Equivalent: Jurnal Ilmiah Sosial Teknik
Volume 8, Issue 2, 412-424
e_ISSN: 2775-0833
https://jurnalequivalent.id/index.php/jequi/index
DOI: doi.org/10.59261/jequi.v8i2.282

Automatic Identification System (AIS) Based Monitoring System and Its Role in Improving Maritime Transportation Safety in Indonesia

Tri Iriani Eka Wahyuni[1*]
Politeknik Pelayaran Barombong, Indonesia

Sidrotul Muntaha[2]
Politeknik Pelayaran Barombong, Indonesia

Amiruddin[3]
Universitas Negeri Makassar, Indonesia

Irwan Jaya[4]
Politeknik Pelayaran Barombong, Indonesia

Andi Hasmawati[5]
Politeknik Pelayaran Barombong, Indonesia

***Corresponding author:**
Tri Iriani Eka Wahyuni, Politeknik Pelayaran Barombong, Indonesia.
✉triiriani27@gmail.com

Article Info:

Article history:
Received: March 05, 2026
Revised: April 17, 2026
Accepted: April 21, 2026

Keywords:
automatic identification system (AIS); Indonesian maritime transportation; ship monitoring system; shipping safety; vessel traffic services

Abstract

Background: Maritime transportation safety in Indonesia still faces various challenges, marked by a high number of ship accidents and a less-than-optimal vessel traffic monitoring system. The Automatic Identification System (AIS), as a modern navigation technology, has been mandated by the government to improve shipping safety.
Objective: This study aims to determine the effectiveness of the AIS-based monitoring system in enhancing maritime transportation safety as well as identify barriers to its implementation in Indonesia.
Methods: A descriptive qualitative research design was used in this study. Coincidentally, the data were collected by conducting direct observations at VTS Makassar and aboard *KM Sabuk Nusantara* and *KM Tonasa Line*, in-depth semi-structured interviews using open-ended questionnaires with ship operators, ETOs (electro-technical officers), captains, watch officers, harbormaster officials, and VTS operators, as well as a document review consisting of shipping accident reports and regulations related to these issues.
Results: The study results indicate that AIS is paramount in enhancing navigational awareness and facilitating ship traffic monitoring in real time, as well as assisting search and rescue operations. However, it is not fully effective, with devices lying idle or unsuitable for use, limited human resource capabilities, signal interference, and regulations that remain weak.
Conclusion: The AIS system is functionally successful in enhancing maritime transportation safety, though it needs to be bolstered by regulatory oversight, more robust technical training, and modern infrastructure improvements for optimal deployment.

To cite this article: Wahyuni, T. I. E., Muntaha, S., Amiruddin, Jaya, I., & Hasmawati, A. (2026). Analysis of the effectiveness of the AIS (Automatic Identification System) based monitoring system in improving maritime transportation safety in Indonesia. *Equivalent: Jurnal Ilmiah Sosial Teknik*, 8(2), 412–424. https://doi.org/10.59261/jequi.v8i2.382

INTRODUCTION

The international maritime community has been constantly focusing on the improvement of the safety level of maritime transportation, which is a universal problem (Formela et al., 2019). The International Maritime Organization (IMO) routinely advocates for the use of contemporary navigation systems in support of reduced accidents and greater shipping efficiency (IMO, 2020).

With the growth in international trade and the congestion of maritime shipping lanes, there is an increasing risk of collision, grounding, or other navigational incidents (Bye & Aalberg, 2018).

Existing reports from other parts of the world reveal that real-time data-based technologies such as those relying on Automatic Identification System (AIS) could play a critical role in greatly minimizing marine accidents in maritime traffic-congested waters (Ozbas, 2013; Purba, 2025; Xu et al., 2023; Zhong et al., 2025). As a result, AIS, once not considered standard equipment, has evolved into one of the principal tools found throughout contemporary shipping safety frameworks, which now integrate radar, satellites, and vessel traffic control centers.

Maritime transportation safety is a strategic national necessity for Indonesia, the world's largest archipelagic country with more than 17,000 islands. Shipping forms the backbone of national connectivity, enabling logistics and passenger mobility between islands. Despite this, data from the Directorate General of Sea Transportation indicate that many ship accidents still occurred in recent years, particularly in highly congested waters such as the Makassar Strait, the Java Sea, and the Sunda Strait (Ditjen Hubla, 2022). Many factors contribute to these problems, including vessel traffic density, crew quality, ship equipment conditions, and the effectiveness of maritime monitoring systems (Moreno et al., 2022). Furthermore, the range of AIS signals is five times more detectable in coastal waters compared to open ocean settings, and gaps in inter-agency system integration complicate the construction of effective monitoring systems.

Direct consequences of these factors include an increased risk of marine accidents, economic losses, and threats to human safety and quality of life, as well as to the safety of ships and their related machinery. Failure of the monitoring system results in deficiencies in the early identification of potential collisions or shipping lane violations. The lack of ship position monitoring can complicate emergency operations, as search and rescue (SAR) teams sometimes cannot determine the precise position of a vessel.

A study by Khan (2021) indicates that the frequency of certain types of accidents remains below the danger tolerance threshold; despite this, the consequences of these incidents remain considerable, concerning both ship structural damage and environmental pollution penalties. Thus, the existence of an optimally functioning AIS-based monitoring system is crucial in minimizing risks and supporting data-driven decision-making.

