The Usage of Automatic Identification System (AIS) Data for Safety during Navigation

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***Abstract*— Estimation of safety on navigation by using safety distance formulation of sea transport is possible with by using data from the Automatic Identification System (AIS). Based on AIS data can be calculated the safety distance and actual distance of the target ship and also closest ship Calculation of safety distance and actual distance of the ship using AIS data closer to the real condition because AIS data provide ship data (time and location) as real-time. This study showed that calculation of safety distance is able to cover all speed more than 5 knots. The results show several ships from 295 total numbers of ships through the Strait of Malacca on 15th November 2013, 8.00 pm until 9.00 pm in danger condition but need to refer to the type of the ship also by using the information from the references website. The ships under the Singapore flag contribute the highest values from the total quantity of the marine traffic on 15th November 2013, 8.00 pm until 9.00 pm follow by Panama, Liberia and Marshall Island. The most high-risk time which danger to the marine transportation and shipping traffic in the Strait of Malacca..**

***Keywords*—** *Safety on navigation, AIS data, Strait of Malacca*

1. Introduction

Safety on navigation between the vessels have become one of the important issues to the entire world community. About 80% of the international trade and movement of goods carried by ship through the sea (UNCTAD, 2010). It is not surprising that in a recent survey, more than 80% of captains of Very Large Cargo Carriers (VLCC) responded that they are worried when transiting the Straits. This number can show the possibility of the accident that can occur between the vessels are very high. For centuries, concerns over safety on navigation have focused on issues of security and the loss of lives and property. Currently of growing significance is concern over environment protection. From this result, the International Maritime Organisation (IMO) objectives the implementation of an Automatic Identification System (AIS) are to enhance safety and efficiency of navigation, safety of life at sea and also maritime environmental protection [1]. The Straits of Malacca and Singapore is one of the most important shipping channels in the world connecting the Indian Ocean with the South China Sea and the Pacific Ocean. The Straits remains as one of the world's most congested straits used for international shipping with an average of 150 ships passes approximately over 60,000 vessels pass through The Straits annually [2]. With high concentration of vessels in a narrow path, multiple risk situation arises. The Strait of Malacca is a narrow stretch of water lying between the east coast of Sumatra Island in Indonesia and the west coast of Peninsular Malaysia, and is linked to the Straits of Singapore at its Southeast end. Approximately 990 kilometers long and 2.7 kilometers wide, the Straits of Malacca connects The Indian and Pacific Ocean and it's recognized as one of the most economically, strategically and the busiest shipping lanes in the world. This study focuses on the Strait of Malacca and Singapore area because it is one of the world's most congested straits used for international shipping where located on the border among three countries of Indonesia, Malaysia and Singapore. The Strait of Malacca is a narrow strait where major hub is to be found and it is one of the heavy marine traffic. Automatic Identification System (AIS) carriage requirements for the Convention on the Safety of Life at Sea (SOLAS) vessels have been adopted by International Maritime Organization (IMO) and entered into forces starting on 1st July 2002. The ships of 300 gross tonnage and upwards, engaged on international voyages are required to be fitted with AIS no later than the first safety equipment survey after 1st July 2004 or by 31st December 2004 [1].

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Based on IMO resolution MSC.74 (69), the recommendation on performance standards for a universal shipborne Automatic Identification System (AIS), the AIS system should satisfying the following functional requirement.

i. In a ship-to-ship mode for collision avoidance

ii. As a means for port authorities or maritime safety bodies to obtain information about a ship and its cargo

iii. As a Vessel Traffic System (VTS) tools for traffic management

Automatic Identification System (AIS) is based on VHF radio transmission and it is designed to transmit and receive information about a vessels such as ships' identity, position, speed and also heading with other relevant information [3]. Vessels within AIS range can receive information on a dedicated AIS display, a chart plotter or a PC using navigation software. Combined with a shore station such as Marine Technology Center in Universiti Teknologi Malaysia (UTM), this system can offers port authorities and maritime safety bodies the ability to manage maritime traffic and reduce the hazards of vessel navigation [4]. A program was developed using the data from Automatic Identification System (AIS). The information regarding the ships' identity, position, and speed and also heading is tracking. From AIS, all the information will be extract and identifying the ship in risk condition using calculation. The program will analyse which vessel are in the dangerous mode of navigation. So, that particular vessel will be advice or warn in term of reducing the speed, change the course and other related in term of collision avoidance. This data is used to evaluate the traffic density of the Strait of Malacca and Singapore area. The initial data will combine with ship database and will be used to determine which ship in The Straits of Malacca that can contribute to the collision during navigation.

