Near Miss Analysis of Marine Traffic in Sunda Strait Indonesia

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Abstract: A near miss condition is an occurrence that does not result in any injury, loss, or damage but has a potential to do so. In the field of safety management as shown by the Heinrich's pyramid that behind one occurrence of accident, there are at least 300 near miss incidents behind it. This marks the importance of near miss analysis to prevent the future accident. This paper evaluates the near miss condition in Sunda Strait vicinity by analysing the AIS data of that particular area. Sunda Strait is the primary route that serves two major shipping lanes; the Archipelagic Sea Lanes (ASL) I and the crossing lane from Merak to Bakauheni for passenger ferries. The near miss events considered are between a passing vessel and a crossing vessel or between two passing vessels. A one-week AIS data of Sunda Strait is utilised to conduct the analysis. The result of the analysis shows the probability of the near miss incident to be 7.72E-2. Furthermore, the location of the near miss condition is also analysed. It is found that the near miss situation mostly happened near the Merak Port. Crossing situation appeared to be the most frequently situation encountered in this area.

1 INTRODUCTION

Indonesia as an archipelagic country has adopted three archipelagic sea lanes ASL) to allow the international ship passing the Indonesia water. One of the sea lanes is the Indonesia ASL (IASL) I, which located in the west part of Indonesia passes the Sunda Strait.Sunda Strait is a water area located in the west of Java Island and connects it with Sumatera Island. The traffic here is quite heavy because there are two main passages, the international passage or the IASL I, spanning in the north and south bound direction, passed by the cargo ships going from or to the Malacca Strait and the other one is a crossing channel, which in east to west bound direction, used by passenger ships from the Port of Merak in West of Java to the Port of Bakauheni in Sumatera.

In response to the above-mentioned situation, the Government of Indonesia proposed a traffic separation scheme (TSS) to regulate the traffic in this vicinity. A new TSS is proposed to the International Maritime Organization (IMO) due to the high traffic density in Sunda Strait, as the traffic is expected to have a continuous increase in the near future (IMO,2018). This may happen due to the port facilities improvement and development as it wants to be the new global transhipment hub as the China's maritime Silk Road passes through Indonesia waters. Another reason is the existence of the Koliot Reefs that is also considered tobe dangerous for the ships passing through this strait due to the risk of grounding.

The passageway of international cargo ships and passenger ferries in Sunda Strait can cross each other in the Sunda Strait area. This may result to a possibility of collision while the number of it should be reduced or eliminated, if possible. Therefore, it would create a safe navigation passage not only for the cargo vessels but also the passenger ferries and there will be no serious injuries caused by the collision accident.

In the safety management field, the Heinrich's safety triangle is known to be a triangle that can make a relation between major accidents, minor incidents and near misses. This triangle was theorized by Herbert Heinrich in 1930s and states a ratio between severe injury, minor injury and near miss to be 1:29:300, respectively (Heinrich, 1941). A near miss condition is an occurrence that does not result in any injury, loss, or damage but has a potential to do so.

This paper is aimed to give a brief preliminary description on the near miss incident in Sunda Strait

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area, as a basic to understand the marine traffic around this water. The paper is divided into five sections. Section 2 outlines the current traffic in Sunda Strait, Section 3 describes about the automatic identification system (AIS) data used for this research, Section 4 discusses about the near miss in the Sunda Strait, and the last, Section 5 gives the conclusion of the paper.

2 TRAFFIC IN SUNDA STRAIT

Sunda strait is one of the major shipping lanes in Indonesia. It is located between Java and Sumatera Island and connects the Java Sea to the Indian Ocean. This strait has become one of the busiest shipping channels in Indonesia together with Lombok Strait, Madura Strait and Malacca Strait. In addition, an island is also located in the Sunda Strait that is appointed as a Marine Nature Park named Sangiang Island. Moreover, there are cluster of coral reefs, named Koliot Reefs and Gosal Reefs, located in that strait that may cause a risk of grounding to the ships passing this area.

2.1 Current Traffic

Two types of ship traffic are navigating in Sunda Strait. The first one is the ferry passenger ship that operated between Merak Port in Banten and Bakauheni Port in Lampung and the other one is cargo ship coming from the Malacca Strait, Indian Ocean, or South China Sea. Moreover, several special ports owned by the industries are located close to the Merak Port that serves some industrial facilities make the traffic in this area becomes heavier (Sunaryo, Priadi, & Tjahjono, 2015). The traffic density in Sunda Strait is shown in Figure 1. The figure shows a crossing point between the traffic of passenger ship and the ships passing in IASL I. As shown in that figure, the traffic here is quite heavy especially in the route used by the passenger ferries crossing the strait. The number of passengers commuting through this strait shown a dramatical increase as depicted by Figure 2.