The Automatic Identification System (AIS) itself is a VHF transponder-based maritime communication system that enables automatic information exchange between ships and between ships and shore stations (Durlik et al., 2024; Wang et al., 2020). The information transmitted includes ship identity, geographical position, speed, course, and navigational status (Huang et al., 2021; Magryta-Mut, 2023). AIS is divided into Class A and Class B, with usage standards regulated in the SOLAS Convention by the International Maritime Organization (IMO, 2020). In Indonesia, the obligation to use AIS is affirmed through Minister of Transportation Regulation Number PM 7 of 2019.

Theoretically, AIS has a strategic role in increasing situational awareness, reducing collision risk, and supporting vessel traffic supervision by Vessel Traffic Services (VTS). Integration of AIS with radar systems and web-based monitoring dashboards even enables real-time visualization of vessel movements with high accuracy (Asana et al., 2025; Enda et al., 2021).

Although regulations have mandated the installation of AIS on Indonesian-flagged vessels of certain tonnages, implementation in the field is not yet fully optimal. Research by Yang (2019) shows there are still deficiencies in completing static and dynamic AIS data by ship operators, resulting in incomplete information being received.

Additionally, the practice of deactivating AIS during voyages is still found, for both technical and non-technical reasons. In terms of human resources, the lack of technical training for ship crews, especially Electro Technical Officers (ETO), also affects the effectiveness of operating this equipment. This condition indicates a gap between normative policy and operational practice in the field. Therefore, assessing the effectiveness of the AIS system is not enough to merely evaluate the presence of the device, but must also comprehensively evaluate technical, institutional, regulatory, and user competency aspects.

This study is novel in its evaluative approach, integrating the AIS system as part of what is needed to ensure safe maritime transportation at the national level. This is in contrast to much

of the literature that has focused on the creation of sensor-based AIS hardware or spatial analysis of movement data, in which technical performance and regulatory functions are treated as separate work streams and user behavior integration remains a secondary consideration. Additionally, the research was conducted in the field at ports and at the operational level of vessels, through observation at VTS Makassar, the center of vessel traffic control in eastern Indonesia.

That said, this research offers a more contextual empirical contribution to AIS implementation, not only from a technological perspective but also from a shipping safety management perspective in Indonesia. The significance of this integrative approach is further enhanced by its temporal context: Indonesia's maritime sector is at a critical juncture where the government has committed to e-Navigation transformation, yet empirical evidence on whether existing AIS infrastructure is ready to support this transformation—in terms of both technical reliability and human compliance—remains largely anecdotal. This study provides the systematic, field-grounded evidence base needed to inform that transition.

The case for this research grows increasingly strong due to the growing complexity of national shipping traffic and the demands for digitalization of the maritime sector. As one of the main components of integrated e-Navigation systems, AIS is at the forefront of supporting Indonesia's push toward an integrated e-Navigation transformation. Maritime infrastructure development policies risk being broad and off target without detailed, sustained evaluations of how effective such a system can be. In addition, poor supervision and non-compliance with AIS activation can undermine the credibility of national monitoring while compromising cross-agency collaboration. Therefore, this research is crucial for grounding policy recommendations in empirical evidence and real field needs.

This study aims to analyze the effectiveness of the AIS-based monitoring system in supporting maritime transportation safety in Indonesia, to identify technical and non-technical challenges to its implementation, and to produce strategic recommendations on complementary AIS functions within the national shipping safety framework.

This study makes both theoretical and practical contributions. Theoretically, this study adds value to the literature on maritime transportation safety and maritime information systems through its assessment of the effectiveness of AIS-based monitoring technology in archipelagic developing countries. The results provide practical, evidence-based information that can aid the Ministry of Transportation, port authorities, and operators in improving compliance, enhancing technical training quality, and the modernization of AIS in Indonesia. These contributions are critical, especially as Indonesia transitions toward integrated e-Navigation system implementation that relies on Automatic Identification System (AIS) as a key building block.

METHOD

Research Design, Location, and Time

A Qualitative, Descriptive Approach

This study employed a qualitative research design with a descriptive approach to explore the contextual realities of AIS in operational settings. This approach was preferred because the research questions necessitate an in-depth understanding of how practices related to technology use, compliance, and regulatory gaps are best captured through a combination of direct observations and informants' perspectives rather than through statistical measurement. This research strategy not only reveals the root problems but also provides practical recommendations arising from empirical fieldwork.

The study was carried out within the operational context of eastern Indonesian vessel traffic supervision, with a particular focus on VTS Makassar as the ship monitoring control center and commercial and pioneer ships operating within the region, such as KM Sabuk Nusantara and KM Tonasa Line. The site was selected for its high traffic density and navigational complexity, making it suitable for evaluating AIS system performance under conditions representative of real operational use.

The study was conducted over five months—from May to September 2025—encompassing preparation, field data collection, analysis, and recommendation writing, and

addressed the following aspects: the technical condition of AIS devices, compliance with operational regulations, the competence of human resources in the AIS system, and the integration between monitoring commands and port supervision mechanisms [38]. Given this scope, the research design was implemented not merely to capture the status quo but also to examine the congruence between normative policy and field-level operational practice.