2. Safety on navigation

The straits of Malacca is the main seaway used for transport of goods between ports in Europe, the Middle East and those in East and South East Asia. The Straits of Malacca provides the shortest route for tankers trading between the Persian Gulf and Japan. As much as 5540 barrels of oil pass through the Straits each day [5]. A survey conducted by the Maritime Academy Malaysia showed that between 150 and 250 steel hull ships pass through the Straits on any given day [5]. Within the Straits of Malacca, water flow in strong tidal currents between the Indian Ocean and the South China Sea [5]. The weather follows an almost daily routine of thunder and squalls increasing in intensity during the monsoon. An interesting finding was made recently when the [5] conducted a survey among the navigating officers. The survey involved a total of 34 serving deck officers and has helped in providing a clearer picture of the actual situation and difficulties faced by ships officers when navigating through the Straits of Malacca. All agreed that traffic density within the Straits is mostly high or dense.

Table 1. The opinion of navigators, the main hazards to navigation in the Straits of Malacca

SITUATION / DIFFICULTIES	PERCENTAGE
Traffic Density	29%
Shallow Water	26%
Fishing Boats	24%
Unavailability of VTS	12%
Lack of coverage of TSS	6%
Others	3

To be effective, any measures taken to improve the safety on navigation in the Straits of Malacca must address the root cause as well as safety in it is entirely. That is, it must encompass all aspects associated with safe ship operation namely the ship, regulation, crew and also environment. Although the sea and its elements may not have changed, the type, size, speed and operations of vessels have and are definitely changing. Likewise, the design and construction of vessels have also changed and it is imperative that they continue to be improved with greater attention given to safety features. Construction rules must be revised where necessary, especially those concerning structural strength, stresses, manoeuvrability, performance in a seaway and safety equipment. Many are of the view that shipping does not lack regulatory instruments as there are numerous convention, codes and resolutions at the international level whilst at national level there are acts, rules, regulations as well as policies. Increasing concern on safety and protection of the marine environment has led to a major review of existing rules and regulations, drafting of new legislation and the tightening of standards. However, as operational system and technology change, so must regulatory aspects be updated and revised accordingly.

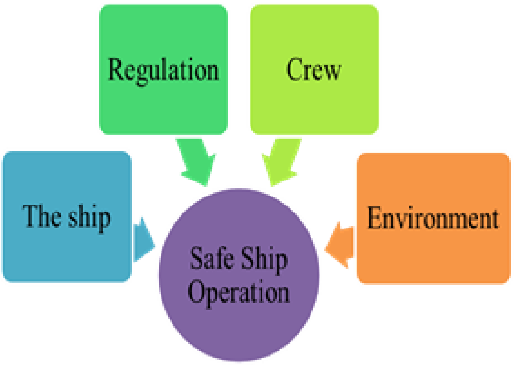

Figure 1. The aspects associated with safe ship operation

3. The Strait of Malacca

The Malacca Straits have long been an important trade route linking the Indian Ocean to the South China Sea and Pacific Ocean. From the seventh to the eleventh century, the Srivijaya empire controlled them, followed in the fifteenth century by the port kingdom of Malacca. Western maritime powers also recognized the strategic importance of the Straits and in 1511, the Portuguese captured Malacca. In 1641, the Dutch occupied what is now known as Jakarta, and from the seventeenth to the eighteenth century, the Dutch East India company controlled the trade in the Straits [5]. The British also recognized the need to control the Straits to ensure the safe passage of British merchant ships on their way to China, and in 1819 established a colony in Singapore. In 1824, the British and the Dutch ended their rivalry with a treaty whereby Britain agreed to `safeguard the Straits and keep them open for other friendly nations' [6]. In recent years, the Straits have become a very important trade route. In 1993 and 1995, over 100 000 oil and cargo vessels traversed it each year, carrying 3.23 million barrels of crude oil through the Straits each day [6]. Shipping accidents have occurred more frequently, recently, which is attributed to heavy traffic in the Straits with shallow, narrow channels and shoals. Despite these hazards, economic efficiency dictates that vessels continue to use the Straits. There were a few factors that contribute to the importance of the Straits of Malacca as the main route such as the geography of the strait, port, trade and navigation.

