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NAVIGATION FACTORS AFFECTING SHIPPING SAFETY IN THE INDONESIAN ARCHIPELAGO SEA LANE (ALKI)

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Abstract

Shipping safety is a crucial aspect in the sea transportation sector, especially in the Indonesian Archipelago Sea Route (ALKI) which is a strategic route for national and international ship traffic. This study aims to identify and analyze navigation factors that affect shipping safety in ALKI. The method used in this study is a quantitative approach with secondary data analysis and interviews with related parties, such as port authorities, captains, and maritime regulators. The results of the study show that several main factors that affect shipping safety at ALKI include hydrographic and oceanographic conditions, ship traffic density, the existence of navigational aids, the level of compliance with shipping regulations, and the competence and readiness of the ship crew. In addition, extreme weather factors and the uncertainty of the marine environment also contribute to the risk of maritime accidents. The implications of these findings lead to recommendations to improve navigation infrastructure, strengthen regulations, and improve the competence of human resources in the maritime industry to reduce the risk of accidents in ALKI waters.

Keywords: ALKI, Maritime Navigation, Navigation Factors, Sea Transportation, Shipping Safety

Introduction

According to Undang-Undang Republik Indonesia Nomor 43 Tahun 2008 Tentang Wilayah Negara, stated that Indonesian waters directly border 10 neighboring countries, namely Malaysia, Singapore, Thailand, India, the Philippines, Vietnam, Papua New Guinea, Australia, and Timor Leste. Based on United Nations Conventions on The Law of The Sea, (1982), Indonesia is an archipelagic state with a total of 17,508 islands spread throughout the archipelago. As an archipelagic country, Indonesia requires adequate transportation facilities to connect islands separated by seas and straits. Transportation facilities are used to facilitate humans in carrying out daily activities efficiently and effectively, both for personal, commercial, and industrial purposes. Currently, transportation facilities consist of land, air, and sea transportation, each of which plays an important role in facilitating the movement of people and goods in various environments and conditions.

According to Kadarisman et al. (2016) land transportation is a type of transportation that takes place above the ground surface, using various modes of transportation that can run on roads or rails. The main purpose is to move people, goods, or animals from one location to another. According to Setiani et al. (2015) Air transport is an important aspect of the global transportation system, enabling fast and efficient mobility around the world. By connecting different parts of the world and facilitating the shipment of goods and passenger travel, air transport plays a key role in supporting economic growth,

international trade and global integration. Air transport facilities include aircraft or aircraft, which are vehicles that can fly in the air. Air transport infrastructure includes airports, which are facilities where aircraft can take off and land. The simplest airports usually have only one runway, while large airports are usually equipped with various additional facilities, both for flight service operators and for their users. According to Pujiastuti (2019) sea transport is a means of moving people or goods from one place to another using ships that are driven by engines. Sea transport has a crucial role in economic development, both at the national and international levels. With the geographical conditions of Indonesia as an archipelagic country, the development of sea transportation facilities and increasing shipping safety are very important (Guard, n.d.-b, n.d.-a; NOAA, 2025; Organization, n.d.; RenewableUK, 2015). All aspects related to transportation in waters, ports, and ship security and safety are part of the scope of sea transportation, where one very important aspect is the availability of safe and efficient shipping lanes.

Indonesia has an obligation to provide a route used for international shipping (Burdon, 2020; Tomasello, 2020). Ships can only undertake international shipping on the ALKI route which provides the right to cross the archipelagic sea lane. The Indonesian Archipelagic Sea Lane (ALKI) is a shipping lane designated by the Indonesian government as a route that must be taken by foreign ships wishing to cross the waters without entering Indonesian land. The determination of ALKI aims to regulate international shipping traffic in Indonesian waters and maintain maritime sovereignty and security. According to Peraturan Pemerintah (PP) Nomor 37 Tahun 2002 Tentang Hak Dan Kewajiban Kapal Dan Pesawat Udara Asing Dalam Melaksanakan Hak Lintas Alur Laut Kepulauan Melalui Alur Laut Kepulauan Yang Ditetapkan, ALKI is divided into three main parts:

ALKI I: This route stretches from the South China Sea through the Karimata Strait, Java Sea, to the Indian Ocean. Route: South China Sea - Karimata Strait - Java Sea - Sunda Strait - Indian Ocean.

ALKI II: This route stretches from the Sulawesi Sea through the Makassar Strait and Flores Sea, to the Lombok Strait and the Indian Ocean. Route: Sulawesi Sea - Makassar Strait - Flores Sea - Lombok Strait - Indian Ocean.