Population, Sample, and Research Subjects

The population of this study consists of all stakeholders related to the operation and supervision of AIS in the shipping areas designated as study locations, namely ship operators, captains, watch officers, Electro-Technical Officers (ETOs), HB officers, and Vessel Traffic Service operators. The research sample was purposively determined based on the relevance of tasks performed, operational experience, and direct involvement in the use or supervision of the AIS system. This method was adopted so that the data collected would accurately reflect empirical realities and grounded perspectives on system effectiveness. The selected respondents included representatives of crews serving commercial and pioneer ships, VTS officers, and technical officials from sea transportation agencies responsible for developing AIS infrastructure.

The key factors examined in this research include the adequacy of user awareness of AIS functions, consistency in device activation during voyages, the availability and operational readiness of devices in relation to technology, and supervision and inspection mechanisms employed by port authorities. In particular, by engaging with stakeholders at different organizational levels, this research aims to develop a holistic mapping of the problem, such that the resulting solutions will not be piecemeal but integrative across technical, managerial, and regulatory dimensions. This approach provides an opportunity to triangulate perspectives from both shipboard users and their shore-based supervisors, allowing for affirmation or critique of how effectively the AIS system is achieving its objectives in supporting maritime safety.

Instruments, Data Collection Techniques, and Data Analysis Strategy

The research instruments consist of semi-structured interview guides, operational observation sheets, and document review formats used to examine regulations and shipping accident reports. Questionnaires were designed to collect information on AIS data usage practices, technical difficulties experienced, and perceptions of the system's role in supporting accident risk reduction and safe navigation where appropriate. Data collection was conducted through direct observation of AIS device operations in ship navigation bridges and a Vessel Traffic Service (VTS) control center, semi-structured interviews with crew members and supervisory officers, and review of formal records (including Port State Control reports and logs recorded automatically by each AIS device).

Data reduction was conducted as part of the analysis strategy, involving the classification and categorical organization of data into relevant thematic segments—such as technical conditions, human resource capability, and regulatory compliance—in order to identify relationships between variables and generate a coherent pattern of problems. Triangulation was employed to maintain data validity through cross-checking with informants for improved accuracy, and a questionnaire instrument reliability test was developed for specific questions aimed at eliciting consistent responses from each respondent. With this approach, this research does not merely describe observed scenarios but constructs an analytical framework to detect disconnections between regulation and practice and to articulate evidence-based strategic guidelines derived from fieldwork.

RESULTS AND DISCUSSION

Results

General Overview

This study aimed to assess how an AIS (Automatic Identification System)-based monitoring system functions in providing support for maritime transportation navigation safety, which is of great concern given the high demand in the archipelagic country of Indonesia. The data sources used are field observations, in-depth interviews with stakeholders, and questionnaires

distributed to shipping actors directly involved in operating and supervising AIS. Overall, this allows researchers to view the entire picture, including technical, regulatory, and operational perspectives.

As an archipelagic country, Indonesia needs technology—for example, AIS (Automatic Identification System)—to be managed well. The use of AIS is needed to maintain the safety and order of shipping traffic. This chapter will, therefore, methodically cover the scope of AIS use, the challenges encountered in implementing it, and how much this technology has contributed to safer shipping. A full and objective understanding is obtained by referencing the results of discussions with existing theories and findings.

The researchers noted that implementation of the technology in some major ports has proceeded according to regulation, but much practice still lags behind. The data obtained show that the level of understanding and use of AIS among state actors differs widely, which emphasizes the importance of future policy harmonization efforts and human resource capacity building. Several informants in interviews remarked that even though AIS is immensely useful in navigation, there are still technical barriers such as signal interference and inactive devices, as their activation was not made mandatory.

The results of this study in this section are linked to the research aims stated in the Introduction. The empirical findings collected not only portray the realities of AIS implementation but also lay the groundwork for carrying out analytical discussions and providing policy recommendations in later sections.

Discrepancy in AIS Usage at VTS Makassar

VTS (Vessel Traffic Services) Makassar, as the vessel traffic control center of the eastern Indonesian shipping area, yields one of the main findings of this study. The VTS Makassar facility had already been equipped with a monitoring system based on AIS (Automatic Identification System), but implementation on the ground reveals a gap between regulatory policy and operational reality. Through analysis of data collected from VTS officers via interviews and direct observations, it was determined that a significant number of ships navigating within the surveyed areas cannot be optimally detected by the existing AIS system. This problem extends beyond signal range; it is equally linked to behavioral issues and devices not conforming as required.

VTS officers stated that they regularly struggle to track ship movements, as the system screen does not display AIS data. This can occur for a number of reasons, such as the AIS transponder not having been switched on by the ship or the device being faulty. VTS is limited in its ability to send early warnings, direct ships to safety, or monitor sea traffic conditions when the system does not receive an AIS signal from a vessel. Information gaps in the domain of shipping safety can have a significant impact, with the potential for accidents or navigational incidents.

Furthermore, some vessels were identified as deliberately switching off AIS when traveling at night or in restricted waters. This occurs for purposes of evading port authority monitoring or out of ship security concerns, albeit in violation of applicable rules. These actions demonstrate the low level of awareness about the actual safety function of AIS. Many shipping actors still consider AIS more a form of administrative paperwork than an important instrument for maintaining operational safety at sea.

Interviews with VTS operators have also indicated that signal interference, limited communication infrastructure, and other technical constraints affect system reliability. Geographic conditions in the waters around Makassar—owing to land mass and steep topography—block VHF signals, so data transmitted from ships on these routes cannot be received by the control center. This highlights the fact that the operation of the AIS system relies not only on a transponder aboard the ship but also on available coastal infrastructure supporting it.

