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The effectiveness of automatic identification system use on ship surveillance in navigation district type a class 1 Makassar

Subehana Rachman[1*], Haerani Asri[2], Meti Kendek[3], Annisa Rahmah[4], Oktavera Sulistiana[5]
[1,2,4,5]Politeknik Ilmu Pelayaran Makassar, Makassar, Indonesia; subehana@pipmakassar.ac.id (S.R.)
haeraniasri25316@gmail.com (H.A.) rahmah.annisa45@gmail.com (A.R.) oktaverasulistiana@pipmakassar.ac.id (O.S.)
[3]Politeknik Ilmu Pelayaran Barombong, Makassar, Indonesia; metikendek22@gmail.com (M.K.)

Abstract: This study aims to evaluate the effectiveness of the Automatic Identification System (AIS) in supporting ship surveillance activities within the Navigation District Type A Class 1 Makassar. The primary objective is to assess how AIS contributes to enhancing maritime safety, improving vessel monitoring accuracy, and supporting decision-making processes for navigation authorities. A qualitative-descriptive methodology was employed, combining field observations, document analysis, and structured interviews with relevant stakeholders, including district officers and vessel operators. Data collected was analyzed to determine the system's strengths, limitations, and overall impact on operational performance. The results show that AIS significantly enhances ship surveillance capabilities, particularly in high-density maritime routes such as the Makassar Strait. The system enables real-time tracking of vessel movements, facilitates the identification of illegal or unregistered ships, and improves communication during emergencies. Nevertheless, the research identified several challenges, including limited AIS coverage in remote areas, outdated equipment on smaller vessels, and the need for continuous technical training for operators. The study concludes that AIS is a vital tool in ensuring maritime safety and efficiency in the Makassar region. Practical implications include the need for infrastructure upgrades, policy improvements, and capacity building. These findings are expected to support future developments in maritime surveillance systems across Indonesia's navigation districts.

Keywords: *AIS usage, Regulation, Situational awareness raising, Vessel identification, Vessel traffic management.*

1. Introduction

In the context of cargo and passenger transportation, shipping is a critical sector of the global economy. The volume of maritime traffic has experienced a significant increase in recent years, which has led to a higher density of ships and a higher risk of accidents in the water. Consequently, ship surveillance has become increasingly critical in order to safeguard the maritime environment and guarantee shipping safety and security [1]. For decades, maritime authorities and the industry have encountered difficulties in effectively monitoring and tracking ship movements, particularly in international waters and border areas [2]. The implementation of more sophisticated and automated monitoring systems has created opportunities to enhance the effectiveness of ship surveillance as a result of the advancements in information and communication technology [3].

The maritime industry has widely adopted the Automatic Identification System (AIS), a radio-based ship tracking system, to enhance situational awareness. This system has established the global standard for the exchange of navigation information between ships and coast stations, as well as for the identification and tracking of ships [4]. AIS is a transponder system that transmits information regarding a ship's identity, position, speed, and direction to a receiving station on land, other ships, and satellites. Maritime industry players and authorities can employ AIS to monitor and track ship movements [5] thereby reducing the risk of accidents, theft, pollution, and violations of maritime law,

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* Correspondence: subehana@pipmakassar.ac.id

and supporting appropriate decision-making. Despite the recognition of AIS as a valuable instrument for ship surveillance, its implementation still faces numerous challenges. Frequently encountered issues include data errors, data manipulation by rogue ships, limited AIS signal coverage, ignored regulations on AIS use, and a shortage of trained human resources to operate this tool [6]. Additionally, some ships fail to activate AIS [7]. Consequently, it is imperative to consistently assess the efficacy of AIS in the surveillance of ships in a variety of regions to guarantee that this system delivers the most advantageous results.

Type A-Class I Navigation of Makassar is a critical region for Indonesian shipping, particularly due to its strategic location as a maritime transportation hub in eastern Indonesia. A variety of ship supervision challenges confront this region, including severe weather changes, complex geographical conditions, and an increase in maritime traffic. As evidenced by the 426 ships that entered the port in January 2023, the 221 ships that anchored, and the 446 ships that departed (Data from VTS Makassar, 2023), the port of Makassar is located in an area with a high volume of maritime traffic. In the course of its responsibilities as a controller and supervisor of shipping traffic, the Type A-Class I Navigation of Makassar in the VTS (Vessel Traffic System) unit has identified numerous instances of ship issues [8]. One such incident involved the Sabuk Nusantara 66 motorboat, which nearly went aground due to its departure from the predetermined shipping route. An additional incident involved a vessel that was prohibited from anchoring in a designated lane [9]. This occurred as a result of the ship's negligence. This is the location where VTS serves as a controller and supervisor of ship traffic in the Makassar waters, particularly the Makassar port area. Consequently, it is crucial to conduct research on the efficacy of AIS use for ship surveillance in the Type A-Class I Navigation of Makassar to identify potential enhancements and recommendations for optimal maritime traffic management practices in this region. This motivates researchers to investigate "the effectiveness of using Automatic Identification System (AIS) on ship supervision in type A-class I navigation of Makassar".

1.1. Problem Formulation

Based on the background above, the problem formulations in this study are: 1) To what extent is the effectiveness of the use of AIS in supporting ship surveillance in the Makassar Type A Class 1 Navigation District?; 2) What is the role of regulations and policies related to the use of AIS in the implementation of ship surveillance?; and 3) What are the obstacles and obstacles faced in the application and use of AIS for ship surveillance?.