ALKI III: This path is divided into:

ALKI III A: From the Maluku Sea through the Seram Sea and Banda Sea to the Arafura Sea.

ALKI III B: From the Maluku Sea through the Seram Sea, Banda Sea, Ombai Strait, to the Indian Ocean.

ALKI III C: From the Banda Sea, covering the waters around the Banda Islands and the Leti Strait.

With ALKI, Indonesia can control and manage international shipping traffic, and ensure compliance with national and international regulations (De Cet Bertin & Montas, 2015). In addition, ALKI also allows Indonesia to take advantage of its strategic geographical position to support economic growth and maritime security. With strategic geographical conditions and passed by 3 international shipping lanes, the Indonesian government should have a system to exchange information quickly and accurately through the Ship Reporting System (SRS). This system allows ships to coordinate with other ships, port authorities and monitoring centres. Through this system, ships can obtain the latest information on sea conditions, weather, and the presence of other ships in the vicinity to ensure the safety of shipping in Indonesian waters. This information is very important to avoid ship accidents such as collisions, sinking, running aground, fires and

can determine the best route for ships that want to cross ALKI. Without the Ship Reporting System (SRS), the risk of accidents at ALKI will increase, which can disrupt the smooth flow of international trade which is highly dependent on sea traffic in the region. With the Ship Reporting System (SRS), ships passing through ALKI can sail more safely and efficiently, supporting maritime safety, and ensuring smooth sea traffic on international shipping lanes (Apriantara et al., 2023; Commercial, 2024; Eliopoulou et al., 2023; Office, 2020; Van Nunen et al., 2018). However, currently ALKI has not fully implemented the Ship Reporting System (SRS), so that ships passing through Indonesian waters are not monitored effectively and result in ship accidents.

Based on data for the 2024 period obtained by the Maritime Coordination Center (MCC), there are There are several facts about ships experiencing accidents due to not implementing the Ship Reporting System (SRS) when ships cross the Indonesian Archipelago Sea Lane (ALKI), including:

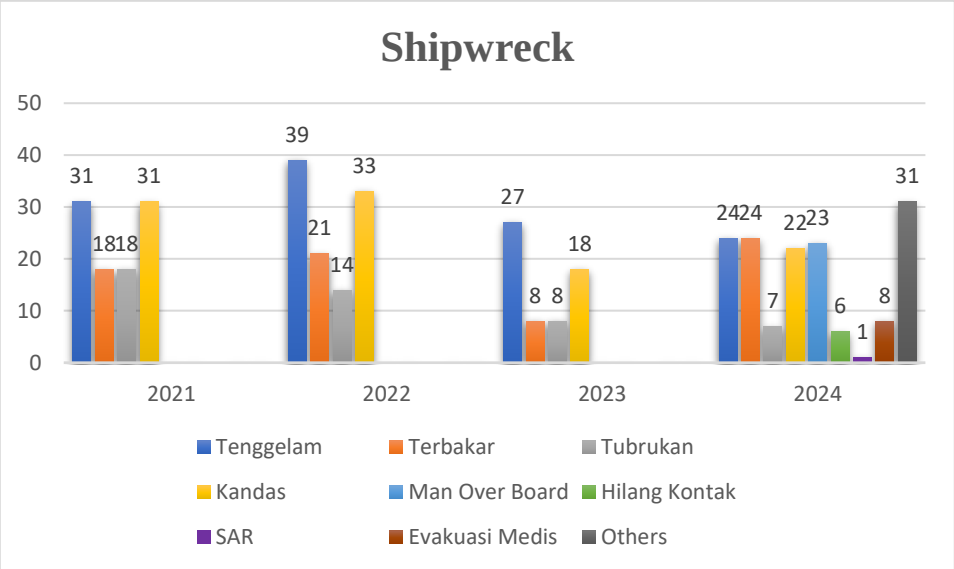


Figure 1. Ship Accident Chart in 2021-2024

Source: Directorate General of Sea Transportation and Maritime Coordination Center (MCC), (2024)

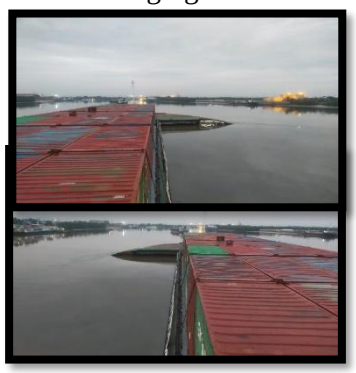
Table 1. Total Ship Accidents that Occurred in 2021-2024