Due to the dense marine traffic in Sunda Strait area, several accidents occurred. One of them is an accident between a gas tanker Norgas Cathinka, an Italian flagged ship, that collided with a passenger ferry named Bahuga Jaya in September 2012. This was a serious accident as it caused 7 fatalities and a major loss for both companies. The accident was caused mainly by human error because the lack of communication skills of the seafarers (NTSC, 2013).

2.2 Traffic Separation Scheme

Traffic separation scheme is a routeing measure used to separating two opposing traffic in a certain waterway by means of traffic lanes and other appropriate means. It was firstly implemented on the Dover Straits, the United Kingdom in 1967 and the number of head-on collisions was found significantly dropped after this measure had been implemented (IMO, n.d.). It is outlined in the book of Ships 'Routeing by the IMO that apart from TSS, there are numerous numbers of routeing measures, for example, inshore traffic zone, precautionary area, two-way route, etc (IMO, 2008).

The implementation of TSS is expected to reduce the collision frequency in a certain waterway. As what has been summarized by (Plant, 1985) from the Ships' Routeing book that the purpose of TSS can be shrunken into two, ship to ship collision avoidance and collision avoidance between ship and static facilities. Usually, the TSS is set in area with a high traffic density as implemented in, for example, the Sunk area in the United Kingdom (IMO, 2006), TSS in the vicinity of Kattegat (Forsman, 2017), and also the TSS in Straits of Malacca and Singapore (Intergovernmental Maritime Consultative Organization, 1978). The other reason for arranging TSS is because the area has some environmental constraints such as in TSS Bay of Fundy in Canada and TSS Cabo de Gata in Spain that have a concern to prevent ship from striking the whale as it is categorized as an endangered species in those water (Silber et al., 2012).

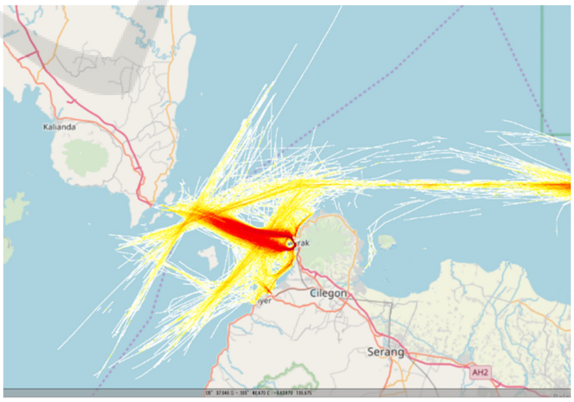

Figure 1: Heat map of Sunda Strait.

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Traffic separation scheme for Sunda Strait has been proposed by the Government of Indonesia (GoI) the Sub-committee on Navigation, Communication and Search and Rescue (NCSR) of IMO on October 2018, then on the 6th NCSR IMO plenary session was approved and ratified. It also has been adopted by the IMO in the 101st IMO MSC meeting and will come into force in the June 2020. The background behind this proposal was not only due to the high traffic density in the Sunda Strait, but also the existence of Koliot Reef nearby the shipping lane that the GoI wants to protect as many grounding incident occurred around this area.

The implementation of TSS is expected to reduce the frequency of collision, especially the head-on collision, and other collision types in general such as overtaking and crossing collision. The purpose of this measure is to separate a traffic lane which has two opposing traffic to have their own lane. Theoretically, this will push the probability of two ships having contra direction to meet in a certain point. Hence, the head-on collision frequency can be reduced. This statement is in a good agreement with the calculation done by (Fujii and Shiobara, 1971) that the number of collision or collision rate for traffic that has a complete separation is much smaller than the one that has a complete mixing traffic, assuming that the density is uniform and the number of vessels coming and leaving are each equal to the half of the total traffic.

The efforts made to reduce the number of collisions by introducing TSS in Sunda Strait is because there are many near miss situations and several incidents happened that lead to a low to serious damage and loss. The near miss situation becomes the main interest in this paper, because this situation happens more frequently rather than the real accident. However, the near miss analysis can be beneficial because it can give a picture in what way the accident might happen, so it can be avoided.