2. Literature Review

2.1. Automatic Identification System (AIS)

The International Maritime Organization (IMO) uses the Automatic Identification System (AIS) on ships and other navigation aids to improve navigation safety and efficiency. AIS is a communication system that uses transponder technology to identify, track, and monitor ships, exchange information between ships and land stations, and transmit real-time data about the position, speed, and direction of vessels [10]. AIS has the potential to enhance maritime safety and prevent accidents at sea [11]. The development of AIS began in the 1990s as a response to the need for advanced vessel tracking and identification systems. In 2000, the IMO mandated the installation of AIS on all passenger ships and ships exceeding 300 GT. AIS technology has undergone rapid evolution, resulting in enhanced data quality and seamless integration with other surveillance systems [12].

The AIS has become an essential component of maritime navigation and safety systems, used in various sectors such as environmental monitoring, law enforcement, search and rescue operations, and navigation and vessel identification. The maritime industry's expanding requirements and technological advancements will continue to stimulate innovation in AIS systems, including data analytics and artificial intelligence [13] the integration of new technologies like the Internet of Things (IoT) [3] and the enhancement of signal reliability [14]. It is crucial to identify a ship's AIS type before studying its principles or functionality. AIS type A and type B work by sending and receiving ship data

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automatically, working on channels 161.975 Mhz and Channel 87B respectively [15]. The information obtained includes ship name, call sign, nationality, MMSI, IMO number, ship weight, ship length, ship width, ship draft, navigation status, ship coordinates, ship destination, ETA, ship speed, and ship heading direction.

AIS operates on VHF radio waves for communication at sea, with ships equipped with an AIS transponder sending information such as ship name, identification number, position, speed, direction, and other information to other ships and AIS coast stations. This information is processed and displayed on a ship monitoring system, allowing real-time monitoring of ship movements [16]. The working principle of AIS involves several stages: AIS signal transmission from ships, reception of AIS signals by other ships or coast stations, AIS information management, exchange of AIS information between vessels, and dissemination of AIS information to authorities [17]. The AIS antenna captures signals from other vessels, the transponder processes the information, and the ship monitoring system displays relevant information [18]. AIS information can be exchanged between vessels to minimize collision risks, and the information is then integrated with the ship's monitoring system [19]. Analyzing the information can help in decision-making, such as predicting collisions and identifying unregistered or suspicious ships.

2.2. Implementation of AIS Enforcement

The International Maritime Organization (IMO) has approved the International Convention for the Safety of Life at Sea (SOLAS), which regulates the use of Automatic Identification System (AIS) [20]. Initially, AIS was only required for ships with a gross displacement of over 300 tons or passenger ships with a passenger capacity of more than 12 people. In 2004, AIS was made mandatory for all ships operating in international waters. In 2014, AIS was required for commercial ships with a size of over 500 gross tons. Indonesian waters are subject to rules requiring ships to have an automatic identification system (AIS). These rules are outlined in the International Maritime Organization Resolution A.1155 (32) on Procedures for PSC and its amendments, and the International Maritime Organization Resolution A.1106 (29) on Revised Guidelines for the onboard operational use of shipborne automatic identification system (AIS) and its amendments.

Indonesian waters are the territorial seas of Indonesia along with its archipelagic waters and inland waters. AIS is a very high frequency (VHF) radio transmitter system that transmits data via VHF data link (VDL) to automatically send and receive information to other ships, Vessel Traffic Service (VTS), and/or coastal radio stations (SROP) [8]. AIS Class A and Class B are used to transmit static and dynamic ship data. A ship is a water vehicle driven by wind power, mechanical power, other energy, pulled or towed, including vehicles with dynamic support, underwater vehicles, and floating equipment and structures that do not move [21]. An Indonesian-flagged ship is a ship registered in the Indonesian ship list, while a foreign ship is a ship that flies a flag other than the Indonesian flag and is not recorded in the Indonesian ship list [22]. Port State Control (PSC) is state supervision of the seaworthiness and security of foreign ships entering the port area to ensure fulfillment of requirements in accordance with the convention implemented by the harbor master [23]. The official inspecting the seaworthiness and security of foreign ships or port state control officer (PSCO) is a civil servant within the Directorate General of Sea Transportation appointed by the harbor master.

AIS installation and activation can be monitored by terrestrial AIS devices located at the coastal radio station (SROP) and the Vessel Traffic Service (VTS) station, as well as by satellite. Sea and coast guard patrol vessels can also keep an eye on things. If the AIS on the ship is not functioning, the captain must record it in the ship's logbook and inform the coastal radio station or VTS at the first opportunity [8]. If the violation of the installation and activation is intentionally carried out by the captain, the sanctions given will be in the form of administrative sanctions or follow up through the maritime court such as temporary freezing of the certificate of confirmation (COE), administrative fines, and/or revocation of the certificate of confirmation (COE).

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2.3. Benefits of Using AIS in Ship Surveillance

AIS (Automatic Identification System) is a crucial technology used by ships and shore monitoring stations to exchange navigation information and ship surveillance. It offers numerous benefits for shipping safety [23] including vessel identification and tracking [10] improving situational awareness [24] ship-to-shore communication [25] collision prevention [26] maritime traffic management [23] search and rescue [10] environmental protection [27] and maritime security [28]. AIS allows vessels to track their movements in real-time, providing valuable information for controlling shipping traffic and reducing accident risks [29]. It also facilitates communication between ships and shore monitoring stations, allowing for quick communication about sea conditions, weather, and navigational obstacles [30]. AIS also aids in maritime traffic management, enabling vessels to manage traffic efficiently and reduce congestion in busy waters. By providing navigational assistance, warnings, and recommendations to vessels involved in difficult or risky situations, AIS increases situational awareness for all parties involved. In emergencies [31]. AIS information can assist in search and rescue operations, as the last recorded location of a vessel in the AIS system can help rescue teams find victims more quickly [32]. Additionally, AIS helps prevent environmental pollution from oil spills, waste discharges, or accidents, as well as damage to marine ecosystems.