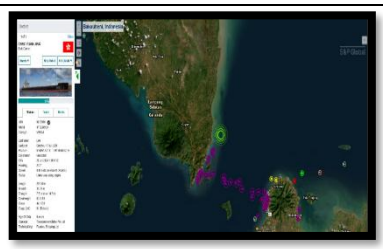
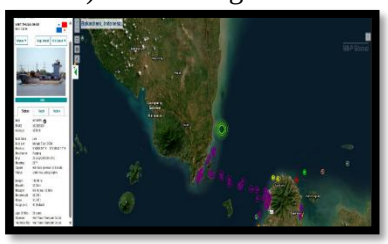
No	Year	Number (of Ships)
1.	2021	100
2.	2022	107
3.	2023	61
4.	2024	150
Total		418

Source: Directorate General of Sea Transportation and Maritime Coordination Center (MCC), (2024)

Table 2. Ship Accident Details in 2022-2024

No	Date	Ship specific	Location / Coordinates	Types of accidents	Information
1	October 26, 2022 at 20:18	Ship name: MT Young Yong Ship Type: OIL tanker Ship Flag: Djibouti Call Sign: J2JZ Ship Tonnage (GT): 153,911 GT Owner/Agent Name: East Wind Ship Management Limited/ PT. Bintang Samudra Utama	001°07' 690" N / 103° 43' 928" E	Run aground	1. Disobeying VTS Batam's order that the vessel was outside the TSS. 
2.	January 19, 2023	MT. DHT EUROPE Call Sign VRTG5 IMO NR 009315159	001 ° – 06' .03.31" N103 ° – 43' – 20.22" E	Run aground	Ship tracking data shows the ship is not moving, suggesting it is undergoing repairs. 
3.	22 April 2023	MV Indian Partnership IMO No. 9521409	Raja Ampat Waters of Papua	Run aground	The bulk carrier reportedly struck a reef on April 22 in the Ceram Sea off the coast of Misool, Indonesia. After hitting the reef, the ship continued under its own power into shallow waters near Misool Island, Indonesia, where it ran aground and remains partially submerged. 

No	Date	Ship specific	Location / Coordinates	Types of accidents	Information
					
4.	July 07, 2024	KM. Lintas Armada Nusantara	The Waters of the Pangkal Balam Channel	Leakage	The ship sank due to the receding current and hit the bow of the KM Sentosa ship, causing the ship to tilt until the bottom of the ship was above the water. There were no passengers on board at the time of the incident. However, the ship's cargo of fertilizer sank, and the crew's belongings were lost. 
5.	July 09, 2024	KM. Lintas Sahabat 2	In the waters of the Banda Sea	Sink	1.The ship did not transmit a Distress Signal at the time of the incident. 2.The entire crew was safe but the ship and its cargo were abandoned.  
6.	July 23, 2024	MV Viet Thuan 56-05 and MV.	05°44.352'S - 105°53.340'E (North of	Collision	1.VTS provides better positioning to two vessels in the TSS North anchorage area.

No	Date	Ship specific	Location / Coordinates	Types of accidents	Information
		CSSC YUAN JING	Sunda Strait TSS)		 2. VTS reports to the Accident VTS Authority (KADISNAV TG. Priok) and PLP Tg. Priok. 

Source: Directorate General of Sea Transportation and Maritime Coordination Center (MCC, (2024)

Based on ship accident data that occurred, the Indonesian Government needs to ensure the safety of navigation, security of navigation and prevention of environmental pollution in the Indonesian Archipelago Sea Lane (ALKI). According to Peraturan Menteri Perhubungan Republik Indonesia PM 4 Tahun 2023 tentang Telekomunikasi-Pelayaran Dan Pelayanan Tata Lalu Lintas Kapal Di Perairan Indonesia ,the function of the Ship Reporting System (SRS), it is to provide the latest information on ship movements, increase efficiency in navigation and protection of the maritime environment, reduce the time interval of contact with ships, determine the location quickly when the ship is in danger whose position is unknown, and increase the security and safety of lives and property at sea.

Based on PM 4 of 2023, the Ship Reporting System (SRS) is a ship reporting system involving ships entering and leaving Indonesian Waters to provide the latest information through Coastal Radio Stations, VTS, Coastal Radio Stations equipped with Automatic Identification System (AIS) Base Stations, and/or National Data Centers (NDC) for Long Range Identification and Tracking of Ship (LRIT) by using radio equipment and marine electronics.

