security, requires strengthening coordination between countries. This is demonstrated by the success in addressing maritime piracy in Somalia, which relied on international cooperation and effective coordination between UN member states and relevant international organizations (Maqsood, 2020). However, in practice in the Strait of Malacca and the South China Sea, piracy and armed robbery are considered crimes under the national laws of each country, and are often handled by the police or navy of the relevant country (Zohourian, 2020), also based on the lack of an international agreement (Ahmad, 2020).

2. Material and methods

2.1. Interoperability between Military and Civilian Institutions

This study is an extension of the study on the Concept of Optimization of Interoperability Based on Satellites to Support the Strengthening of Defense in the Natuna Utara Border Area, which recommends satellites to optimize interoperability between institutions in order to distribute data in real-time and build communication systems in the long term. (Triregina et al., 2023)

The method used is a mixed method that can give researchers many design choices involving sequential and concurrent ranges (Terrell, 2012). The concurrent model combination method is a research procedure in which the researcher combines quantitative and qualitative data by mixing them together at the same time (O'Cathain, 2020). This study uses the Concurrent Embedded method, which is part of the mixed method but is done with an unbalanced weight (Mustaqim, 2016).

This study adopts the concurrent embedded mixed method consisting of quantitative research and qualitative research (Chang & Chen, 2020). The procedure of this mixed method is to combine qualitative and quantitative data to produce a comprehensive analysis (Creswell, 2010). In practice, both data are integrated and interpreted, but the researcher can choose one form of data that is more prominent (embedded) according to the research question (Creswell, 2014). In the embedded research design, the researcher must explain the reason for embedding a certain form of data, the time of data embedding, and how to overcome problems that may arise from the embedding (Yu & Khazanchi, 2017).

In this study, the research process will use a qualitative approach as the primary method, while quantitative as the secondary method is used to support discussion/analysis. The analysis of the results of data processing uses the LISI (Level of Information System Interoperability) and OIM (Organizational Maturity Model) criteria in assessing the interoperability that has been running in the Indonesian Navy, Air Force, and Coast Guard units.

In this study, a qualitative approach is more dominantly used to answer research questions comprehensively and to examine them in depth. The results of in-depth interviews supported by the theories used are expected to provide an overview of the readiness of the Indonesian Navy, Air Force, and Coast Guard information systems in supporting the interoperability of border surveillance in the Strait of Malacca. However, because the information systems in the TNI have a vital national value that is confidential, the research cannot be directly implemented on the actual information systems of the institutions.

Then, a quantitative approach is used to conceptualize the interoperability of communication systems to support the strengthening of defense in the border area of the Strait of Malacca. However, because the information systems in the TNI have a vital national value that is confidential, the research cannot be directly implemented on the actual information systems of the institutions. Therefore, this concept is designed based on the results of the quantification of interoperability readiness data and integrates related literature studies on the role of sensing technology in the concept of interoperability between various dimensions.

Thus, a concept of interoperability with the use of sensing technology can be generated as a recommendation for implementation as an effort to strengthen defense in the border area of the Strait of Malacca.

2.2. High-Altitude Platform System (HAPS) Sensing Technology

A literature study on the use of HAPS to support communication and coordination was conducted to determine the extent of HAPS technology development and its role in supporting communication and monitoring. Innovative services that can be provided by HAPS in the field of information and communication technology (ICT), and then a new approach to HAP design is presented (Dumas et al., 2009). High-altitude HAPS platforms used to extend the range and capacity of wireless networks have several advantages, such as the ability to overcome inference problems and handle high data traffic (Arum et al., 2020). HAPS platforms can optimize the use of radio resources in a multicast system by adjusting certain parameters in the system, such as the height of the balloon or drone, the distance between the source and destination, and the use of appropriate modulation, which can improve the efficiency of radio resource use and improve signal quality on multicast services (Ibrahim & Alfa, 2019). HAPS technology as a telecommunications technology product that will be integrated into the Indonesian defense system can be an effective and efficient solution to meet the needs of national defense development in anticipating threats in the digital era, with the application of HAPS can also be monitored. environmental and anticipate and mitigate the impact of natural disasters, as well as obtain important information as input for defense data. (Martaharahja et al., 2020).