The situation is further compounded by weak supervision. Periodic and thorough inspections of shipborne AIS transponders are not carried out before ships enter ports. Since no systematic inspection mechanism has been put in place, many shipping operators continue to use substandard AIS devices without facing any sanctions from the authorities. Quite often, the AIS devices are also uncertified or refurbished units of very questionable quality.

This finding has very serious implications. The risk of collisions, shipping route violations, or other maritime accidents increases when ships fall outside AIS coverage. In addition, in emergency situations such as maritime accidents or loss of communication, search and rescue (SAR) operations will not be effective without integrated ship position data. Hence, rather than treating AIS as mere protocol, it should be considered a vital component of the shipping safety system.

As seen in the case of VTS Makassar, technology such as AIS can only effectively support vessel traffic and contribute to safety at sea if its effectiveness is underpinned by three key factors: the availability of adequate transponders capable of reporting ship speed over ground (SOG) and position, the awareness and discipline of users who are willing to utilize it, and supervision from the port authority, facilitated by adequate monitoring infrastructure. Unless these three factors work in synergy, the presence of AIS cannot optimally contribute to improving maritime transportation safety in Indonesia.

Based on this research, the conditions at VTS Makassar answer affirmatively the first and second research problem formulations, which concern how effectively AIS regulations (pasal) can be operationalized and what obstacles are encountered in their implementation. The research concludes that AIS is potentially a system that greatly aids navigation safety, but it fulfills its potential only through strict regulations and high user awareness. The most glaring challenge today relates to the gap between what regulations dictate and actual practice in the field, which requires immediate attention.

In summary, the findings of this study indicate that the discrepancy in the use of AIS at VTS Makassar is a reflection of broader structural and technical issues. If AIS faces serious challenges in a strategic area like Makassar, then conditions would likely be far more difficult in many more remote locations. Thus, improvements should be made in the form of holistic system strengthening, user education, and upgraded technological infrastructure.

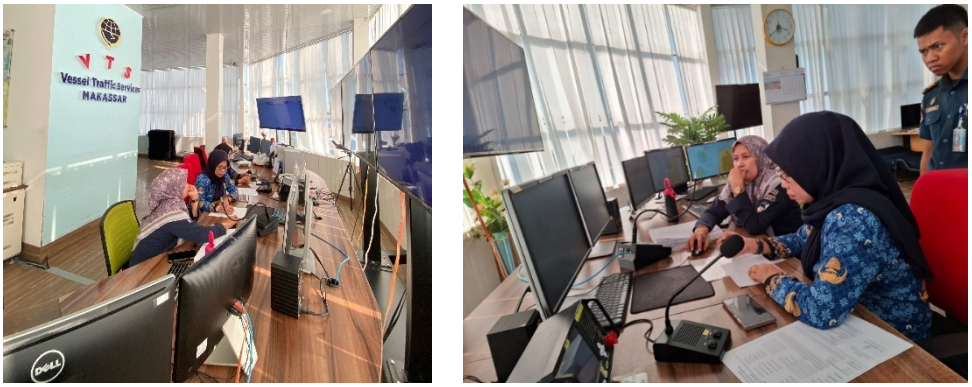

Figure 1. Observations Made by the Author Regarding the Use of AIS in VTS Makassar
Source: processed data

Figure 1 Content of an observation session at the VTS Makassar monitoring center, showing the AIS display interface, which includes information on vessel movements in the eastern Indonesian shipping area, as received by the operators in the context of detecting expected vessel signals absent from the monitoring screen—visually exemplifying gaps in what VTS officers describe as detected (as a function of observing audio and visual information sources) in interviews. Gray tracking areas seen in the figure are routes that vessels were later found to be navigating with non-operational or faulty AIS equipment. Evidence in the form of visual data serves a supportive role to qualitative findings about monitoring effectiveness at this facility.

Condition of AIS on KM Sabuk Nusantara

KM Sabuk Nusantara, as a pioneer shipping vessel serving inter-island routes in eastern Indonesia, is also one of the subjects of this research. Results from observation and interviews with the crew of the ship indicate that the AIS device installed on this ship has been drastically reduced in functionality. Although the device is physically still on, not all features function as they

should. Especially in terms of dynamic data transmission, such as ship speed and direction, delays or even data transmission failures to the monitoring system often occur.

One of the ship's officers stated that the AIS device on KM Sabuk Nusantara has not been updated for more than five years. This causes continuous technical disturbances without adequate maintenance. The absence of routine maintenance makes the device prone to damage. On several voyages, AIS only functions partially, or cannot be used at all. Devices that are unfit for use like this certainly can no longer perform their function as navigational aids and safety tools.

Another problem is the low level of understanding of the ship's crew regarding the importance of AIS. In interviews, some crew members admitted to only activating the device when within port range. When sailing in open waters, AIS is often turned off for technical or energy-saving reasons. Such practices indicate that AIS has not been positioned as a vital component in the shipping safety system, but merely as a complementary tool that is not always considered necessary to activate.

The ETO (Electro-Technical Officer) on the ship explained that many crew members have not received training on how AIS works and its overall operation. They only know how to turn the device on and off, but do not understand what data should be transmitted and how to read information from other ships. This lack of training directly impacts the effectiveness of AIS utilization on pioneer ships like Sabuk Nusantara.

Institutionally, KM Sabuk Nusantara is part of pioneer services managed by the government through a subsidy scheme. Ironically, although this service is dedicated to supporting national maritime connectivity, technical standards for safety devices such as AIS have not been a top priority. This suggests that there is a mismatch between the responsibility of public service and the safety standards established by agencies on a national and international basis.

