Traffic analysis for enhancing safety in the Singapore Straits using AIS data

M B Zaman¹, E Kobayashi² and A Zubaydi³

¹Department of Marine Engineering, Institut Teknologi Sepuluh Nopember, Surabaya, 60111, Indonesia
²Faculty of Maritime Science, Kobe University, Japan
³Department of Naval Architecture, Institut Teknologi Sepuluh Nopember, Surabaya, 60111, Indonesia

e-mail: druz_zaman@ne.its.ac.id

Abstract. Enhancing transportation safety is an important step that should be taken. In this study, traffic analysis was carried out in the Singapore Strait. The location has a density of traffic in the world as well as the potential for ship accidents. In addition, the Singapore Strait is the world’s main route connecting to several countries. The purpose of the study was to analyze the traffic conditions in the Malacca Strait by using AIS data. The method was using MySQL to analyse AIS which was converted with GIS. AIS provides information in real time. IMO has recommended the use of AIS on ships to improve safety. The results of this analysis are very useful for improving ship safety in the Singapore Strait.

1. Introduction

The Singapore Strait is recorded as a strait that has a high chance of ship accidents. This area has a high level of risk [1-3]. Some causes of ship accidents are influenced by 5 factors, namely the condition of the ship, human error, environmental factors, damage to machinery and electricity and management factors [1,4].

This strait is very meaningful for world trade 30 the crossing of the strait includes Japanese oil transportation 80 and China 40 oil imports from the Middle East which are expected to soar to 80 by 2030 through the Singapore Strait [1]. The trading will increase by 44 in 2020 and will double in 2031[1]. If this prediction is realized the density of the Singapore Malacca Strait will clearly increase sharply [5,6].

AIS data is used to conduct research with objectives to improve ship safety. The data received from AIS are IMO number, MMSI, ship speed, ship dimension, COG and others [1]. Safety is an important issue that should be prioritized. Ship accidents that occur in the strait of Singapore there are several types, namely collisions, fires, sinks and foundered [4]. In this study, AIS is used as a source of data and provide data information. Then do an analysis of traffic density. Decision making must be made for the crew of the ship so that the risk of ship accidents can be minimized [7]. The characteristics of the Singapore Strait and the density of ship traffic require high effort and safety awareness [5]. Based on the survey, human error is still in the first place as the main cause of ship accidents. Ship condition (28%), human error (34%), environmental factors (11%), machinery and electricity damage (15%), and management (11%) [5].
2. Methods

2.1 Study Area
The study area used in this paper is the Singapore Strait. AIS is installed at Universiti Teknologi Malaysia (UTM) to obtain AIS data. The AIS data is then analysed using mySQL and converted to GIS to get tracking of ship traffic. In Figure 1 shows the Singapore strait as a study area.

![Figure 1. Ship’s tracking using AIS data and GIS](image)

2.2 AIS Analysis
Automatic identification system (AIS) is an automatic tracking system on ships that can display other ships around it through display monitors, the Electronic Chart Display Information System (ECDIS) / System Electronic Navigation Chart (SENC) or Electronic Navigation Chart (ENC) [8,9]. This device will automatically send AIS Message in all directions. The message is sent through a very high frequency (VHF) radio communication system, which is in the frequency of 161.975 MHz and 162,025 MHz. The information obtained from AIS complements information from radar which primarily serves to avoid collisions, so that shipping safety can be improved. In addition, the use of AIS is also beneficial for maritime security, search and rescue (SAR), as well as investigations when accidents occur. Information sent by AIS Transceiver includes: (1) Static data, such as mobile maritime system identification (MMSI) or ship ID, IMO Number, Call sign, ship type, ship length, and location of the antenna position on the ship. (2) Dynamic data, such as ship position, UTC time, speed, navigation status, ship's movement rate. Shipping data, such as, ship laden height, cargo hazard type, destination and ETA. With the installation of AIS Transceiver on board, the Vessel Tracking System (VTS) can monitor traffic situations in the area of supervision and can provide direction or guidance in the event of a dangerous situation [10,11].