Maritime security is enhanced by AIS, helping navigation districts and security authorities identify suspicious or non-compliant vessels, allowing authorities to take necessary actions to maintain safety and order in the waters. Technology development and innovation are essential for improving situational awareness and shipping safety in the maritime world [33]. The use of data analytics, artificial intelligence, and IoT technology can enhance AIS systems and optimize maritime traffic surveillance. AIS promotes a culture of safety among ship crews, operators, and relevant authorities, fostering a stronger safety culture that reduces accident risks, protects the environment, and ensures the sustainability of the maritime industry. AIS also reduces the risk of environmental accidents by allowing crews and authorities to detect and avoid situations that could lead to accidents, such as collisions with reefs, beaches, or underwater structures. By increasing situational awareness, AIS helps prevent accidents that could cause significant environmental damage [31]. Maritime education and training are also crucial aspects of AIS's role in the maritime industry [34]. By teaching crews about situational awareness, decision-making, and effective communication techniques, AIS prepares them to deal with challenging situations at sea and reduces accident risks. In conclusion, AIS has proven to be a critical technology in the maritime industry, contributing significantly to situational awareness, shipping safety, and sustainability.

2.4. Effectiveness of Using AI in Ship Surveillance

The use of Automatic Identification System (AIS) in ship surveillance has numerous benefits, including increased security and safety, reduced risk of accidents, theft, pollution, and violations of maritime law. However, the effectiveness of AIS use is influenced by obstacles such as data errors, data manipulation by rogue ships, limited AIS signal coverage, and difficulties in integrating AIS with other information systems. Additionally, studies have noted the potential for misuse of AIS by irresponsible parties like pirates, smugglers, and terrorists [35-37]. The Navigation District Office is an institution established by the government to implement laws and regulations to ensure shipping safety [38]. Its tasks include planning, operation, procurement, and supervision of navigation aids, shipping telecommunications, marine observation activities, hydrographic surveys, and monitoring of routes and crossings using installation facilities for shipping safety. The office has several functions, including preparation of operational plans and programs, needs planning, implementation of operating and maintenance programs, sea observations and hydrographic surveys, logistics affairs, analysis and evaluation of operation, manning and maintenance of navigation aids, financial affairs, personnel, secretariat, household, public relations, data collection and processing, documentation, and preparation of reports.

Vessel Traffic Service (VTS) is one unit in the navigation district office that monitors shipping

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traffic implemented by the port or shipping fleet management. The VTS system uses Radar, radio frequency (VHF), and automatic identification system (AIS) to find out or follow ship movements and provide navigation information. The use of VTS internationally is regulated based on recommendations from SOLAS Chapter V Reg. 12 and IMO Resolution A.857 (20) [8]. This system is crucial to encourage the implementation of AIS usage rules for ships sailing in domestic and foreign waters for almost all types of ships. Shipping safety is a crucial aspect of the marine industry, aiming to prevent accidents, protect human lives, maintain the marine environment, and protect property [39]. International bodies like the International Maritime Organization (IMO) play a significant role in developing and promoting shipping safety standards [40]. Key regulations include SOLAS (International Convention for the Safety of Life at Sea), COLREGs (International Regulations for Preventing Collusions at Sea), ISM Code (International Safety Management Code), and ISPS Code (International Ship and Port Facility Security Code).

Shipping safety and security are essential for smooth sea transportation and preventing accidents. The determination of shipping lanes ensures safety by providing corridors for ships sailing across waters and marking for navigational hazards [41]. Implementation of shipping lanes includes program activities, arrangement, construction, operation, and maintenance, ensuring the capacity and capability of the lane based on the ship's weight. Regulation of the use of waters for transportation determines shipping lanes in the sea, rivers, and lakes, and conducts hydrographic surveys to update data on water conditions for sailing safety. Maritime safety guarantees the safety of various activities at sea, including shipping activities, exploration and exploitation of natural and biological resources, and environmental conservation. Maritime governance and law enforcement are needed to ensure safety, security, order, and protection of the marine environment. Compliance with shipping safety regulations is key to maintaining the integrity and security of maritime activities worldwide.

3. Methodology

3.1. Research Design

In carrying out research, a research design is needed to assist in determining research steps. This research design is expected to facilitate and be able to achieve the target by what is desired. To facilitate this research activity, it will be carried out in an organized manner, namely in the form of systematic stages, in the form of:

1) Collecting initial research data based on existing literature and documents as a basis for determining research methodology.
2) Collecting data from the field, which is then processed with an appropriate and interrelated methodology and then analyzed.
3) The discussion is carried out by presenting the results of data analysis from both approaches, namely the quantitative approach and the qualitative approach.

To be able to better direct the course of research and be able to produce careful and thorough research results, a research conceptual framework is needed as a guide in its implementation. The conceptual framework is prepared and equipped as a basis for conducting research, including various factors that affect the direction/objectives of the research to be achieved, as in the previous chapter.

3.2. Type of Research

The type of research used in this study is mixed methods, which is a research approach that combines elements of qualitative and quantitative research in one study. This approach is designed to utilize the strengths of both types of research and produce a more comprehensive understanding of the phenomenon under study.

Mixed methods research is a flexible and comprehensive approach that allows researchers to delve deeper into complex phenomena by combining the strengths of qualitative and quantitative methods.

This quantitative approach begins with collecting data and then analyzing it using descriptive statistics to assess the effectiveness of using AIS in ship surveillance at VTS Makassar. The qualitative

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approach is carried out by collecting qualitative data through interviews or observations of several samples/informants at the Makassar VTS type A class I office.

3.3. Research Location and Time

3.3.1. Research Location

The place of this research is Makassar at the navigation district office, class I type A.

3.3.2. Research Time

The research time was carried out for approximately 8 months, starting from data collection, data processing, and preparation of research reports. The Research Proposal was carried out in May 2023, followed by data collection in August 2023, and will be disseminated in November 2023. Target completion of the improvement of seminar results in November 2023.