Based on PM 4 of 2023, it has been explained that the Ship Reporting System has an important role in creating shipping safety (safety of navigation) with various indicators through navigation aspects. Currently, several countries in Asia have implemented the Ship Reporting System such as Japan has JASREP, Australia has ASREP, China has CHISREP, Korea has KOSREP, STRAITREP (The Strait of Malacca and Singapore). However, currently in Indonesia, the Ship Reporting System has not been implemented even though there are already established regulations, so this study can be a recommendation for the Indonesian Ship Reporting System.

The government requires ship owners, ship operators, or captains to notify the arrival of ships at the port via SROP or VTS, and send a radio telegram to the relevant authorities. The captain must report the ship's midday position to the nearest SROP or VTS, which

then forwards the information to the local harbor master. The implementation of this telecommunications system aims to improve shipping safety and monitor ships passing through the Indonesian Archipelago Sea Lane (ALKI).

Based on the description above, it shows that some ships when experiencing accidents in Indonesian waters do not transmit emergency distress signals (distress alerting) such as not transmitting Emergency Position Indicating Radio Beacon (EPRIB), Digital Selective Calling (DSC), Search and Rescue Radar Transponder (SART), MF HF radio, and VHF. Ships that do not transmit distress alerting are caused by:

1. Human Resource Factors in Operating Maritime Telecommunication Equipment.
2. The telecommunications facilities and infrastructure on board the ship was not subjected to self-testing and calibration.
3. The suboptimal communication between ships and radio stations on land has resulted in ships passing through Indonesian waters not being monitored.
4. Limited capacity of facilities and infrastructure at Vessel Traffic Services (VTS) and Coastal Radio Stations (SROP).

This proves that navigation has an important role in the creation of safety of navigation in the waters. Therefore, the implementation of the shipping telecommunications system must be carried out properly. If the telecommunications system is carried out properly, when an emergency occurs it will facilitate rescue efforts, reduce the risk of accidents, facilitate coordination between ships and authorities, and facilitate obtaining emergency services in handling emergency situations in Indonesian waters.

Previous research has examined various aspects of maritime safety, particularly in the context of shipping routes such as the Indonesian Archipelagic Sea Lane (ALKI). For instance, Lestari et al. explored the influence of navigational aids and maritime safety information on the safety of ships navigating through Indonesian waters, highlighting the importance of communication and real-time information sharing in preventing maritime accidents. Similarly, Nurbaya and Widyanto (2018) examined the role of radiocommunication and ship reporting systems in ensuring safe navigation in the ALKI routes, finding significant correlations between communication effectiveness and the reduction of navigational errors. However, these studies primarily focused on specific variables without a comprehensive model addressing multiple factors simultaneously. This study introduces a new perspective by combining Maritime Safety Information, Radiocommunication, Aids to Navigation, and the Human Factor as independent and intervening variables, and analyzes their combined impact on the Safety of Navigation. The novelty of this research lies in its incorporation of the Human Factor as an intervening variable, which has not been widely explored in previous studies, particularly in relation to the Indonesian Archipelagic Sea Lane. This approach aims to provide a more holistic understanding of the elements affecting navigation safety and to propose improvements in maritime safety protocols.

This study examines the supervision of ships passing through the Indonesian Archipelago Sea Lane (ALKI) I and II by utilizing and improving navigation to realize safety of navigation. Furthermore, a modeling modification will be carried out on the navigation dimension to become novelty in this study which will be tested including Maritime Service Information (X_1), Radiocommunication (X_2), Aids to Navigation (X_3) And as an independent variable, Human Factor (X_4) as an intervening variable, and Safety of Navigation (Y) as the dependent variable. It is expected that the results of this study can determine how much influence each dimension of navigation has on Safety of

Navigation, as well as to determine how much influence the Human Factor has on ship accidents, and as a parameter for data on ships crossing Indonesian waters and entering Indonesian ports in monitoring and evaluation efforts, so that it can be a recommendation for implementing the Indonesia Ship Reporting System.

Research Method

The research stages in this study start from the pre-research survey, namely the process of observing, seeing and hearing all phenomena in the field; reviewing literature studies related to the use of relevant theories related to determining grand theory, middle theory and variable theory and continuing to review the results of previous studies. Then continue to identify research variables accompanied by indicators of each variable, then compile a questionnaire as a research instrument for the data collection process. At this stage, the questions in the instrument are tested to measure the validity and reliability of each question item with the basis for decision making using the Pearson product moment correlation test with the help of the SEM-PLS analysis tool if there are questions that are not valid or reliable, improvements are made, but if the items are valid and reliable, the next process is to draw the research design.