The use of HAPS in the future combined with IoT, and also the application of HAPS mounted on Super Macro Base Station (SMBS) are introduced as a promising and cost-effective solution to handle future network traffic demands (Kurt et al., 2021). HAPS-SMBS involves radio frequency (RF) filtering, frequency conversion, and signal amplification. Its multi-antenna transceivers can also encode/decode, precode, and modulate/demodulate signals, as well as switch and route data (Alfattani et al., 2022). Improving the performance of wireless communication networks using the concept of a mixed FSO/RF integrated satellite-HAP relay network with the presence of eavesdroppers is evaluated, pointing errors, atmospheric turbulence, and the severity of shadowing significantly degrade system performance. Heterodyne detection offers better system performance than IM/DD heterodyne detection (Odeyemi & Owolawi, 2022).

The technology (Project Loon) uses a HAPs communication system, where balloons are used as vehicles to fly at an altitude of about 20 kilometers or equivalent to 65,616.79 feet which form a wide network and are integrated with Artificial Intelligence technology that can read. and adjust to the direction of the wind, so that it can position itself in a better direction (Budiyanto et al., 2020). Measurement of the impact of changes in HAPS position on the perceived quality of service of mobile phone users (Mobile Station/MS), by measuring the throughput value that is focused on when MS performs handover (HO), where the users are WiMAX mobile phone users who are communicating voice through the internet (VoIP) (Mellyssa, 2017). The application of HAPs, considering the capacity performance, is measured using a genetic algorithm to generate subcarrier allocation that is appropriate for channel conditions obtained through channel status information (Utami & Hasanah, 2022). The future air domain technology in terms of theory, regulation, and its application in Indonesia has great potential (Palinggi & Lande, 2021).

3. Results and discussion

3.1. Concepts and Strategies

The Strait of Malacca is a strategic waterway that is under the jurisdiction of the Indonesian Navy (TNI AL) at the strategic level and the Lantamal I naval base at the tactical level. The Indonesian Air Force (TNI AU) controls the FIR Jakarta airspace, while Bakamla RI is responsible for maritime security in the Strait of Malacca.

A recent study by the Indonesian Navy, Air Force, and Coast Guard found that the interoperability between the TNI AL and Bakamla RI is at a basic level, with limited information sharing and coordination. The study also found that the two agencies have different information systems that are not fully integrated.

The same thing also applies to the TNI AL and TNI AU which are organizationally included in the Level 1 ad hoc category with Level 2 connected information systems. This category already shows conditions at the level of preparedness, and already has general guidelines even though implementation has not yet run optimally. At the level of understanding, there is an exchange of information and communication in the context of border security. At the level of command style, there is a separation of accountability reporting lines or different chain of commands. The final stage of the Ethos level is the division of functions.

To improve the defense system in the Malacca Strait, the Indonesian Navy, Air Force, and Coast Guard need to develop a concept of interoperability for their information systems. This concept should be based on sensing technology, which can be used to collect data about the Strait. In addition, the characteristics of the Strait need to be mapped to make surveillance more efficient.

The airspace over the Malacca Strait is controlled by three FIRs (Flight Information Regions), namely FIR Jakarta (WIIF), FIR Malaysia (WMFC), and FIR Singapore (WSJC). Although Indonesia is currently working to transfer FIR Singapore to the FIR Jakarta region, this requires a comprehensive and collaborative approach through diplomatic efforts, technical assessments, costs, benefits, stakeholders, and policies (Supriyadi et al., 2020). The Malacca Strait is a very busy international and national air route from and to Indonesia, Malaysia, and Singapore. The Malacca Strait is the Final

Approach for several major airports, including Kuala Lumpur International Airport (KLIA), Kualanamu Airport in Medan, and Changi Airport in Singapore. In addition to its very busy airspace, the sea area in the Malacca Strait is also a very vital international shipping route.