3.4. Population and Sample

In conducting a research activity, it is not possible to study all individuals or the total number of research objects. The total number of objects studied is called the population.

1) Population, The population in this study was people who worked at the Makassar navigation district office in the VTS unit.
2) Samples, The sampling technique in this study was random sampling, namely random sampling, and as the sample was Ka. unit VTS traffic, people who operate AIS at VTS Makassar, and AIS technicians, with a total sample of 20 people.

3.5. Research Variables and Operational Definition of Variables

The variables of this study include the dependent variable of the effectiveness of the use of AIS for ship surveillance and ship safety, and three interconnected independent variables, namely increased situational awareness (awareness), shipping traffic management, and AIS-related regulations.

1) The effective use of AIS for ship surveillance and ship safety is an automatic tracking system used on ships to exchange information with other ships, as well as with shore stations, to improve the safety of navigation and ship surveillance, and increase efficiency and safety.
2) Situational awareness (*awareness*) is the process of increasing an individual's or group's understanding or comprehension of the situation around them. Situational awareness is the ability to notice, understand, and respond appropriately and effectively to the surrounding environment.
3) Shipping traffic management is a management system that aims to improve the safety and efficiency of ship traffic in certain waters, which includes various activities, such as monitoring ship traffic, regulating ship traffic, and controlling ship navigation
4) AIS-related regulations are rules or regulations set by governments, regulatory bodies, or international organizations to govern the use and operation of AIS systems on ships operating in certain waters. It aims to improve the safety and efficiency of vessel traffic and facilitate better maritime surveillance.

3.6. Data Collection Methods

The data collection methods used in this study are:

1) Literature study, namely studying reference books and documents that have to do with the object under study. This is done to obtain theoretical foundations that are able to provide an overview of the effectiveness of AIS in ship surveillance.
2) Observation, namely by making direct observations on the object of research to see up close the activities carried out. Observation in this study is used to see the symptoms and problems that exist at the research location when conducting a preliminary study. Then researchers also use observation to observe and collect data, which aims to support and reinforce data to determine the effectiveness of using AIS for ship surveillance at VTS Makassar.

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3) Interviews, namely in-depth interview activities conducted by the research team when collecting data in the field with related parties related to the use of AIS for ship supervision and safety.
4) Questionnaires, namely, researchers making questionnaire questions on each variable to be studied using a Likert scale. The form of this scale is a value range of 1 to 5, where each question consists of 5 choice items which are categorized as follows: Choice A value = 1, Choice B value = 2, Choice C value = 3, Choice D value = 4, and Choice E value = 5. If the positive statement is scored 5 and so on, and if the negative statement is scored 1.

3.7. Data Analysis Technique

The form of data analysis technique used in solving the problems in this study is to use Quantitative and qualitative descriptive analysis methods based on secondary and primary data obtained. The data will be presented in the form of numbers, which are then interpreted in a description.

This quantitative approach begins with collecting data and then analyzing it using descriptive statistics. This analysis technique will provide an initial description for each variable in the study, Each variable will be seen from the Mean, (average), median, mode, standard deviation of the maximum and minimum values for each variable studied.

The qualitative approach is carried out by collecting qualitative data through interviews or observations of several samples/informants at the Makassar VTS type A class I office. Data obtained through interviews is analyzed and interpreted to understand certain phenomena or concepts. In the context of the effectiveness of the use of AIS in ship surveillance at VTS Makassar navigation district, data analysis techniques can be used to explore in-depth understanding of how the use of *AIS* (*Automatic Identification System*) on surveillance and its function to identify and track ships, increase awareness, shipping traffic management, and its influence on regulations on AIS.

4. Results and Discussion

4.1. Results

4.1.1. Automatic Identification System

According to the *International Maritime Organization* (*IMO*), *Automatic Identification System* (AIS) is an automatic identification system used on ships and other aids to navigation to improve the safety of navigation and the efficiency of ship traffic.

IMO views the *Automatic Identification System* (AIS) as a communication system based on transponder technology to identify, track and monitor ships and exchange information between ships and ground stations. AIS uses the Global *Navigation Satellite System (GNSS)* to provide *real-time* position, speed and course information of ships [42].

AIS is a technology used to detect and track the position of ships in *real-time* by utilizing radio signals, AIS has great potential to improve shipping safety and prevent accidents at sea, [43].

The above opinion views AIS as a system that allows ships to communicate and see each other at sea. AIS has important benefits in improving communication and coordination between ships at sea.

AIS (*Automatic Identification System)* is a system used to detect and monitor ships at sea using radio signals sent and received by ships, [36].

Yan, et al. [44] AIS is an automatic identification system used to monitor ships and improve shipping safety by providing accurate and real-time information about ships at sea. This opinion views that AIS has great potential to improve shipping safety by providing accurate and real-time information about ships at sea. The information transmitted through AIS includes the vessel's identity, position, speed, course, and destination, as well as other relevant navigational information. AIS can be used by authorities and maritime industry players to monitor and track vessel movements, support decision-making, and reduce the risk of accidents, theft, pollution, and maritime law violations.

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4.1.2. Shipping Safety

Shipping Safety is defined as a state of fulfillment of safety and security requirements concerning water transportation and port. There are many causes of ship accidents, due to the disregard of the necessity for each vehicle on board to be lashed, to the issue of placing goods that do not take into account the ship's weight point and stable arm force. Thus, the cause of a ship accident cannot be stated with certainty, but needs to be assessed.