3 AIS DATA

3.1 AIS System

Automatic Identification System (AIS) is an automated ship tracking system that can make navigational data exchange becomes possible, between one ship to others or from ship to the shore-based station. The data that can be stored in the AIS includes static and dynamic data. Static information is stored since the initial installation of AIS such as Maritime Mobile Service Identity (MMSI) number, IMO number, call sign, ship's name, etc. While the dynamic data is the data that keep changing depends on the ship's position. Those included in this type of data are the position (longitude and latitude), course over ground (COG), speed over ground (SOG), heading, and so on (IMO, 2003). AIS transponder shall be installed onboard of all passenger ship, all ships above 300GT or above and bound for international voyage and cargo ships of 500GT or above and not bound for international voyage as required by the IMO since 31 December 2014 (IMO, n.d.)

AIS has been widely utilized in the marine sector because its ability to store a broad range of data, which is up to 27 message types, for many purposes, such as, for the tracking system when it combined with the Inmarsat and satellite for navigation(Yang et al., 2011), estimating the traffic pattern in a certain waterway (Chen et al., 2018), (Gunnar Aarsæther and Moan, 2009), risk assessment and collision avoidance (Miyake et al., 2015), (Mou et al.,2010) and (Nguyen et al., 2018), spatial planning (Le Tixerant et al.,2018), illegal fishing detection (Longépé et al., 2018) and the last is the use of AIS data for near miss collision as studied by Goerlandt et al. (2012) and Zhang et al. (2016).

3.2 Data Collection

This research is utilizing AIS data to see the manoeuvring process of the ship passing in the vicinity of Sunda Strait. AIS data for the period of one year was collected for the purpose of this research started from 8th of October 2018 until 21stof October 2019. However, a sample of a one-week data started from 8th of October 2018 until 13th of October 2018 is taken and analysed. A one-week data is selected to make sure that near miss situations are exist in that area. That period of time is chosen because there are too many data gaps and that makes analysing the AIS data continuously becomes difficult. The distribution of data gap is shown in Figure3.The red area shows that there is no data recorded in that time

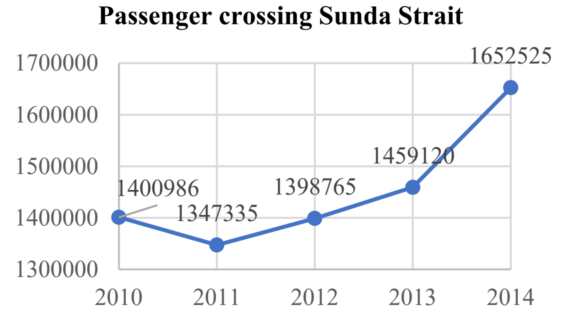

Figure 2: Number of passengers using passenger ferries in Sunda Strait.

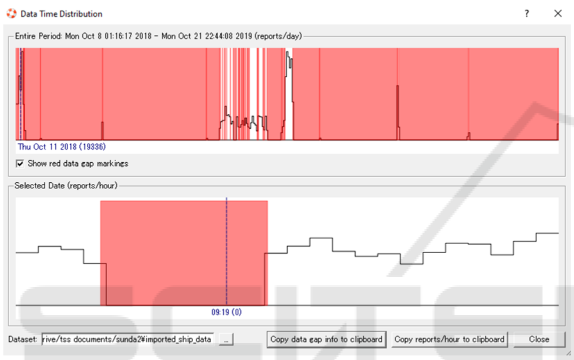

Figure 3: Distribution of AIS data.

There are 132093 of AIS data used for this paper. The AIS data structure used in this research consists of:

a. static data: MMSI, ship name, ship callsign, ship type, GT, DWT, length, depth, beam, draft, year built, and flag.
b. dynamic data: latitude, longitude, rate of turn, speed over ground, course over ground, heading, and timestamp.

3.3 Data Collection

The AIS data that has been collected in the previous step is then used to get the extracted trip. This can be done by using a software named IALA waterway risk assessment program (IWRAP) developed by International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA). IALA is an organization that collect and provide some information regarding nautical matters. The IWRAP software is developed to make the calculation of collision and grounding collision easier.