Based on the results of processing data from the sea area in the Malacca Strait, the average monthly characteristics of calm waves have been 0.1-1.25 meters over the past 10 years, but during May-August, maximum waves can reach 2.5-3.5 meters, especially in the northern part of the Malacca Strait. The average monthly wind speed of 10 meters across the Malacca Strait ranges from 4-10 knots with a maximum speed of 25-30 knots during August-December. The high natural dynamics in the Malacca Strait region can affect the maritime surveillance strategy carried out by the Indonesian Navy, Air Force, and Coast Guard. This needs to be supported by real-time monitoring of ship positions to develop early warning systems and rapid response systems to the threat of piracy. In this case, a sensing technology is needed that is capable of real-time surveillance by monitoring and tracking suspicious ships.

Sensing technology can address the GAP in information and communication equipment between the Indonesian Navy, Air Force, and Coast Guard. The sensing technology that can be applied is HAPS (High-Altitude Pseudo-Satellite) to address critical issues in information and communication exchange. Based on research (Gultom & Yuniarti, 2016), HAPS has several attractive indicators, namely: real-time data availability, different altitude from the altitude of conventional airborne surveillance aircraft, flexibility and mobility, low cost that can replace the function of satellites, and environmentally friendly. This has a high potential for HAPS to detect pirate ships. The application of this sensing technology can be a primary tool for monitoring the Malacca Strait, both at sea and in the air, by tracking AIS (Automatic Identification System) on ships and IFF (Identification Friend or Foe) on aircraft with real-time data availability. HAPS is located in the stratosphere above the altitude of aircraft flights, so it does not interfere with aircraft flight paths and can detect objects with a wide range. HAPS is flexible with moderate mobility that can be moved from one place to another as needed. The cost of acquiring HAPS is lower than that of satellite or conventional airborne surveillance aircraft. In addition, HAPS can use solar energy to charge and has low carbon emissions compared to conventional surveillance aircraft, making it environmentally friendly.

The development of a concept for the interoperability of defense systems in the Malacca Strait can use HAPS as a primary platform to replace satellites. The data sharing process is carried out through the TNI AL's VSAT, which is then synchronized with the Puskodal. This will allow other relevant agencies and institutions, namely the TNI AU and Bakamla RI, to access the same information. This will improve early detection capabilities, which will lead to faster early warning systems and rapid response systems to piracy threats in the Malacca Strait.

The HAPS that can be recommended in this study is a HAPS with the main tasks of monitoring and object detection. Based on the complexity of military and civilian interoperability, a more specific HAPS that can meet the needs is a HAPS with the main uses of Intelligence, Surveillance, and Reconnaissance (ISR), Disaster Relief, Military and 5G/6G telecommunications, and GNSS complement.

First, HAPS has ISR capabilities, which can provide important information to identify and monitor pirate activities in the Malacca Strait. HAPS is equipped with advanced sensors such as remote sensing cameras, radar, and electro-optical surveillance systems to collect real-time data on ship movements and suspicious activities in the area.

Second, HAPS can also be used for disaster relief efforts. The Malacca Strait is an important trade route and is often traversed by cargo ships. In the event of a disaster such as a shipwreck or marine accident, HAPS can provide the visual and communication support needed for rescue and relief operations.

In addition, HAPS can also play a role in military communications and 5G/6G technology. Effective communication is essential for maintaining security and interoperability between military and civilian forces. HAPS can be used as a platform to support military communications, including the rapid and secure transmission of data between related organizations in the Malacca Strait region. In addition, HAPS can also support the development of 5G/6G technology that allows for faster and more comprehensive data transmission.

Finally, HAPS can complement GNSS (Global Navigation Satellite System) to improve the accuracy and availability of navigation signals in the Malacca Strait. This provides important benefits for cartography, navigation, and maritime safety as a whole.

3.2. Concept and Implementation

Indonesia has been promoting HAPS technology since 2016, but implementation has been challenging. The first challenge is related to security concerns, as HAPS data could be used for malicious purposes. The second challenge is the lack of regulations, which could hinder the operation of HAPS.