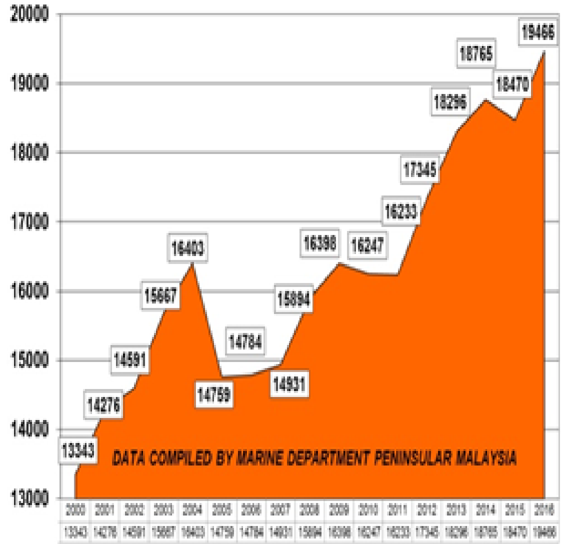

Figure 2. Average shipping traffic through Straits of Malacca

4. Automatic Identification System (AIS)

Automatic identification systems (AIS) are designed to be capable of providing information about the ship to other ships and to coastal authorities automatically [1]. International Maritime Organization (IMO) has adopted AIS carriage requirements for SOLAS (Convention on the Safety of Life at Sea) and starting force on July 2002 for ship 300 gross tonnage and above engaged on international voyages, cargo ships of 500 gross tonnage and upwards not engaged on international voyages and all passenger ships irrespective of size which became effective for all ships by 31 December 2004. According to [1], the AIS should improve the safety of navigation by assisting in the efficient navigation of ships, protection of the environment, and operation of Vessel Traffic Services (VTS). On the installation process of AIS on shipborne shall comply with the requirements of the Radio Regulations ITU-R Recommendation M.1371-1. The standard definition of detail how the AIS works, and as such is the primary AIS standard. [1] requires each ship included in the regulation shall provide information including the ship's identity, type, position, course, speed, navigational status and other safety-related information-automatically to appropriately equipped shore stations, other ships and aircraft, then receive automatically such information from similarly fitted ships and shall provide exchange data with shore-based facilities. The information provided by AIS should include as below.

i. **Static information**

- IMO number (where available)
- Call sign & name
- Length and beam
- Type of ship
- Location of position-fixing antenna on the ship (aft of the bow and port or starboard of centerline)
- Maritime Mobile Service Identity (MMSI) number. This part is explained on IMO (2003)

ii. **Dynamic Information**

- Ship's position with accuracy indication and integrity status
- Time in UTC*
- Course over ground
- Speed over ground
- Heading
- Navigational status (e.g. NUC, at anchor, etc. manual input)
- Rate of turn (where available)
- Optional - Angle of heel (where available)
- Optional - Pitch and roll (where available)

iii. **Voyage related**

- Ship's draught
- Hazardous cargo (type)
- Destination and ETA (at masters discretion)
- Optional - Route plan (waypoints)

iv. **Short safety-related messages**

v. **Dynamic Information**

Table 2. Information updates rates for AIS dynamic information

TYPE OF SHIP	REPORTING INTERVAL
Ship at anchor	3 min
Ship 0-14 knots	12 Sec
Ship 0-14 knots and changing course	4 Sec
Ship 14-23 knots	6 Sec
Ship 14-23 knots and changing course	2 Sec
Ship > 23 knots	3 Sec
Ship > 23 knots and changing course	2 Sec

Information update rates of AIS also includes on the [1]. AIS information of every ship is needed to update at specified time frame. The different information types are valid for a different time period and thus need a different update.

i. Static information shall update at every 6 min and on request

ii. Dynamic information shall update dependent on speed and course alteration according to the table below

iii. Voyage related information shall update at every 6 min, when data have been amended and on request

iv. Safety-related message shall update as required

Types of ship are recorded by AIS use a certain digit of the number which has particular meanings. Type of AIS is explained in [7] as guidelines for AIS installations on-board ship. The way AIS work is started where AIS transponder receives the signal transmitted by a variety of locations, such as other vessels, radio frequency towers, National Oceanic and Atmospheric Administration (NOAA) weather buoys, offshore oil platforms, and geostationary satellites. The information which received by AIS from the locations then plotted at a land based VTS facility and showing the position of the vessel, speed, type of vessel and others in much the same manner as a radar display on the vessel. The figure below shows the operation of AIS where the signal is transmitted and received by other AIS transponders in a variety of locations of vessel [8].

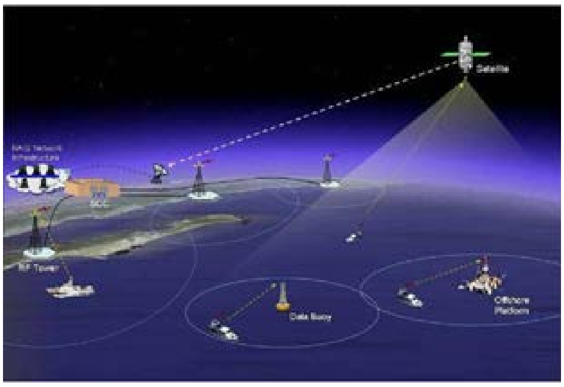

Figure 3. Automatic Identification System (AIS) operation view [8].