Shipping safety is a top priority in the marine industry. The aim is to prevent accidents at sea, protect human lives, maintain the integrity of the marine environment, and protect property. Shipping safety rules are very strict and are regulated by various international bodies including the IMO which plays an important role in developing and promoting shipping safety standards. Here are some rules related to safety, among others: 1) SOLAS (International Convention for the Safety of life at Sea), an international treaty issued by the IMO that regulates ship safety standards, safety equipment, and emergency procedures at sea. SOLAS regulates various aspects such as rescue equipment, fire planning, evacuation procedures, and navigation; 2) COLREGs (International Regulations for Preventing Collisions at Sea). International regulations governing the actions and responsibilities of ships to prevent collisions, including the use of navigation lights, beacons, and rules to be followed by all ships; 3) ISM Code (International Safety Management Code), the ISM Code is an international standard governing safety management and environmental protection on ships. It requires all ship operators to have an effective management system in place to ensure the safety of ship operations; and 4) ISPS Code (International Ship and Port Facility Security Code), the ISPS Code is a regulation governing the security of ships and port facilities to protect against the threat of terrorism and marine criminal acts.

4.1.3. AIS Working Principle

The working principle of AIS consists of several stages, namely:

a) Transmitting AIS signals from vessels. When a vessel is equipped with an AIS transponder, the system transmits information such as vessel identity, position, speed, course, and other information via VHF radio signals. These signals will be continuously transmitted at certain intervals, usually 2-10 seconds, to ensure that the information received is always updated.
b) Receipt of AIS signals by other vessels or shore stations. AIS signals transmitted by a vessel will be received by other vessels or shore stations that are within the AIS signal range. Vessels equipped with AIS can receive AIS information from other vessels within a radius of up to 40 nautical miles or approximately 74 kilometers, depending on atmospheric conditions.
c) Management of AIS information Once AIS signals are received, the information will be processed and displayed in the vessel monitoring system. This system will display information about other vessels in the vicinity of the vessel, such as the vessel's identity, position, speed, course, and other information. In processing AIS information, there are several main components, namely the AIS antenna, AIS transponder, and ship monitoring system. The AIS antenna captures AIS signals from other ships, the AIS transponder processes the received AIS information, and the ship monitoring system displays relevant information in the ship monitoring system. The processing of AIS information requires sufficient technical expertise and analysis to ensure its accuracy and reliability.
d) Exchange of AIS information between ships. Vessels equipped with AIS can exchange AIS information with other vessels to minimize the risk of collision. In this case, the vessel will transmit information such as vessel name, vessel identification number, position, speed, and course to other vessels that are within the range of the AIS signal. Identification of vessels that wish to exchange AIS information must be able to identify other vessels within the AIS signal range. Information exchange request Once the vessel is identified, the vessel wishing to exchange AIS information will send an AIS information exchange request to the other vessel. Information exchange approval the other vessel will then give approval to exchange AIS information. Verification of information the received AIS information needs to be verified to ensure its accuracy and reliability.

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e) Dissemination of AIS information to authorities. AIS information received from vessels or shore stations can be forwarded to authorities, such as port authorities or sea traffic control, for surveillance and control of vessels at sea.

4.1.4. Implementation of AIS Enforcement

The use of AIS is regulated by the International Convention for the *Safety of Life at Sea (SOLAS)* approved by the *International Maritime Organization* (*IMO)*. Initially, the use of AIS was required only for certain ships with a gross capacity of more than 300 gross tons or passenger ships with a passenger capacity of more than 12 persons operating internationally. However, in 2002, the IMO adopted amendments to SOLAS that made the use of AIS mandatory for all ships operating in international waters in 2004. In 2014, IMO issued the latest amendment regarding the use of AIS, which requires all commercial vessels over 500 gross tons to install AIS that can track the position of the vessel every 5 seconds. The use of AIS has also become mandatory in certain waters, such as around the United States and Canada, where the use of AIS is required for commercial and non-commercial vessels with a gross tonnage of more than 65 feet (about 20 meters). In addition, some countries have also adopted local regulations that expand the scope of AIS use, such as in France, which requires fishing vessels smaller than 24 meters to use AIS.

International maritime organization resolution A.1155 (32) on Procedures for PSC and its amendments, as well as international maritime organization resolution A.1106 (29) on revised guidelines for the onboard operational use of shipborne automatic identification system (AIS) and its amendments, need to regulate the obligation to install and activate the automatic identification system (AIS) on ships that carry out activities in Indonesian waters. The Indonesian government through the Regulation of the Minister of Transportation Number PM 7 of 2019 concerning the installation and activation of automatic identification systems for ships sailing in Indonesian waters as amended by the regulation of the minister of transportation Number PM 58 of 2019 concerning amendments to the regulation of the minister of transportation number PM 7 of 2019 concerning automatic identification systems for ships sailing in Indonesian waters is no longer by legal developments in the installation and activation of automatic identification systems for ships carrying out activities in Indonesian waters, which was later amended again with the Regulation of the Minister of Transportation of the Republic of Indonesia Number PM 18 of 2022 concerning automatic identification systems for ships carrying out activities in Indonesian waters.

4.1.5. Conceptual Framework

To give direction to this research, the following framework will be presented, which contains the variables measured to determine the effectiveness of the use of the automatic identification system (AIS) on ship surveillance in the navigation district type A class I Makassar.

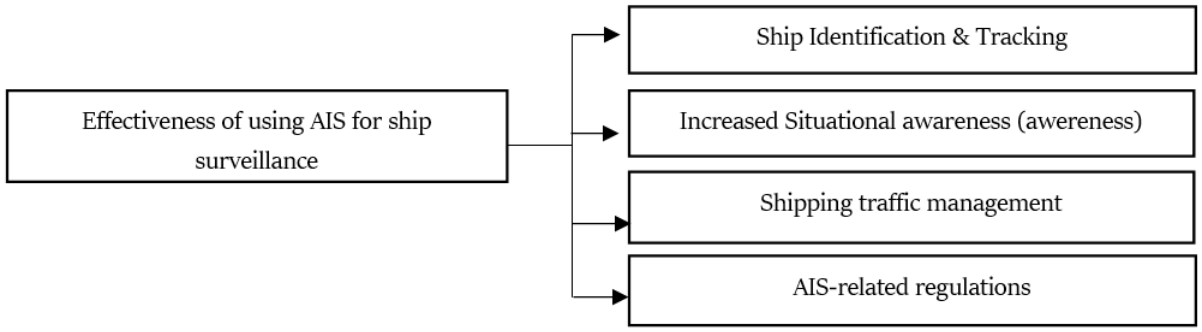

Figure 1.
Conceptual Framework.