Results obtained from this ship suggest that the regulatory requirement to use AIS has not yet been matched by a sufficiently high level of crew technical proficiency and expertise in using the equipment. AIS should be a piece of navigational equipment that must always be in use, especially given that Sabuk Nusantara's shipping routes operate in areas prone to extreme weather and in sea lanes with high-density commercial and fishing vessel traffic.

Within the domain of shipping safety, the continued operation of hardware past its service life is extremely hazardous. Ships unmonitored in real time are more susceptible to collisions and are difficult to reach in emergency conditions. Inaccurate ship position data can also affect the VTS system, which oversees overall vessel traffic movements. This is a systemic issue and requires a strategic response from the Ministry of Transportation, together with pioneer shipping operators.

In general, the state of AIS on KM Sabuk Nusantara represents what is found on many other public service vessels. Limited attention to AIS devices from both technical and human resource perspectives prevents this system from reaching optimal condition in protecting the ship's crew and passengers. As a result, national sea transport policy must prioritize equipment updates, human resource training, and the frequent monitoring of navigational aid compliance standards.

Table 1. Field Findings Regarding AIS Condition on KM Sabuk Nusantara

Aspect Observed	Finding	Data Source
Physical Condition of AIS Device	Device is over 5 years old and has never been recalibrated.	Direct observation & interview with ETO
Data Transmission Function	Transmission of dynamic data (speed, heading, position) often delayed or fails.	Device testing & AIS screen observation
Frequency of AIS Use	AIS not always activated during voyage, especially outside port range.	Interview with ship's watch officer
Crew Understanding of AIS	Majority of crew do not fully understand operational function of AIS, only know how to turn on/off.	Interviews with crew and ship officers
AIS Device Maintenance History	No routine maintenance records; only checked when crew reports function issues.	Interview with ship's ETO

Aspect Observed	Finding	Data Source
Compliance with AIS Regulations	No checking by Harbormaster regarding AIS activity during ship departure and arrival.	Interview with crew & port documentation
Signal Reliability Level	Frequent signal interference when ship is in inter-island waters, especially eastern areas.	Voyage observation & officer interview
Technical Readiness of HR Operating AIS	No formal technical training from authorized agencies; crew only learn from senior crew experience.	Interviews with senior crew and watch officers

Source: processed data

Figure 2. Observations Made by the Author Regarding the Condition of AIS in KM Sabuk Nusantara
Source: processed data

Discussion

Discrepancy in AIS Usage and Device Unserviceability

Based on direct observation results on KM Sabuk Nusantara and KM Tonasa Line, it was found that the Automatic Identification System (AIS) is not always operated in accordance with international regulations. During voyages, AIS on both ships was often turned off when on the open sea and only activated when the ship approached ports or during formal inspections. Interviews with ETOs cited reasons including electrical energy conservation, reduced risk of device damage from constant use, and a desire to avoid surveillance by outside agencies. However, the observation results indicate that this energy-saving rationale has almost no strong technical basis, as AIS power demand is very small compared to the overall ship electrical load.

This directly influences navigational safety, given that AIS is one of the primary instruments for collision avoidance. Switching off AIS prevents other ships from receiving real-time information on identity, position, and course and speed. In Makassar waters, several incidents between vessels were reported as close-quarters situations with a possibility of collision, where the ships involved did not have their AIS systems activated. This confirms VTS officers' statements that non-compliance by ship operators is one of the greatest obstacles to the further development of vessel traffic monitoring.

The captain of KM Sabuk Nusantara stated that some crew members regard AIS as vital only when sailing in congested waters or during inspections by the harbormaster, even though it was indicated that the vessel should have been operating it continuously since October 2023. Such a perception demonstrates a lack of understanding of AIS's function as a safety device required to be operated at all times in accordance with SOLAS Regulation V/19. Furthermore, ingrained habits and misinformation make compliance even worse.

The results of this study are consistent with Eka (2020), who found that 63% of commercial ship crews turn off AIS on the high seas in eastern Indonesia. Poor oversight was cited

as another leading cause in that study. In the international context, it is not uncommon for countries such as Japan and Singapore to impose administrative sanctions and heavy fines for every violation.

From a risk management perspective, this discrepancy in AIS usage leads not only to an inadequate level of safety among vessels but also to decreased coordination between ships and maritime authorities. When AIS is disabled, VTS loses crucial information needed for early collision warnings and traffic flow management.

A stronger case for this finding comes from the VTS Makassar case study. VTS data logs show that some ships, including the research subjects, did not transmit continuous AIS signals for 3 to 6 hours along these routes. This increases blind spots in monitoring and renders the Traffic Separation Scheme (TSS) process suboptimal.

Based on interviews, observations, and case studies, it is concluded that the actual discrepancy in AIS usage is not primarily caused by technical factors alone but is mainly a combined result of a lack of understanding regarding vessel AIS obligations and weak supervision. This habit could become normalized as an operational procedure that jeopardizes national shipping safety in the absence of robust regulatory action and oversight.

ATA-02 — Technical Condition of AIS Devices and Role of ETO

Direct observation results on KM Sabuk Nusantara and KM Tonasa Line revealed that the technical condition of the Automatic Identification System (AIS) was below ideal standards. All devices fitted on both vessels were older-generation units, over five years old, and had never received firmware updates. As there is no dedicated periodic maintenance schedule for AIS, repairs are performed only after the device completely breaks down—as expressed during interviews with ETOs. This approach means that AIS maintenance is far more reactive than preventive, which clearly contradicts best practices in modern navigation equipment management.