5. Navigational risk assessment using AIS data

It is well know that risk is a concept consisting of the probability of occurrence and consequences of an undesired event. The risk is commonly assessed as the product of the probability of occurrence of an undesired event and the expected consequences. At present, collision probability of vessels is commonly expressed based on study of Fujii and Shiobara (1971) where the number of collision occurrences over the studied time period, N_{coll} is estimated as:

$$N_{coll} = N_A P_c \quad (1)$$

where N_A refer to number of vessel encounter in a time period or number of collision candidates and P_c is the probability of failing to avoid a collision when the vessel on a collision course due to technical failure, which is generally known as the causation probability. Historically, ship traffic analysis has been bound by the difficulty in collection of vessel manoeuvring data through particular area. With introduction of AIS, it has proven to be a valuable source for ship traffic information. [9] have successfully used AIS to provide data of the major traffic patterns and their density to study the possible location of oil spills. [8] also enables the production of a simplified ship traffic model to generate traffic statistics using AIS data. It has been recognised that AIS contains various types of errors include data corruption, erroneous MMSI numbers, faulty position reports and errors in transmitted speed over ground [10]. These errors complicate the data handling since a pre-processing procedure to cleanse the data is required to gain benefit from the collected data. For this, a set of data cleansing procedures are proposed by [2]. Furthermore, data broadcasted by AIS are overabundance and make it time consuming to sifting through these data manually. Facilities and techniques to analyse these data are thus importance to utilize this data source to its fullest potential. Even through the techniques used in existing literature are simplified model and only an approximation, they constitute valuable tools in AIS data analysis. Further refinement of such techniques is still being required. In this paper, AIS data are processed using SQL database management program to manage and retrieve the required information for further applied in qualitative ships collision risk analysis. The subject vessel have been take into account only ships that have an encounter in the Traffic Separation Scheme (TSS) for Straits of Malacca and Singapore. Principal dimensions and details of the subject vessel are tabulate in Table 3.

Table 3. Details and dimensions of the subject vessel

Parameter	Value
Length, L (m)	180
Breadth, B (m)	30
Period of passage, T (hr)	1
Mean speed, V (knot)	10
Course over ground (degree)	245

Traffic density of the study area are calculated as

$$\text{Traffic Density, } \rho_S = \frac{N_m}{D_C W_C} \quad (2)$$

Where N_m is the number of ships using the channel; D_c and W_c are the length and width of channel in meter. Encounter of ships in this study of marine navigation risk are expressed in head-on, overtaking and crossing situations which require separate method in probability estimation. Probability of collision per passage of subject vessel is estimated by combining the probabilities for the three situations above. Distinction between crossing, overtaking and head-on encounters follows the definitions given in the Collision Regulation are shown in Figure 4.

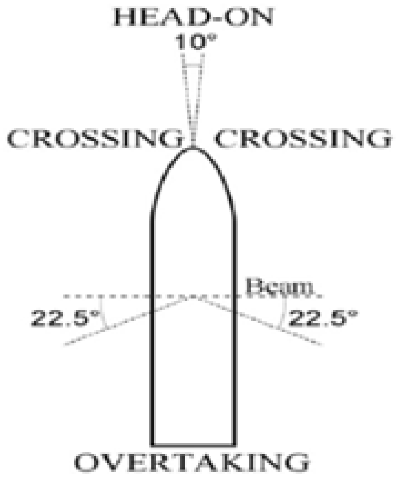

Figure 4. Encounter types according to COLREG

Expected numbers of collisions per passage for each type of encounter were estimated from the formulae below using the above mentioned traffic density and type of encounter.

$$N_{i,Head-on} = 4BPD_{s\rho s} \quad (3)$$

$$N_{i,Overtaking} = 4BPD_{s\rho s} \quad (4)$$

$$N_{i,Crossing} = \frac{N_m}{D_c}\left[\frac{4}{\pi}L + 2B\right] \quad (5)$$

Where L and B are the mean length and beam of subject vessel (meter); D_s is the sailing passage distance, which can be calculated as

$$D_s = T \times V \quad (6)$$

Where T is the period of passage (hour) and V is the mean speed of subject vessel (knot). Based on the equations above, probability of collisions per passage computed as