The process of drawing the research design is carried out using the help of SEM (structural equation modeling) analysis tools based on PLS (partial least square) followed by designing a measurement model in the construction of the research design. Furthermore, the diagram is converted into a statistical equation in the form of a regression formulation, then parameter estimation measurements are carried out with the Mahala Nobis distance test and assessment of normality. After that, it is continued by evaluating the measurement model that has been prepared, namely by testing the validity and reliability of each construct/manifest variable using the CFA (Confirmatory Factor Analysis) test, convergent validity, AVE (Average Variance Extracted), discriminant validity and construct reliability with the help of the PLS-SEM analysis tool. According to Hair, Ringle, and Sarstedt (2011) the characteristics of PLS-SEM are: (1) Estimation of Endogenous Variable Loadings Values (Dependent Variables), (2) Significant or Insignificant, (3) Based on Linear Regression, (4) Models A and B, and (5) Path models in PLS-SEM.

The data collection method used in this study was a questionnaire instrument, namely a set of instruments containing questions asked to Indonesian sailors who were the samples in this study. The type of research questionnaire then used a closed system, namely the questionnaire submitted had already been provided with answers, so that respondents only had to choose and answer directly. The measurement scale of the variables in this study refers to the Likert scale, namely an internal scale that is able to show how strong the level of agreement or disagreement of a respondent is with a statement submitted (McDaniel & Gates, 2014).

The data analysis method used in this study is using SEM (structural equation modeling) analysis based on PLS (partial least square). SEM is a statistical technique used to build and test statistical models that are usually in the form of causal models. According to Ghozali (2013), SEM is a statistical modeling technique that is very cross-sectional, linear and general. Another definition states that structural equation modeling (SEM) is a statistical technique used to build and test statistical models that are usually in the form of causal models.

Results and Discussion

The Influence of Maritime Safety Information on Human Factors

In this section, a hypothesis test will be conducted on the influence of Maritime Safety Information on Human Factor. The results obtained using the SMARTPLS 3 program for the proposed hypothesis can be seen as below.

Table 3. Maritime Safety Information Hypothesis Test on Human Factors

Path	Beta	T Statistics	P Values	
Maritime Safety Information →. Human Factors	0.207	2,719	0.007	Supported

Based on the results obtained, it is known that Maritime Safety Information has a direct effect on Human Factor with a T Statistics value = 2.719 (T Statistics ≥ 1.96) and p value = 0.007 ≤ 0.05, which means that hypothesis 1 is supported. The magnitude of the influence of Maritime Safety Information on Human Factor is 0.207.

The influence of Maritime Safety Information on Human Factor is positive and significant. This means that the higher/positive Maritime Safety Information , the higher/positive Human Factor, meaning that the more respondents feel that detailed navigation warning information helps operational decision making in navigation, and meteorological and weather warning information is available at all times, the more respondents feel that physical and psychological health are important factors in being able to carry out tasks on board, Leadership attitudes on board are needed to create good cooperation among the crew to maintain safety, and the ship's crew is aware of the importance of safety in navigation.

The Influence of Radiocommunication on Human Factors

In this section, a hypothesis test will be conducted on the influence of Radiocommunication on Human Factor. The results obtained using the SMARTPLS 3 program for the proposed hypothesis can be seen as below.

Table 4. Radiocommunication Hypothesis Test Results Against Human Factors

Path	Beta	T Statistics	P Values	
Radiocommunication →. Human Factors	0.197	2.955	0.003	Supported

Based on the results obtained, it is known that Radiocommunication has a direct effect on Human Factor with a T Statistics value = 2.955 (T Statistics ≥ 1.96) and p value = 0.003 ≤ 0.05, which means that hypothesis 2 is supported. The magnitude of the influence of Radiocommunication on Human Factor is 0.197.

The influence of Radiocommunication on Human Factor is positive and significant. This means that the higher/positive Radiocommunication , the higher/positive Human Factor, meaning that the more respondents feel that GMDSS equipment inspections are carried out routinely to ensure that ships can send distress signals effectively and quickly, and the results of these inspections are recorded systematically in the Radiocommunication Logbook as evidence of routine equipment inspections, the more respondents feel that physical and psychological health are important factors in being able to carry out tasks on ships, leadership attitudes on ships are needed to create good cooperation among crews to maintain safety, and ship crews are aware of the importance of safety in navigation .

The Influence of Aids to Navigation on Human Factors

In this section, a hypothesis test will be conducted on the influence of Aids to Navigation on Human Factor. The results obtained using the SMARTPLS 3 program for the proposed hypothesis can be seen as below.