When the ship is outside the range of the AIS Base Station, the message sent by the AIS Transceiver can be received by the AIS Receiver Satellite device which will then be sent back to VTS, so that the vessel's position can always be monitored on VTS. In general, AIS consists of two types namely, AIS class A, and AIS class B. AIS class A uses a frequency of 161,975 MHz and is generally used on ships listed in SOLAS Chapter V, while the use of AIS class B, usually for non markets-SOLAS. AIS class B uses less power and is relatively cheaper than class A AIS.

Initially, the use of AIS was intended for maritime security factors. However, by members of the International Maritime Organization (IMO) who participated in the 69th Maritime Safety Committee (MSC) session and the 22nd assembly session, the benefits of using AIS devices were expanded, namely to maintain safety, security, navigation efficiency in the sea [12-15]. Recommendations for the use of
AIS on ships over 300 GT on international shipping, contained in SOLAS V/19 issued by IMO since 31 December 2004.

Figure 2 shows the AIS receiving system that installed at UTM Malaysia. AIS receiver has installed at UTM Malaysia, with antenna, store data to file’s in HDD, network connection and other installation.

3. Results and Discussions
Figure 3 shows the traffic density in Singapore per hour. Data was taken based on AIS data on June 24, 2013. From the analysis of traffic density, the density occurred at 12:00, which amounted to 1,440. Then at 9:00 a.m. it decreased by the number 890. Morning conditions until 9:00 were still no increase. Start at 10:00 to 12:00 experienced an increase in the number of ships. Then in the afternoon, from 17:00 to 22:00 the ship continues to decline.

Figure 3. Traffic density per hour at 24 June 2013
Figure 4. Traffic density per day at 24 June 2013

In Figure 4 shows the traffic density per day in the strait of Singapore. Data was taken based on AIS data in June 2013. On the 24th, the highest number reached 1,530 ships. The density of Singapore strait traffic in June has a high density compared to other months. So that the analysis of traffic density is taken in June. From June 1 the number of ships reached 1,132, then declined on June 6 to 990 ships. Traffic density conditions began to increase, occurring on June 8 which fell again on June 20 with the number of ships reaching 1,000. Then it rose again to reach the highest number on June 24.

The traffic density condition requires careful of ship’s crews to pass through the Singapore strait. Boat accidents often occur in heavy traffic conditions. Therefore, vigilance is needed and must always check the condition of the ship, environmental conditions, human factors, machinery conditions and management [5].

Figure 5. Type of ship

Figure 5 shows the types of ships that pass through the Malacca Strait. Knowing the type of ship that passes through the Malacca Strait is very necessary and important. This will affect the level of danger as well as decision-making and caution when crossing the strait. Based on AIS data, the most frequent type of tankers when passing through the Singapore Strait reached 46%. Then followed by cargo ships reaching 26%. Some other types of ships such as passenger and tug reached 26%. There are not too many LNG ships passing through the Singapore Strait, only 0.5%.

From the traffic conditions and types of ships that pass through the Singapore Strait it can be used as a reference for the decision making of navigators who bring ships through the Singapore Strait. AIS data is very useful as material for traffic analysis and as material for decision making for navigators. For
example; if navigators know the density of ship traffic occurs during the day, then careful action will be taken and can reduce speed.

![Figure 6. Heading of ship](image)

Ship heading data can be shown in Figure 6. AIS data provides accurate information about the position of ship heading in the Singapore Straits area. This will be very useful to improve ship safety [16]. Data headings can also be used to determine the probability of a collision and to calculate the hazard level using AIS data.

3.1 Decision Making

Decision making by the navigator can be done based on information from AIS data. AIS that is installed in the port can be used to monitor ships that are sailing. Whereas AIS which is installed on ships can be used to communicate between ships and between ships to ports. The monitoring and communication step are a step for material decision making. Basic information is sourced from AIS data. IMO's recommendation that the ships install AIS is indeed the right step to improve ship safety while sailing.

3.2 Future Work

The study in this paper is to analyze traffic density in the strait of Singapore. The AIS data in this paper is to provide information as a basis for the process of monitoring and decision making to improve ship safety in the strait of Singapore.

Singapore Strait is a strait that has a high risk category. So the future research by using AIS to analyze risks and step forward in depth safety analysis needs to be done in the future. Many methods can be used, where AIS is useful as a data source.