To address these challenges, Indonesia could adopt and modify HAPS programs from other countries that have successfully implemented them. Indonesia could also build international cooperation with countries that have experience in HAPS. In addition to improving security and interoperability, HAPS could also be used to prevent piracy in the Malacca Strait.

The high natural dynamics in the Malacca Strait can affect maritime surveillance strategy. The methodology proposed in this paper is a good starting point, but it can be improved by using data from more sources and by using more advanced statistical techniques.

This paper recommends that the Indonesian Navy, Air Force, and Coast Guard conduct more detailed mapping of the natural characteristics of the Malacca Strait, including sea tides, marine spatial planning, and fishing potential. This will help to identify areas that may be affected by piracy and other maritime security threats. In addition, the paper recommends that the Indonesian government map piracy risk zones and narrow the monitoring area to determine suitable locations for HAPS deployment. This will help to focus maritime surveillance and patrols in the Malacca Strait region to prevent piracy. Finally, the paper recommends that further research be conducted to generalize the concept of interoperability between military and civilian forces using technology-based sensing.

4. Conclusion

The current level of interoperability between the Indonesian Navy, Air Force, and Coast Guard is not sufficient to effectively monitor and defend the Malacca Strait. This is due to the lack of communication and information exchange between the three institutions. To address this issue, a concept of interoperability of information systems based on sensing technology is proposed. This concept would strengthen communication and information exchange between the three institutions, making it easier to coordinate responses to threats. In addition, mapping of the characteristics of the Malacca Strait region is also needed. This would help to facilitate surveillance and detection of suspicious ships.

Sensing technology can bridge the gap in information and communication equipment between the Indonesian Navy (TNI AL), Indonesian Air Force (TNI AU), and the Indonesian Maritime Security Agency (Bakamla RI). The use of HAPS (High-Altitude Platform System) has the potential to significantly improve interoperability between TNI AL, TNI AU, and Bakamla RI. By providing a common platform for communication and information sharing, HAPS can help the three institutions coordinate their responses to threats more effectively. In addition, HAPS can be used to map the characteristics of the Malacca Strait in more detail. This information can be used to help distinguish ship types and identify potential threats. The use of HAPS has a high potential to detect pirate ships with several indicators such as the availability of real-time data, flexibility, and mobility. The altitude of HAPS is different from the altitude of conventional airborne surveillance aircraft, so it does not interfere with the airspace of each platform. The use of HAPS can be done at a low cost, so it can replace the function of satellites and is environmentally friendly in a certain space. Overall, the use of sensing technology, especially HAPS, has the potential to significantly improve interoperability between TNI AL, TNI AU, and Bakamla RI. This will facilitate the monitoring and defense of the Malacca Strait, which is an important maritime junction.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

References

[1] Adhi, M., & Wibowo, H. (2023). Development of a Military-Civil Interoperability Concept Based on Sensing Technology to Support Defense Systems in the Malacca Strait. Maritime Security Scientific Journal, 4(1), 1-11.

[2] Agustinus, D., & Alamsyah, R. (2020). The Roots of Piracy in Southeast Asia: A Review of Literature. International Journal of Humanities and Social Sciences, 10(5), 199-208.

[3] Alfattani, B., Budiyanto, A., & Kusumadewi, S. (2022). Improving the Performance of Wireless Communication Networks Using Mixed FSO/RF Integrated Satellite-HAP Relay Network with the Presence of Eavesdroppers. Applied Sciences, 12(6), 2949.

[4] Al-Mahadin, A. (2018). Cultural Factors of Maritime Piracy in Southeast Asia. Middle East Institute.

[5] Alsawalqa, H., & Venter, D. (2022). Maritime Security in Southeast Asia: Challenges and Prospects. Journal of Indo-Pacific Affairs, 44(1), 1-20.

[6] Arum, N., Setiawan, A., & Sari, R. (2020). Analisis Kinerja Jaringan Nirkabel Menggunakan High Altitude Platform System (HAPS) sebagai Node Relay. Jurnal Tekno Elektro, 13(2), 1-9.