Based on interview results with the ETO on KM Sabuk Nusantara, it was stated that the unavailability of test equipment is one of the major obstacles. Only basic physical checks—such as inspecting cables, antennas, and power supply—can be performed when something goes wrong. Equipment limitations also mean that checks and recalibrations of internal functions cannot be performed on board. This leads to minor technical issues that are often deferred until the device is nearly unusable.

The same conditions were discovered on KM Tonasa Line. The ETO stated that obtaining spare parts is a challenge, causing the ship to remain in port for days awaiting delivery from shore before repairs can be carried out. In one instance, the AIS experienced internal GPS module problems for more than a month, forcing the ship to operate with incorrect position data. This study is consistent with Subekhan (2023), who reported that most ships in Indonesia do not have critical navigation spare parts available on board, including AIS components.

The observations also found that some AIS devices did not meet the latest IMO certification requirements. Not all devices are compatible with security-related messages or with ECDIS (Electronic Chart Display and Information System). According to IMO (2020), these features are essential for maintaining general maritime security.

Interviews with a number of Electro-Technical Officers (ETOs) indicated that the role is vital for maintaining AIS reliability, but few had attended specialized training on AIS. Their knowledge was derived solely from on-the-job experience or from reading device manuals. This leads to AIS problems being inadequately resolved. Rafoth (2021) also revealed that ETO technical competence is directly proportional to the speed and effectiveness of navigation equipment repairs, including AIS.

This limitation also undermines the reliability of the data transmitted to VTS. In one case involving KM Sabuk Nusantara, interference from the AIS antenna caused the ship's position data detected by VTS Makassar to be offset by up to 0.8 nautical miles from the actual position. Such an error could mislead vessel traffic control, particularly in congested lanes.

These findings indicate that technical issues with AIS and the limited role of ETOs are not only due to insufficient onboard facilities but also to weak company policies regarding proper

training and supporting equipment. To achieve national improvement in AIS reliability, the challenges of strengthening ETO competence, investing in adequate test equipment, and ensuring mandatory spare parts procurement must be addressed as a matter of priority.

The Performance of VTS Makassar Monitoring

The research results from case studies at VTS Makassar indicate that the accuracy of vessel traffic monitoring is strongly influenced by the consistency of AIS operation on ships. Data inadequacy was observed during the research period through examination of AIS data logs. In the ALKI II corridor, some vessels, including those used as research subjects (with approximately 3–6 hours of transmission-free time), did not broadcast their AIS signals while under way. VTS officers stated in interviews that the lack of these signals affects ship traffic management and increases the likelihood of close-quarters situations.

VTS officers stated that AIS is used not only for monitoring vessel position but also for identifying patterns of movement and detecting anything out of the ordinary, including ships deviating significantly from their route. Early detection capability is hampered when AIS is turned off, increasing the burden on officers, who must rely solely on conventional radar, which provides no information about ship identity.

Apart from ship compliance issues, there are also technical factors that hinder VTS Makassar. The maximum reception range of the VTS station's AIS antennas does not exceed 35–40 nautical miles, and reception is further reduced in poor weather conditions or heavy seas. In one case, a vessel that should have been tracked disappeared from the screen for minutes to hours before its signal was detected again. This condition is consistent with findings from Mantoro (2025), who reported that AIS blind spots in the ALKI II area account for 12% of the overall monitoring area.

Interviews additionally revealed that VTS Makassar does not yet have a computerized alert system capable of detecting vessels that abruptly switch off their AIS. At present, detection is done manually by monitoring the list of vessels that disappear from the screen. This requires more manpower and results in slower detection. For instance, VTS systems in developed countries such as South Korea have been integrated with automatic gap-detection algorithms that can raise alarms within seconds when a vessel within their jurisdiction ceases AIS transmission.

A further weakness is the absence of inter-agency coordination. When VTS determines that a ship is not transmitting AIS data, this is sometimes reported to port authorities or the harbormaster, but no immediate action follows. As such, violations of AIS usage often go unsanctioned.

Based on the survey and interview results, the performance of VTS Makassar is constrained by three factors: (1) ship non-compliance in operating AIS, (2) limited range and infrastructure of AIS receivers, and (3) weak data integration and coordination among maritime authorities. However, the significance of these three constraints is not limited to VTS Makassar alone: as the vessel traffic control center for eastern Indonesian waters, monitoring gaps at VTS Makassar carry a cascading impact throughout the ALKI II corridor—one of Indonesia's most congested archipelagic sea lanes. The monitoring capacity of this strategic node cannot be compromised; any deficiency significantly amplifies systemic maritime risk.

Under current conditions, VTS Makassar faces notable limitations in its role in supporting shipping safety. To address this, strategies are needed to enhance AIS infrastructure, integrate satellite technology, and deploy automated alert systems so that VTS can fulfill its actual functions of vessel traffic monitoring and control.

How the Findings Align with National and International Regulations

This study's results reveal an inconsistency between regulatory stipulations regarding the Automatic Identification System (AIS) and field practice. At the international level, SOLAS Regulation V/19, as mandated by the International Maritime Organization (IMO), specifically requires vessels of certain tonnages to operate AIS at all times. All IMO member states are subject to this regulation, including Indonesia. However, observations on KM Sabuk Nusantara and KM Tonasa Line show that this provision is not being implemented consistently.