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Data collection for this research was carried out at the Type A Navigation District office, class I Makassar, which was carried out in August 2023. This navigation district office is an agency under the Ministry of Transportation that handles navigation and signaling issues, including the operation of VTS (*Vessel Traffic System*). Monitoring carried out by VTS navigation district type A class I Makassar is by using AIS (*Automatic identification system*), which is also connected to several supporting devices in its operation, such as Radar and GPS, with a range of 30 nautical miles.

VTS Makassar navigation district, in carrying out its duties as an operator in regulating ship traffic really needs AIS equipment to support its performance. The functions of AIS include collision prevention, monitoring and controlling ship fleet movements, maritime security, navigation aids, search and rescue, accident investigation, and sea surface current estimation. One of these functions is to regulate the traffic movement of ships in the Makassar water area within its range, with a very large frequency of ship movements.

The data results in this study are about the effectiveness of the use of AIS on ship surveillance at VTS Makassar and data related to ship identification and tracking data, *awareness* raising, ship traffic management, and AIS-related regulations. The following will be attached data on the number of ship movements in the Makassar area from January to August 2023.

Table 1.
Number of ships arriving, docking, berthing, and departing in the Makassar shipping channel, January to August 2023.

NO	Month	Ship movements of the makassar waterway					Departure	Total
		ARRIVAL	DOCKING	LEAD				
				SOETTA	MNP	PAOTERE		
1	January	426	221	279	32	16	448	1422
2	February	337	227	211	42	18	368	1203
3	March	408	216	274	52	29	403	1382
4	April	415	201	238	32	23	378	1287
5	May	377	185	260	35	26	410	1293
6	June	368	191	243	29	27	399	1257
7	July	404	197	259	58	26	435	1379
8	August	396	184	229	53	28	414	1304
TOTAL								10527

Source: VTS Navigation district office Makassar, 2023.

From table 1 above, it shows that the number of ships entering the Makassar waters is very large every month with the movement of arrivals, berths, berths and departures so that a tool system is needed that can detect the movement of these ships and their arrangements must be such as to avoid collisions, aground and others.

4.1.6. Image of Ship Identification and Tracking

This study covers the tendency of respondents to the effectiveness of AIS use for ship surveillance and ship safety. The data obtained is then described using descriptive analysis in the form of mean, median, mode, standard deviation, minimum, and maximum values. The following are descriptive results for each research variable:

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Table 2.
Descriptive analysis results of Ship Identification and Tracking.

Statistics		
Ship Identification & Tracking		
N	Valid	20
	Missing	0
Mean		32.8000
Median		32.5000
Mode		33.00
Std. Deviation		3.86073
Variance		14.905
Minimum		28.00
Maximum		40.00

Furthermore, the analysis then continued to see the distribution of respondents' answers regarding ship identification and tracking, which is illustrated in the following table:

Table 3.
Distribution of Respondents' Answers Regarding Ship Identification and Tracking

Category	**Range**	**Frequency**	**Percent**
Very Low	9 – 15	0	0
Low	16 – 22	0	0
Medium	23 – 29	4	20.0
High	30 – 36	12	60.0
Very High	37 – 43	4	20.0
Total		20	100.0

Based on Table 3 shows that of the 20 research respondents, 4 respondents responded that ship identification and tracking was still in the medium category, 12 respondents responded that ship identification and tracking was in the high category, and 4 respondents responded that ship identification and tracking was in the very high category.

4.1.7. Increased Situational Awareness

Increased situational awareness (*Awareness*) consists of 5 questions in the form of a questionnaire. The answers obtained from 20 respondents and the data obtained are then described using descriptive analysis in the form of mean, median, mode, standard deviation, minimum, and maximum values. The following are descriptive results for each research variable.

Table 4.
Results of Descriptive Analysis of Increased Situational Awareness.

Statistics		
Improved Situational*Awareness*(*awereness*)		
N	Valid	20
	Missing	0
Mean		20.6500
Median		21.0000
Mode		22.00
Std. Deviation		2.34577
Variance		5.503
Maximum		24.00

Furthermore, the analysis was then continued to see the distribution picture of respondents' answers regarding increasing situational awareness (*awareness*), which is illustrated in the following table:

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Table 5.
Distribution of Respondents' Answers to Increasing Situational Awareness.

Category	Range	Frequency	Percent
Very Low	5 – 8	0	0
Low	9 – 12	0	0
Medium	13 – 16	2	0
High	17 – 20	5	35.0
Very High	21 – 24	13	65.0
Total		20	100.0

Based on Table 5, it shows that of the 20 research respondents, 2 respondents responded that increasing situational awareness (*awereness*) was still in the medium category, 5 respondents responded that increasing situational awareness (*awereness*) was in the high category and 13 respondents responded that increasing situational awareness (*awereness*) was in the very high category.

4.2. Discussion

4.2.1. Ship Identification and Tracking

Automatic identification systems (AIS) are a technology that has become standard in modern shipping. This system allows ships to automatically send and receive information about the identity, position, speed, and course of the ship. AIS used by VTS Makassar in terms of ship surveillance can track the whereabouts of any ship equipped with AIS at a range of 30 Nm.