4. Conclusions

AIS data provides accurate and real time information about ship size data, speed, heading, MMSI, IMO number, ship type and traffic conditions. This can be used to provide information to navigators in making decisions to improve ship safety and reduce risks during shipping. In this research, traffic density is analysed based on AIS data for hourly conditions, per day and vessel type conditions and heading conditions. These conditions are important conditions for the navigators to know.

In the Singapore Strait, heading positions at 270°-315° reach the highest percentage of up to 28%. Then the lowest number is 90°-135° by reaching 5%. Headings position on 0°-45° reaches 10%. The heading condition is the basis for analysing traffic to reduce the level of danger on the ship.

The use of AIS has been recommended by IMO to reduce the level of risk on shipping conditions. The density of ship traffic in the Singapore Strait is of concern to the world because the area is a danger area whose level must be reduced. The existence of AIS is very useful to be applied in ships, ports and even as important data for the development of research on navigation safety on ships.
Acknowledgements
Thanks to member of Laboratory of Marine operation and Maintenance, Marine Engineering ITS Surabaya for the discuss and sharing the AIS data.

References
[1] Gran, S. (1999). “The impact of transportation on wildlife in the Malacca Straits”. TED Case Studies 9(3):573.
[2] Thia,-Eng. C, Inggrid, R.L. and Adrian Ross, G.S. (2000). “The Malacca Straits”. Elsevier 41:160-1778.
[3] Qu, X., Meng, Q. and Suyi, L. (2011). “Ship collision risk assessment for the Singapore Strait, accident analysis and prevention”. Elsevier 43(6):2030-2036.
[4] Zaman, M.B., Kobayashi, E., Wakabayashi, N., Pitana, T. and Maimun, A. (2013). “Fuzzy FMEA model for risk evaluation of ship collision in the Malacca Strait”. J. of Sim 1:91-104.
[5] Zaman, M.B., Kobayashi, E., Wakabayashi, E., Khanfir, S. and Maimun, A. (2012). “Implementation of automatic identification system (AIS) for evaluation of marine traffic safety in strait of Malacca using analytic hierarcy process (AHP)”. J. of Japan Soc Nav Archit and Ocean Engineers (JASNAOE) 16:141-153.
[6] Zaman, M.B., Kobayashi, E., Wakabayashi, N. and Maimun, A. (2015). “Risk of navigation for marine traffic in the Malacca Strait using AIS”. Proc. Earth and Planetary Science 14:33-40.
[7] Mou, J., Ligteringen, H. and Gan, L. (2010). “A Study on collision avoidance in busy waterways by using AIS data”. Ocean Eng. 483-90.
[8] Jiacai, P., Qingshan, J., Jinxing, J. and Zheping, S. (2012). “An AIS data visualization model for assessing maritime traffic situation and its applications”. Procedia Engineering pp. 365-69.
[9] Zaman (2016). “Study on safety of navigation using automatic identification system for marine traffic area case study Malacca Straits”. J. of Marine Eng. Innovation and Research (IJMEIR) 1:26-31.
[10] Pedersen, P.T. (2000). “Collision risk for fixed offshore structures close to high-density shipping lines”. J. of Engineering for the Marine Environment 216:29-44.
[11] Otto, S., Pedersen, P.T. and Amuelides, S.M. (2002). “Element of risk analysis for collision and grounding of a RoRo passenger ferry”. J. of Marine Structure 15:461-474.
[12] Kwok, W.Y, Alan, H.S and Duffy, V.G (2011). “Using AHP for determining priority in a safety management system”. J. of Emerald Group Publishing Limited 14:430-450.
[13] Hoang, N. (2009). “The application of the AHP method in ship system risk estimation”. J. of Pol. Mar. Res. 16:78-82.
[14] Tesfamariam, S. and Sadiq, R. (2006). “Risk based environmental decision-making using fuzzy analytic hierarchy process (F-AHP)”. J. of Stoch Env Risk Assessment 21:35-50.
[15] Ying, X. et al. (2009). “Combining AHP with GIS in synthetic evaluation of eco-environment quality-A case study of Hunan Province-China”. J. of Eco. Mod. Elsevier 209:97-99.
[16] Wang, J. and Foinikis, P. (2010). “Formal safety assessment of containership”. Elsevier Science Direct J. of Marine Structure 143-157.