The AIS data is then processed to get the traffic density, heat map, extract the route of the ships, as well as to see the movement of each ship. The ship's trips are visually observed to determine whether they are engaged in a near miss condition and then the type of encounter is decided. The analysis is made to know the traffic conditions in Sunda Strait. Near miss analysis issued to see the characteristic of a certain water without expecting a collision to occur. For example, we can predict the traffic pattern by understanding where the near misses are likely to occur.

4 NEAR MISS ANALYSIS

The near miss analysis is carried out to understand the characteristic of marine traffic in Sunda Strait. As it has been previously mentioned that near miss analysis can help avoiding the real accident by studying how the ships began to manoeuvre while they are facing the risk of collision in Sunda Strait that has a high traffic density.

The analysis of near miss condition in this paper includes:

a. The probability of near miss situation in the period of analysis
b. The location which the near miss condition occurred,
c. The time where most of the near miss situation occurred.

4.1 Probability of Near Miss

The near miss situation in Sunda Strait is marked by the movement of the ships that tend to avoid the other ships by doing such manoeuvres. This research is utilizing AIS data to see the manoeuvring process of the ship passing in the vicinity of Sunda Strait. The frequency of it can be used to predict the number of minor and major accidents and help to avoid those conditions by understanding the factors that lead to the accident.

Figure 4a to 4d show how the ship has successfully manoeuvred while encountering the collision risk with two other ships. The blue point shows the CPA between two ships encountered each other, the black line is the course over ground line, while the red line indicates the heading. In Figure 4a, Cipta Anyer is approaching KMP Bahuga Pratama and Trimas Kanaya. The heading of Cipta Anyer slightly changed to avoid the collision course with both ships and the heading also further changed in

Figure 4c. Figure 4d shows that the Cipta Anyer can safely passed the near miss condition.

Analysis of the near miss frequency is done by carefully watch or can be said as visually observing the ship's movements. The total of 55 near miss conditions were observed during the designated one-week period. The traffic during one week of observation is outlined in the Table 1. The detail of it is shown in Figure 5. This figure shows three different types of encounters, head on, overtaking, and crossing with each type of encounter occurred 4, 2 and 49 times, respectively and shown in Figure 5, Crossing encounter is found to be the most frequently happened encounter due to the present traffic in Sunda Strait is still unregulated due to the TSS has not been come into force, so there are many ships cross each other in the waterway. Probability of the near miss is calculated by using this following equation.

$$P = \frac{N_{NM}}{V} \quad (1)$$

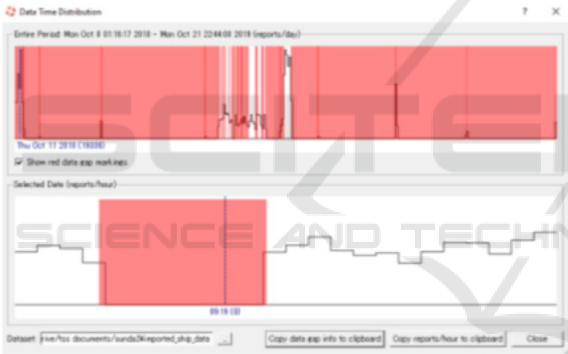

Figure 4: Distribution of AIS data.

Where;

N_{NM} : number of near miss situation (events)

V : total traffic volume (trips)

Equation 1 yields the probability of near miss condition in the Sunda Strait during six days started from 8th of October to 13th of October 2018 to be 7.72E-2 event per six-day.

4.2 Distance between Ship

IWRAP has utilized the concept of closest point of approach (CPA). This theory is then used to calculate

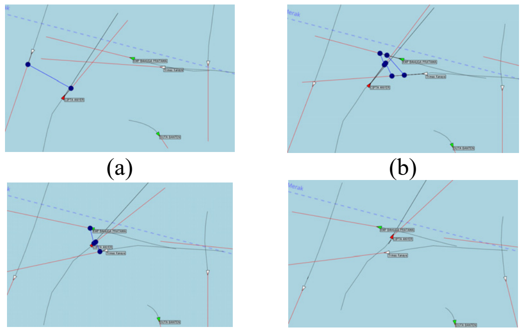

Figure 5: Manouver made by a ship encountering other ships.

the distance of closest point of approach and the time of closest point of approach. This paper uses the distance to CPA of two ships to understand how close the distance between two ships. The Figure6 below is the graph that shows the distance to the closest point of approach (DCPA) that is shown by IWRAP. It is shown that most of them encounter other ships in the distance of less than 1.3km or approximately 0.7 nm.