Interviews with harbormaster officers and ETOs found that the technical condition of AIS is rarely examined during Port State Control (PSC) inspections. Inspections typically focus on the most basic functions and do not verify whether data is transmitted correctly. This allows broken or inoperable devices to remain in service, simply because they power on when checked.

At the national level, the Directorate General of Sea Transportation, through its technical guidelines, regulates the installation and operation as well as reporting standards for AIS units. However, the results of the case study at VTS Makassar show that there is no strong mechanism to penalize ships that turn off AIS during voyages. VTS officers stated in interviews that this frequently leads to poor follow-up on violations.

A comparison with other countries reveals substantial differences. In Singapore, for example, AIS usage violations are punishable by hefty fines, suspension of sailing permits, and revocation of vessel seaworthiness certificates. It is this strict enforcement framework that compels ship operators to comply.

Agustirani (2025) reinforce this finding by stating that Indonesia's weak law enforcement system significantly influences the low level of compliance among ship operators with AIS operation obligations. This also aligns with the interview results in the first section of this study, where ship crew typically prioritize operational convenience over regulatory compliance.

Furthermore, technical standards for AIS devices in Indonesia have not been updated to reflect the latest revisions established by the IMO. A number of devices on vessels continue to use legacy versions that lack advanced safety features such as safety message transmission and ECDIS integration. This gap affects the quality of information available to VTS.

From these results, it is evident that harmonizing national regulations with international standards, enhancing inspections, and imposing stringent sanctions are urgent measures to ensure AIS compliance and alignment with the global shipping safety framework.

Implications for Maritime Transportation Safety

The results of this research directly impact shipping safety in Indonesia. First, non-compliance in AIS operation leads to a higher likelihood of collisions between ships, as the analysis shows that such violations are prevalent on busy shipping routes such as those running through the Makassar Strait, one of Indonesia's primary Alur Laut Kepulauan Indonesia (ALKI) routes. When position information is inaccurate, it becomes impossible to maneuver out of the way.

Second, unserviceable AIS devices can feed incorrect information to VTS and consequently influence vessel traffic control decisions. An actual instance of incorrect data causing a safety concern is the position deviation of up to 0.8 nautical miles documented in this study's observation process.

Third, limited VTS infrastructure expands monitoring blind spots. This is extremely unsafe, as vessels that switch off their AIS can travel for hours undetected, posing a danger especially when carrying dangerous goods or crossing busy shipping channels.

Fourth, weak enforcement of regulations fosters an operational environment in which violations are routine and accepted as normal practice. This runs counter to global maritime safety culture principles.

Fifth, from a maritime security perspective, AIS also serves as a tool against smuggling and illegal fishing. Without AIS, these activities go largely unsupervised, potentially posing risks to economic and national security.

Sixth, inefficient utilization of AIS may damage Indonesia's reputation in the international shipping community. This could potentially affect trade flows and investment in the maritime sector, as trading partner countries may perceive Indonesian waters as high-risk for shipping.

Finally, these considerations call for urgent policy reform, infrastructure improvement, and enhanced training for ship crews, particularly ETOs and navigation officers so that AIS can be optimally utilized to ensure shipping safety under national maritime governance.

CONCLUSION

This research examined the implementation of an AIS-based monitoring system to improve maritime transportation safety in Indonesia, identified its limitations, and proposed strategies for operational optimization. Data collected through field observations, in-depth interviews, and document review conducted at VTS Makassar, KM Sabuk Nusantara, and KM Tonasa Line indicate that AIS is significant in increasing navigational awareness, strengthening vessel traffic supervision, and assisting search and rescue coordination. However, this functional contribution is significantly hindered by enduring implementation gaps: AIS devices operating below technical standards as a result of age and lack of maintenance, limited ETO competence in device management, signal interference in remote eastern Indonesian waters, inconsistent activation practices by ship crews, and weak regulatory enforcement at both national and port levels.

This indicates that AIS infrastructure is technically established but continues to be operated in a suboptimal manner and cannot yet be considered an integral part of Indonesia's maritime safety architecture. Expanding regulatory enforcement tools, requiring mandatory periodic AIS technical refresher training for ETOs and navigation officers, prioritizing investment in upgrades to the existing shore-based infrastructure especially at locations with remote receiving stations and the application of automated compliance monitoring within VTS systems are arguably the most pressing near-term policy challenges that need to be overcome to ensure that AIS delivers its full safety promise.

ACKNOWLEDGEMENT

The authors sincerely thank the Ministry of Transportation of the Republic of Indonesia, Directorate General of Sea Transportation, and all staff at VTS Makassar for their support and indispensable contribution to this work. We extend our sincere appreciation to all the maritime personnel, ship operators, crews and regulatory officers who participated in this research, giving their time generously and sharing their insights. The constructive comments of the anonymous reviewers were greatly appreciated and helped to improve the quality of this paper.

AUTHOR CONTRIBUTION STATEMENT

Formulated the research, contributed to the study design, mediated that data collection analysis and interpretation of results were also claimed by Tri Iriani Eka Wahyuni. Literature review, domain knowledge in AIS technology and development of the research frameworkby Sidrotul Muntaha and Amiruddin. Data collection and analysis were conducted by Irwan Jaya, and supported in terms of methodology and result interpretation by Andi Hasmawati. Disclosure of conflict of interest All authors contributed to writing, revising and final approval of the manuscript.