Ship surveillance carried out by VTS Makassar Navigation district using AIS is very important considering the large number of ships moving in Makassar waters, this can be seen in Table 4.1. In January the movement of ships starting arrivals, anchored, and departed as many as 1422 ships, February as many as 1203 ships, March 1382 ships, April 1287 ships, May 1293 ships, June 1257 ships, July 1379 ships, August 1304 ships so that the total ships that moved from January 2023 to August 2023 were 10527 ships.

Overview of ship identification and surveillance. The processed results of the questionnaire data obtained based on Table 4.2. On the statement of the use of supporting features other than AIS, the existence of ships that turn off AIS, the ability to overcome the lack of data displayed by AIS is in the medium category, namely 20%. For statements on the use of AIS in conducting ship surveillance, the use of other devices such as radar and EC-DS, the accuracy of data received by AIS devices, and the ease of accessing data on AIS is in the high category, namely 60%. And 20% who stated that AIS equipment often experienced interference, the inability of personnel to overcome AIS devices when there was damage was in a very high category.

Based on the results of researchers' interviews with informants explaining that AIS is very important to use as a monitoring function for ships moving in Makassar waters, Mrs. Fatriani (Interview: 2023) stated: "After AIS began to be effectively used at the Makassar type A class 1 navigation district VTS office in 2016, the movement of ships is very easy for us in monitoring and supervising ships that move both the arrival of ships, docked or out. we provide information to both ships and scouts regarding ship movements. From this AIS tool, VTS gets the ship's movement in real-time and gets the ship's identity, ship type, ship speed, and ship's bow".

From the informant's explanation of the facts in the field that there were several ships that experienced problems, such as ships leaving the shipping lanes, which could cause the ship to sink. With the supervision and monitoring carried out by VTS through AIS, they can continue to monitor the movement of ships in real-time, so that they call ships by radio to ships that leave the safe route. This also applies to ships that first enter Makassar waters, the VTS can guide these ships by providing a safe route for the ship to find its destination. This is often done by VTS and researchers argue that the function of AIS on ships and VTS is very important and effective in monitoring and surveillance functions.

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4.2.2. Improved Situational Awareness

Vessel traffic surveillance systems (VTS) are a key element in ensuring the safety and efficiency of maritime transportation. Increasing situational awareness *of* VTS includes several important aspects, namely continuous and round-the-clock monitoring, identification, and verification of ship data.

An overview of increasing situational awareness about the use of AIS from table 4.3 which 20 respondents studied, 2 respondents, or 10%, were in the medium category, 5 respondents, or 25%, were in the high category, and 13 respondents, or 65%, were in the very high category. In the medium category there are statements that only a small proportion of ships turn off their AIS when the ship is at anchor, the use of AIS can help ships to avoid potential collisions and run aground are in the medium category, and the use of AIS helps ships to increase navigation safety is in a very high category. This shows that the use of AIS to increase situational awareness is very effective.

From the results of interviews with informants about the use of AIS to increase situational awareness, the VTS Operator (interview, 2023) stated that: "The use of AIS on VTS is very helpful to increase situational awareness where VTS can provide warnings to moving vessels of possible collisions and navigation hazards for shipping safety".

Vessel Operators monitor and provide an accurate picture of the location, direction, and speed of vessels moving within the Makassar waters within their range. This is what makes VTS able to identify potential conflicts or collisions that occur, and this has been experienced by VTS Makassar where there is an archipelago 66 belt ship that moves at night and does not pay attention to the surrounding situation which almost causes a run aground, the ship has made a *passage plan* but the map used is likely an old map. In this situation, VTS carried out its supervisory function to call the ship and give warnings and directions that you must turn so that the archipelago belt ship would not run aground in the Kodingareng Island area.

4.2.3. Overview of Shipping Traffic Management

Automatic Identification systems have become an important component in shipping traffic management worldwide. Originally used to improve shipping safety, the system has now become an important instrument in vessel traffic control. VTS can monitor ship traffic to regulate ship movements to avoid overlaps and ship accidents.

An overview of the effective use of AIS in terms of shipping management, where the availability of human resources and technology, awareness and skills of staff in operating AIS, knowledge of procedures for using AIS, and other supporting devices are in the high category of 70%, can be seen in Table 4.7. The statement that staff understanding of the data displayed by AIS, collaboration with navigation authorities and stakeholders, or AIS users, and development training related to the use of AIS is in the high category at 15%. The statement that staff/technician skills handle interference with AIS and other supporting devices, communication with moving vessels, is in the medium category at 15%.

An overview of the use of AIS as a shipping traffic management, interview conducted with the head of shipping traffic (interview, 2023): "As a shipping traffic control center in the Makassar water area how VTS can regulate the movement of ships that arrive, dock, berth, and depart with large volumes. How is the arrangement and coordination carried out both with the ship or with collaboration with parties related to shipping activities, and the actions taken if the AIS is disturbed or damaged?".

From the results of the interviews conducted, it can be illustrated that VTS, whose function is to monitor the movement of ships and the safety of shipping traffic management vessels, uses AIS as a supporting tool. From AIS, they get accurate information and communicate with the ship. In a predetermined position, namely the boundaries of the west, north, and south where the VTS is authorized, every ship coming in or out must report to VTS. Data on each ship can be received by AIS at VTS, among others, in the form of static information including the ship's mobile maritime system identification (MMS) number, IMO number, ship name and call sign, ship length and width, ship type, and positioning antenna location. Dynamic information can also be received, namely ship position, time

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in UTC, and course over ground (COG). Voyage information in the form of the ship's laden height, type of cargo, destination, and estimated time of arrival. All the data received by the VTS is information in organizing and managing related parties, including scouting to collaborate with VTS and request data regarding ship movements. One of the interesting things the author found was that most ships entering the Makassar area still do not report to VTS but directly to the pilot station while the pilot station requests data and ship information such as arrival time and in which position the ship will dock to VTS because only VTS does have tools to detect ship movements. From the information the author obtained, some areas are no longer part of VTS, namely in positions where the steward has taken over, but VTS is still monitoring. There are many incidents of ships leaving the established channel, usually by cutting the path without considering the depth and draft of the ship. VTS is what will provide accurate information according to the data obtained from AIS which works by allowing ships to automatically send and receive important information about themselves, identity, position, speed, and direction of travel so that VTS can regulate the movement of ships with the help of AIS in conflict management between ships especially in heavy traffic situations or in areas with complicated navigation. This is done to regulate shipping traffic and maintain shipping safety.