The distance between two ships encountering a collision situation is very close until they made such a manoeuvre to avoid each other. Hence, it can be inferred that the decision made by the officer on watch (OOW) was not made until he believes that the collision cannot be avoided if he does not make any effort.

4.3 Time of Near Miss

The near miss situation can happen due to many factors. Time of day was thought to be one of the contributions to the near miss situation. It was firstly considered that the near miss situation is encountered during the night-time as the traffic of the cargo ships are denser during this time.

Figure 7 depicts how the time in a day give an effect to the near miss situation. The available data is processed to see when the near miss situations are most likely to occur. The observation came up with the result that the near miss often occurred during 9 pm to 12am. However, at6am to 9am and 12pm to 3pm, both have the same number of near misses happened during that time.

Table 1: Traffic volume in Sunda Strait.

Date	8-Oct-18	9-Oct-18	10-Oct-18	11-Oct-18	12-Oct-18	13-Oct-18	Total
Traffic volume	76	90	162	128	184	72	712

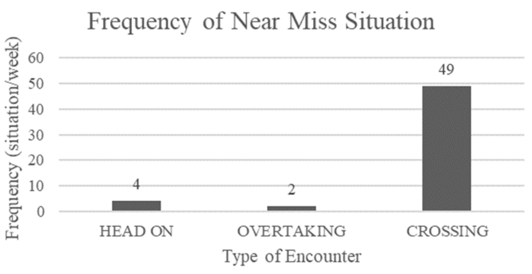

Figure 6: Near Miss Frequency for each type of encounter.

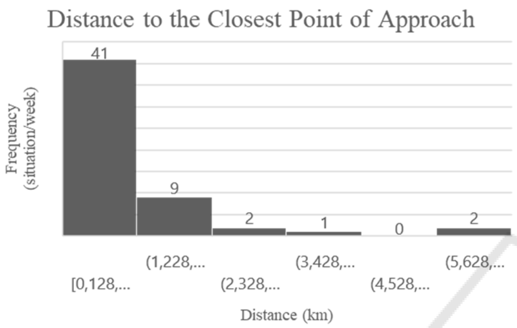

Figure 7: Summary of distance to the CPA.

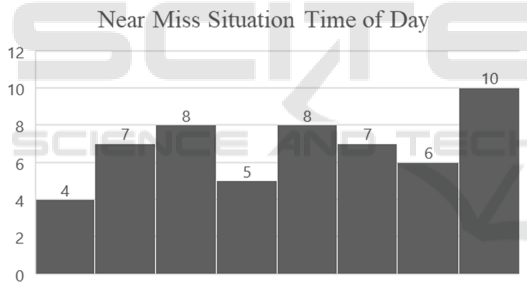

Figure 8: Near miss frequency for each type of encounters.

5 CONCLUSIONS

A near miss condition is an occurrence that does not result in any injury, loss, or damage but has a potential to do so. Near miss collision in. the vicinity of Sunda Strait is studied in this paper. AIS data is collected for one year, from 8th of October2018 until 21st of October 2019. However, only a six-day period is used in this research to understand the traffic conditions in this area.

There are three key points of the near miss condition that become the main focus, those are, the probability of the near miss, the distance between two ships in the near miss situation and the time when the near miss happened. The first one, the probability of the near miss condition is 7.72E-2 for the duration of six days. Next, the distance to the closest point of approach observed between two ships during the time interval mostly less than 1.3km or 0.7nm. Lastly, the time when most of the near miss happened is during 9pm to 12am.

The first finding of this research shown that the crossing situation occurred mostly during a week. This result has a good agreement with the fact that the passage of cargo ships which follow the IASLI crosses the passage of passenger ferries from Merak to Bakauheni. This situation leads to the development of the precautionary area, which is the area where the vessel must navigate with caution to reduce the risk of, which in this case is, crossing collision

The second result, we found that the vessels which is in an encountering situation tend to stay on their speed and course and take a collision avoidance action when the distance is less than1 nm. This action shall be taken as early as possible or when one of the vessels is realizing the risk of collision, to avoid the vessel involved in a close quarter situation.

The last result corresponds to the near miss situation that frequently happened during midnight (21:00–24:00). This can be happened due to low visibility, misunderstood the ship light with an inshore light, or other factors. A further study needs to be conducted in order to understand the factors involved in the collision accident or near miss in Sunda Strait.

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