Table 5. Aids to Navigation Hypothesis Test on Human Factors

Path	Beta	T Statistics	P Values	
Aids to Navigation →. Human Factors	0.148	2,861	0.004	Supported

Based on the results obtained, it is known that Aids to Navigation has a direct effect on Human Factor with a T Statistics value = 2.861 (T Statistics ≥ 1.96) and p value = 0.004 ≤ 0.05, which means that hypothesis 3 is supported. The magnitude of the influence of Aids to Navigation on Human Factor is 0.148.

The influence of Aids to Navigation on Human Factor is positive and significant. This means that the higher/positive Aids to Navigation, the higher/positive Human Factor, meaning that the more respondents feel that the implementation of AtoN in accordance with international regulations provides a sense of security for ships in navigating, and the determination of the ATON location considers aspects of vision both during the day and at night, the more respondents feel that physical and psychological health are important factors in being able to carry out tasks on the ship, the attitude of Leadership on the ship is needed to create good cooperation among the crew to maintain safety, and the ship's crew is aware of the importance of safety in navigation .

The Influence of Maritime Safety Information on Safety of Navigation

In this section, a hypothesis test will be conducted on the influence of Maritime Safety Information on Safety of Navigation. The results obtained using the SMARTPLS 3 program for the proposed hypothesis can be seen as below.

Table 6. Results of the Hypothesis Test of Maritime Safety Information on Safety of Navigation

Path	Beta	T Statistics	P Values	
Maritime Safety Information →. Safety of Navigation	0.101	2,076	0.038	Supported

Based on the results obtained, it is known that Maritime Safety Information has a direct effect on Safety of Navigation with a T Statistics value = 2.076 (T Statistics ≥ 1.96) and p value = 0.038 ≤ 0.05, which means that hypothesis 6 is supported. The magnitude of the influence of Maritime Safety Information on Safety of Navigation is 0.101.

The influence of Maritime Safety Information on Safety of Navigation is positive and significant. This means that the higher/more positive Maritime Safety Information is, the higher/more positive Safety of Navigation is, meaning that the more respondents feel that Detailed navigation warning information assists operational decision-making in navigation, and meteorological and weather warning information is available at all times , the more respondents feel that ship conditions, safety equipment, and crew training in dealing with emergency situations can support navigation safety, and effective monitoring of weather conditions, ships, and crew safety can help prevent accidents that occur during shipping.

The Influence of Radiocommunication on Safety of Navigation

In this section, a hypothesis test will be conducted on the effect of Radiocommunication on Safety of Navigation. The results obtained using the SMARTPLS 3 program for the proposed hypothesis can be seen as below.

Table 7. Radio communication Hypothesis Test Results on Safety of Navigation

Path	Beta	T Statistics	P Values	
Radiocommunication →. Safety of Navigation	0.157	3,804	0.000	Supported

Based on the results obtained, it is known that Radiocommunication has a direct effect on Safety of Navigation with a T Statistics value = 3.804 (T Statistics ≥ 1.96) and p value = 0.000 ≤ 0.05, which means that hypothesis 7 is supported. The magnitude of the influence of Radiocommunication on Safety of Navigation is 0.157.

The influence of Radiocommunication on Safety of Navigation is positive and significant. This means that the higher/positive Radiocommunication , the higher/positive Safety of Navigation, meaning that the more respondents feel that GMDSS equipment inspections are carried out routinely to ensure that ships can send distress signals effectively and quickly, and the results of these inspections are recorded systematically in the Radiocommunication Logbook as evidence of the implementation of routine equipment inspections , the more respondents feel that ship conditions, safety equipment, and crew training in dealing with emergency situations can support navigation safety, and effective monitoring of weather conditions, ships, and crew safety can help prevent accidents that occur during shipping.

The Impact of Aids to Navigation on Safety of Navigation

In this section, a hypothesis test will be conducted on the effect of Aids to Navigation on Safety of Navigation. The results obtained using the SMARTPLS 3 program for the proposed hypothesis can be seen as below.

Table 8. Results of Hypothesis Test of Aids to Navigation on Safety of Navigation

Path	Beta	T Statistics	P Values	
Aids to Navigation →. Safety of Navigation	0.162	4.207	0.000	Supported

Based on the results obtained, it is known that Aids to Navigation has a direct effect on Safety of Navigation with a T Statistics value = 4.207 (T Statistics ≥ 1.96) and p value = 0.000 ≤ 0.05, which means that hypothesis 8 is supported. The magnitude of the influence of Aids to Navigation on Safety of Navigation is 0.162.