In the statement of obstacles encountered in the use of AIS in the navigation district VTS office, it can be described that if there is a disturbance or damage to the AIS device and its supporting tools, the human resources in the VTS office have not been able to overcome and repair it this is because the staff or technicians have not been equipped with the competence to repair if there is a disturbance. Limited to operation. So to overcome disturbances or damage must bring in the vendor of the tool.

4.2.4. Overview of AIS-related Regulations

Regulations related to AIS are regulated by the IMO (*International Maritime Organization*) and by the Government issued Regulation of the Minister of Transportation of the Republic of Indonesia Number PM 18 of 2022 concerning automatic identification systems for ships carrying out activities in Indonesian waters. The use of AIS related to regulations that have been set by the government can be described in Table 4.9. The results of the descriptive analysis can be illustrated that 35% are in the high category for the statement of the implementation of AIS regulations for ships that do not turn on AIS without fundamental reasons, there are still ships that do not report to VTS, and reprimands given to ships or companies that violate AIS rules. In the statement of ship compliance with AIS-related regulations, knowledge of human resources related to AIS regulations, increased awareness and enforcement of rules, and reporting by ships entering and exiting the port are in the very high category of 65%.

An overview of the use of AIS related to regulations, an interview conducted with the head of shipping traffic (interview, 2023): "As long as AIS has been used at the Makassar VTS office have you ever found ships that do not turn on their AIS, are there ships that do not report when the ship arrives, are there sanctions given to ships that violate this regulation."

From the results of the interviews conducted, it can be described that the ship has installed AIS and activated according to the class of the ship, both foreign-flagged ships and Indonesian-flagged ships to fulfill the provisions of the 1974 *Safety of Life at Sea* (SOLAS) *convention.* The skipper is obliged to activate and provide correct information through AIS, and VTS continues to monitor directly. However, some ships turn off their AIS because the AIS is damaged and recorded in the log book and must be submitted and informed at the first opportunity to the coastal station. (SROP) and/or *vessel service station* (VTS). Some ships activate their AIS but do not report their arrival to VTS. In this case, VTS can still monitor and supervise the movement of the ship. In such instances, the VTS has given a direct warning to the vessel. But if on the next occasion the ship is still doing the same thing, VTS will write to the shipping company to warn the ship in question, and the last sanction if it does not heed will be imposed administrative sanctions. Where the VTS will not approve the license to sail for the ship.

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5. Conclusion

Based on the research results that have been obtained, the conclusions in this study are as follows:

1) The use of AIS in supporting ship supervision in the Makassar Type A Class I Navigation District is very effective, it can be seen that of the variables studied and analyzed from 31 items of question items only 5 items are in the medium category, the rest are in the high and very high categories.
2) The role of regulation is very effective in supervising and monitoring the use of AIS for ships that are required to install and activate AIS, this is because there are sanctions applied to violations of this regulation.
3) The obstacles faced in the application and use of AIS for ship surveillance are still at a technical level, where if there is damage or constraints on AIS equipment, you have to wait for the vendor to fix it. Human resources, in this case technicians, have not been able to overcome such obstacles.

6. Research Limitations

This study has several limitations that should be considered when interpreting the results and conclusions. First, the scope of the research is limited to the Navigation District Type A Class 1 Makassar, so the findings may not be directly generalizable to other navigation districts in Indonesia, which may have different geographic conditions, vessel traffic volumes, and infrastructure capacities. Second, the data were primarily obtained through interviews and field observations conducted over a specific period, which may not fully capture seasonal or incidental operational dynamics.

Third, limited access to comprehensive technical data and internal AIS system documentation restricted the depth of analysis regarding system integration, hardware reliability, and real-time reporting effectiveness. Furthermore, external factors such as weather conditions, signal interference, and varying operator competencies in the field were not explored in detail in this study.

Therefore, further research with a broader geographic scope, a longer observation period, and a more comprehensive quantitative approach is recommended to obtain a more thorough understanding of the effectiveness of AIS use in ship surveillance.

7. Novelty

The novelty of this study lies in its focused assessment of the operational effectiveness of the Automatic Identification System (AIS) within a specific institutional and geographic context Navigation District Type A Class 1 Makassar. While AIS has been widely studied in global maritime safety literature, there remains a limited number of empirical studies that explore its practical implementation and real-world challenges within Indonesian navigation districts, particularly in Eastern Indonesia. This research offers a unique contribution by providing an in-depth, field-based analysis of how AIS is utilized for vessel monitoring, early warning, and coordination by local navigation authorities.

Unlike previous studies that often rely on secondary data or simulations, this study incorporates direct observations and stakeholder interviews, offering real-time insights into both the benefits and operational constraints of AIS. It identifies specific regional challenges such as signal blind spots, uneven equipment standards among vessels, and gaps in operator training.

By grounding the analysis in actual operational practices, this research not only enriches the academic discourse on maritime surveillance technology but also provides actionable recommendations for improving policy, infrastructure, and human resource capacity in Indonesia's maritime sector. This localized, practical perspective on AIS usage represents the core innovation and contribution of the study.

Transparency:

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

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