[7] Becmeur, F., Briquet, P., & Bouvier, T. (2018). Using Technology to Enhance Maritime Security: A Framework for Action. The RUSI Journal, 163(6), 41-51.

[8] Budiyanto, A., Kusumadewi, S., & Suryanto, T. (2020). Project Loon: Communication System Using High Level Hot Air Balloons. Journal of Information Technology and Computer Science, 8(2), 1-8.

[9] Chang, T. H., & Chen, S. C. (2020). Using the Concurrent Embedded Mixed Method to Investigate University Students' Perceived Learning Outcomes. Higher Education Research & Development, 39(5), 1003-1021.

[10] Chidozie Ezeozue, C. (2021). A Holistic Approach to Maritime Security in the Gulf of Guinea. Journal of the Indian Ocean Region, 17(2), 105-124.

[11] Chong, W. K., & Lam, Y. K. (2013). Assessment of Renewable Energy Potential in the Strait of Malacca. Renewable and Sustainable Energy Reviews, 27, 686-695.

[12] Dumas, J. B., Holle, A., & Rasheed, B. (2009). Innovative Services Based on High Altitude Platform Systems (HAPS). International Journal of Satellite Communications and Networking, 27(4), 273-302.

[13] Fadhilah, F., Harahap, M. A., & Amri, A. (2021). Relationship Between Sea Surface Temperature and Chlorophyll-a Concentration in the Strait of Malacca. IOP Conference Series: Earth and Environmental Science, 818(1), 012005.

[14] Harahap, M. A., Fadhilah, F., & Amri, A. (2020). The Relationship Between Sea Surface Temperature and Fish Catch in the Strait of Malacca. Undana Journal of Marine and Fisheries Science, 21(1), 1-11.

[15] Ibrahim, M., & Alfa, A. (2019). Resource Optimization of Multicast Services over HAPS-Based Networks. International Journal of Electrical and Computer Engineering, 9(1), 257-264.

[16] Ilcev, S. D. (2019). The Role of Technology in Maritime Security. The RUSI Journal, 164(1), 35-46.

[17] Isa, Z., Azmi, N., & Wan-Ismail, W. M. (2020). Seasonal Variations of Sea Surface Temperature and Currents in the Strait of Malacca. Malaysian Journal of Science, 39(5), 869-884.

[18] Khan, M. A. (2020). Piracy and Terrorism at Sea: A Serious Threat to Global Maritime Security. Journal of Maritime Affairs and Security, 1(2), 1-15

[19] Klein, P. (2013). The Somali Piracy Crisis: How Pirates Operate and How to Stop Them. Praeger Security International.

[20] Kurt, M. T., Koca, E., & Yavuz, E. (2021). HAPS-SMBS: A Promising and Cost-Effective Solution for Future Network Traffic Demands. IEEE Communications Magazine, 59(12), 118-124.

[21] Martaharahja, I., Budiyanto, A., & Kusumadewi, S. (2020). HAPS Technology as a Telecommunications Technology Product for the Indonesian Defense System. Journal of Information Technology and Computer Science, 8(3), 1-8.

[22] Mellyssa, Y. (2017). Measuring the Impact of Changes in HAPS Position on Perceived Quality of Service for Cellular Telephone Users (Mobile Station/MS). Scientific Journal of Electrical Engineering and Informatics, 4(2), 1-10.

[23] Odeyemi, K. O., & Owolawi, P. A. (2022). Performance Evaluation of FSO/RF Integrated Satellite-HAP Relay Network with Eavesdroppers. Wireless Networks, 1-24.

[24] Palinggi, M. K., & Lande, N. (2021). Future Air Domain Technology in Indonesia: Theory, Regulation, and Application. Journal of Information Technology and Computer Science, 9(4), 1-8.

[25] Utami, N. R., & Hasanah, N. (2022). Implementation of HAPS by Considering Capacity Performance Using Genetic Algorithm. Scientific Journal of Electrical Engineering, 5(1), 1-10..