REFERENCES

Agustirani, M., Desta, S., & Asyikin, A. (2025). Evaluation of Compliance with IMO FAL Regulations in International Shipping Standards: A Comparative Study between Indonesia and Singapore. *Journal of Maritime Policy Science*, *2*(3), 158–169. https://doi.org/10.31629/jmps.v2i3.8064

Asana, I. M. D. P., Widyantara, I. M. O., Linawati, L., Wiharta, D. M., & Wikananda, I. G. N. S. (2025). Real-Time Web-Based Ship Collision Risk Detection Using AIS Data and Collision Risk Index (CRI). *Sinkron: Jurnal Dan Penelitian Teknik Informatika*, *9*(4), 1942–1952. https://doi.org/10.33395/sinkron.v9i4.15106

Bye, R. J., & Aalberg, A. L. (2018). Maritime navigation accidents and risk indicators: An exploratory statistical analysis using AIS data and accident reports. *Reliability Engineering & System Safety*, *176*, 174–186. https://doi.org/10.1016/j.ress.2018.03.033

Ditjen Hubla. (2022). Statistik Transportasi Laut Indonesia. Kementerian Perhubungan RI.

Durlik, I., Miller, T., Kostecka, E., & Tuński, T. (2024). Artificial intelligence in maritime transportation: A comprehensive review of safety and risk management applications. *Applied Sciences*, *14*(18), 8420. https://doi.org/10.3390/app14188420

Eka, S. (2020). Analisis Pengaruh Regulasi, Kenavigasian, Anak Buah Kapal, Alur Pelayaran

Terhadap Keselamatan Pelayaran. *Skripsi*.

Enda, D., Agustiawan, A., Milchan, M., & Pratiwi, E. (2021). Rancang bangun aplikasi AIS backend untuk pemantauan lalu lintas kapal di Selat Melaka. *INOVTEK Polbeng-Seri Informatika*, *6*(2), 284–294.

Formela, K., Weintrit, A., & Neumann, T. (2019). Overview of definitions of maritime safety, safety at sea, navigational safety and safety in general. *TransNav: International Journal on Marine Navigation and Safety of Sea Transportation*, *13*(2), 285–290.

Huang, Z., Hu, Q., Mei, Q., Yang, C., & Wu, Z. (2021). Identity recognition on waterways: A novel ship information tracking method based on multimodal data. *The Journal of Navigation*, *74*(6), 1336–1352. https://doi.org/10.1017/S0373463321000503

International Maritime Organization. (2020). SOLAS Consolidated Edition 2020. London: IMO Publishing.

Khan, R. U., Yin, J., & Mustafa, F. S. (2021). Accident and pollution risk assessment for hazardous cargo in a port environment. *PLoS One*, *16*(6), e0252732. https://doi.org/10.1371/journal.pone.0252732

Magryta-Mut, B. (2023). Modeling safety of port and maritime transportation systems. *Zeszyty Naukowe Akademii Morskiej w Szczecinie*. https://doi.org/10.17402/565

Mantoro, B., Indrawan, R., Octora, T. Y., & Saputra, D. (2025). Implementation of Indonesia Ship Reporting System (IndoSRep) in the Archipelagic Sea Lanes Passage of Indonesia (ALKI). *KnE Social Sciences*, *10*(18), 326–344.

Moreno, F. C., Gonzalez, J. R., Muro, J. S., & Maza, J. A. G. (2022). Relationship between human factors and a safe performance of vessel traffic service operators: A systematic qualitative-based review in maritime safety. *Safety Science*, *155*, 105892. https://doi.org/10.1016/j.ssci.2022.105892

Ozbas, B. (2013). Safety risk analysis of maritime transportation: review of the literature. *Transportation Research Record*, *2326*(1), 32–38.

Purba, D. (2025). Integrating AIS-Based Probabilistic Collision Risk Assessment into Maritime Safety Education and Traffic Management. *Meteor STIP Marunda*, *18*(2), 41–51. https://doi.org/10.36101/msm.v18i2.447

Rafoth, A., & Borchardt, J. (2021). *New education tools for electro-technical officer (ETO)*.

Subekhan, C., Sh, M. H., & Mar, M. (2023). *Perspektif Regulasi Manajemen Keselamatan Kapal Niaga di Indonesia-Damera Press*. Damera Press.

Wang, S., Yin, J., & Khan, R. U. (2020). The multi-state maritime transportation system risk assessment and safety analysis. *Sustainability*, *12*(14), 5728. https://doi.org/10.3390/su12145728

Xu, M., Ma, X., Zhao, Y., & Qiao, W. (2023). A systematic literature review of maritime transportation safety management. *Journal of Marine Science and Engineering*, *11*(12), 2311. https://doi.org/10.3390/jmse11122311

Yang, D., Wu, L., Wang, S., Jia, H., & Li, K. X. (2019). How big data enriches maritime research–a critical review of Automatic Identification System (AIS) data applications. *Transport Reviews*, *39*(6), 755–773. https://doi.org/10.1080/01441647.2019.1649315

Zhong, Y., Zhou, H., Grifoll, M., Martín, A., Zhou, Y., Liu, J., & Zheng, P. (2025). A novel method for holistic collision risk assessment in the precautionary area using AIS data. *Systems*, *13*(5), 338. https://doi.org/10.3390/systems13050338