The influence of Aids to Navigation on Safety of Navigation is positive and significant. This means that the higher/more positive Aids to Navigation , the higher/more positive Safety of Navigation, meaning that the more respondents feel that the implementation of AtoN in accordance with international regulations provides a sense of security for ships in navigating, and the determination of the ATON location considers aspects of visibility both during the day and at night, the more respondents feel that the condition of the ship, safety equipment, and crew training in dealing with emergency situations can support navigation safety, and effective monitoring of weather conditions, ships, and crew safety can help prevent accidents that occur during shipping .

The Influence of Human Factors on Safety of Navigation

In this section, a hypothesis test will be conducted on the influence of Human Factor on Safety of Navigation. The results obtained using the SMARTPLS 3 program for the proposed hypothesis can be seen as below.

Table 9. Human Factor Hypothesis Test on Safety of Navigation

Path	Beta	T Statistics	P Values	
Human Factors →. Safety of Navigation	0.323	4.845	0.000	Supported

Based on the results obtained, it is known that Human Factor has a direct effect on Safety of Navigation with a T Statistics value = 4.845 (T Statistics ≥ 1.96) and p value = 0.000 ≤ 0.05, which means that hypothesis 11 is supported. The magnitude of the influence of Human Factor on Safety of Navigation is 0.323.

The influence of Human Factor on Safety of Navigation is positive and significant. This means that the higher/positive the Human Factor , the higher/positive the Safety of Navigation, meaning that the more respondents feel that physical and psychological health are important factors in being able to carry out tasks on the ship, the leadership attitude on the ship is needed to create good cooperation among the crew to maintain safety, and the ship's crew is aware of the importance of safety in navigation ; then the more respondents feel that the condition of the ship, safety equipment, and crew training in dealing with emergency situations can support navigation safety, and effective monitoring of weather conditions, ships, and crew safety can help prevent accidents that occur during the voyage .

The Mediating Effect of Human Factors Can Increase the Influence of Maritime Safety Information on Safety of Navigation

In this section, hypothesis testing will be carried out regarding the mediation effect. Human Factor can increase the influence of Maritime Safety Information on Safety of Navigation. The results obtained using the SMARTPLS 3 program for the proposed hypothesis can be seen as below.

Table 10. Results of the Hypothesis Test of Maritime Safety Information on Safety of Navigation with Human Factor as a Mediating Variable

Path	Beta Mediation	Beta Total	T Statistics	P Values	Conclusion
Maritime Safety Information →. Human Factors →. Safety of Navigation	0.067	0.168	2.264	0.024	Supported

Based on the results obtained, it is known that the magnitude of the mediation effect of Maritime Safety Information on Safety of Navigation through Human Factor is 0.067, while the magnitude of the total influence of Maritime Safety Information on Safety of Navigation through Human Factor is 0.168 and the T Statistics value = 2.264 (T Statistics ≥ 1.96) and p value = 0.024 ≤ 0.05 which means that hypothesis 12 is supported.

The mediation effect of Human Factor between Maritime Safety Information and Safety of Navigation is positive and significant. This means that the higher/more positive the Human Factor , the stronger the effect of Maritime Safety Information on Safety of Navigation , meaning that the more respondents feel that physical and psychological health are important factors to be able to carry out tasks on the ship, the Leadership attitude on the ship is needed to create good cooperation among the crew to maintain safety, and the ship's crew has an awareness of the importance of safety in navigation ; then it strengthens the Detailed navigation warning information assists operational decision making in navigation, and meteorological and weather warning information is available at all times. so that in the end the condition of the ship, safety equipment, and crew training in dealing with emergency situations can support navigation safety, and effective monitoring of weather conditions, ships, and crew safety can help prevent accidents that occur during the voyage.

The Mediating Effect of Human Factors Can Increase the Influence of Radiocommunication on Safety of Navigation

In this section, we will test the hypothesis regarding the mediation effect. Human Factor can increase the influence of Radiocommunication on Safety of Navigation. The results obtained using the SMARTPLS 3 program for the proposed hypothesis can be seen as below.

Table 11. Radiocommunication Hypothesis Testing on Safety of Navigation with Human Factor as a Mediating Variable

Path	Beta Mediation	Beta Total	T Statistics	P Values	Conclusion
Radiocommunication →. Human Factors →. Safety of Navigation	0.064	0.221	2,397	0.017	Supported

Based on the results obtained, it is known that the magnitude of the mediation effect of Radiocommunication on Safety of Navigation through Human Factor is 0.064, while the magnitude of the total influence of Radiocommunication on Safety of Navigation through Human Factor is 0.221. and the T Statistics value = 2.397 (T Statistics ≥ 1.96) and p value = 0.017 ≤ 0.05 which means hypothesis 13 is supported.

The mediation effect of Human Factor between Radiocommunication and Safety of Navigation is positive and significant. This means that the higher/more positive the Human Factor , the stronger the effect of Radiocommunication on Safety of Navigation , meaning that the more respondents feel that physical and psychological health are important factors to be able to carry out tasks on the ship, the Leadership attitude on the ship is needed to create good cooperation among the crew to maintain safety, and the ship's crew is aware of the importance of safety in navigation ; then it further strengthens the GMDSS equipment inspection is carried out routinely to ensure that the ship can send distress signals effectively and quickly, and the results of the inspection are recorded systematically in the Radiocommunication Logbook as evidence of the implementation of routine equipment inspections; so that in the end the condition of the ship, safety equipment, and crew training in dealing with emergency situations can support navigation safety, and effective monitoring of weather conditions, ships, and crew safety can help prevent accidents that occur during the voyage.

The Mediating Effect of Human Factors Can Increase the Influence of Aids to Navigation on Safety of Navigation

In this section, hypothesis testing will be carried out regarding the mediation effect. Human Factor can increase the influence of Aids to Navigation on Safety of Navigation. The results obtained using the SMARTPLS 3 program for the proposed hypothesis can be seen as below.

Table 12. Results of Hypothesis Testing of Aids to Navigation on Safety of Navigation with Human Factor as Mediating Variable

Path	Beta Mediation	Beta Total	T Statistics	P Values	Conclusion
Aids to Navigation →. Human Factors →. Safety of Navigation	0.048	0.210	2,391	0.017	Supported

Based on the results obtained, it is known that the magnitude of the mediation effect of Aids to Navigation on Safety of Navigation through Human Factor is 0.048, while the magnitude of the total influence of Aids to Navigation on Safety of Navigation through Human Factor is 0.210 and the T Statistics value = 2.391 (T Statistics ≥ 1.96) and p value = 0.017 ≤ 0.05, which means that hypothesis 14 is supported.

The mediation effect of Human Factor between Aids to Navigation and Safety of Navigation is positive and significant. This means that the higher/more positive the Human Factor , the stronger the effect of Aids to Navigation on Safety of Navigation , meaning that the more respondents feel that physical and psychological health are important factors to be able to carry out tasks on the ship, the Leadership attitude on the ship is needed to create good cooperation among the crew to maintain safety, and the ship's crew is aware of the importance of safety in navigation ; then it further strengthens the implementation of AtoN in accordance with international regulations to provide a sense of security for ships in navigating, and the determination of the ATON location considers aspects of visibility both during the day and at night; so that in the end the condition of the ship, safety equipment, and crew training in dealing with emergency situations can support navigation safety, and effective monitoring of weather conditions, ships, and crew safety can help prevent accidents that occur during the voyage .

Conclusion

Based on the results of hypothesis testing and the discussion in the previous chapter, in general, Maritime Safety Information, Radiocommunication, Aids to Navigation, Ship Routing, and Ship Reporting System have an effect on the Human Factor. Meanwhile, Maritime Safety Information, Radiocommunication, Aids to Navigation, and the Human Factor have an impact on the Safety of Navigation. In more detail, the following conclusions can be drawn: First, the impact of Maritime Safety Information on the Human Factor is positive and significant, indicating that improving the effectiveness of Maritime Safety Information will result in an increase in the Human Factor. Second, the influence of Radiocommunication on the Human Factor is positive and significant, showing that enhancing the effectiveness of Radiocommunication will lead to an increase in the Human Factor. Third, the influence of Aids to Navigation on the Human Factor is positive and

significant, meaning that improving the effectiveness of Aids to Navigation will result in an increase in the Human Factor.

Furthermore, the influence of Maritime Safety Information, Radiocommunication, and Aids to Navigation on the Safety of Navigation is also positive and significant, indicating that improving the effectiveness of these factors will enhance the Safety of Navigation. The impact of the Human Factor on the Safety of Navigation is also positive and significant, demonstrating that improving the effectiveness of the Human Factor will increase the Safety of Navigation. A novel finding in this study is the mediation effect of the Human Factor, which can amplify the influence of Maritime Safety Information, Radiocommunication, and Aids to Navigation on the Safety of Navigation. This shows that improvements in the effectiveness of the Human Factor will result in a stronger influence of these factors on the Safety of Navigation, making this contribution a significant advancement compared to previous studies.

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