$$P_a = P_i \times P_c \quad (7)$$

Where P_i is probability of collision with subject vessel per passage of voyage and P_c is the probability of losing navigational control per passage of voyage. It can be assumed $N_i = P_i$; where N_i is expected number of collisions per passage and

$$P_c = \mu_c \times T \quad (8)$$

Where μ_c refer to probability of navigational failure per nautical miles or hour and T is the period of passage in hour. And thus, collisions per year can be computed as

$$N_a = P_a \times (365 \times 24 / T) \quad (9)$$

The probability of navigational failure per nautical miles per hour is selected from previous representative literature by Lewison (1978). The value of 1.5×10^{-5} for μ_c was applied for head-on, crossing and overtaking encounter in this study. The quantitative calculation of a ship's inertial stopping distance plays a very important role in the ship engineering field. Especially for the restricted areas such as bridge water area, the reversing stopping distance of a ship needs to be predicted accurately by quantitative calculation of the motions of a ship. The stopping and reversing stopping distance can be calculated by many different methods currently. Empirical equations are adopted by Ship's Handling. However, these theory equations do not consider the practice deeply in the calculation. Hence, the calculation result to some degree is inaccurate. More sophisticated methods is needed to handle this issue [11]-[15]. In order to provide precise prediction performance of ship's inertial stopping distance, this study introduces an ALE (Arbitrary Lagrangian Eulerian) algorithm to improve the prediction accuracy. The prediction result is compared with the physical model tests and related empirical equations to show high effectiveness of the proposed method in the prediction the ship's inertial stopping distance.

6. Methodology

A program are developed using the data from Automatic Identification System (AIS). The information regarding the ships' identity, position, speed and heading is tracking. From AIS data, all the information will be extract and the ships database are created. The program is created to calculate the safety distance between the ships by using the stopping distance calculation. By using this program, the ships which are in danger condition can be identified. Once the ships which is in danger condition are identified, that particular ship will be notify or warn to reduce the fatality to be occur.

6.1 AIS data collection

Primary data of ships which obtained from an AIS receiver in the study are MMSI of the ship, IMO number, receive time, position of the ship (longitude and latitude), speed of ground (SOG) and COG. These all the data obtained from an AIS receiver installed in Marine Technology Laboratory (Marine Technology Center (MTC)), Faculty of Mechanical Engineering, Universiti Teknologi Malaysia (UTM).

6.2 Ship database collection

Develop the databases is an important step because of the high number of ship recorded by AIS receiver. The data will be process and simplify by perform the calculation using

Microsoft Office Excel. The software is used to identify the traffic in the Strait of Malacca based on AIS raw data which obtained from AIS receiver. The raw data of the vessel that will be taken from Automatic Identification System (AIS) is from year 2013. The traffic of each day during a month in 2013 will be obtained through Excel program. So from the database in a month 2013, the busiest hour will be determined.

6.3 Safety navigation assessment

The calculation of safety distance between the ships can be apply by using the stopping distance formula. Numerous observations [11] have been made concerning the stopping distance, D of the ships in function with their speed. The principle results of manoeuvring trials carried out in the fully laden condition of vessels ranging from 20 000 to 200 000 dwt are recorded for an initial speed of the ship 5 knots. In conclusion from observation made in Le Havre include the following:

i. The stopping distance, D will not be less than 5 times the length, L of the ship.
ii. For the speeds, V exceeding 2.5m/s or 5 knots, the stopping distance is given by formula:

$$D = 4L \times [V / 2.5]^{3/4} + L \quad (10)$$

After the safety distance by using the stopping distance calculation for the particular vessel have found, the status of safety on navigation for that particular vessel with the other vessel will be determine. If the values of safety distance less than 5 times the length, L of the ship, so here can conclude that that particular vessel is in danger condition. But before that the value of safety distance for the particular ship will be compare with the actual distance of the ship base on the longitude and latitude of that particular ship provided from the automatic identification system (AIS) data. The Haversine Formula expressed in terms of a two-argument inverse tangent function to calculate the actual distance between two points on the Earth.

$$dlon = lon2 - lon1 \quad (11)$$

$$dlot = lat2 - lat1 \quad (12)$$

$$a = \sin^2\left(\frac{dlat}{2}\right) + \cos(lat1)\cos(lat2)\sin^2\left(\frac{dlon}{2}\right) \quad (13)$$

$$c = 2 \times a\tan^2\left(\sqrt{a}, \sqrt{1-a}\right) \quad (14)$$

$$d = R \times c \quad (15)$$

where R is the radius of the Earth.
Radius of the Earth = 6373 km.

6.4 Safety distance determination using programming

The safety distance of the ship can be calculated using the program that has been developed. In this program, the safety distance between the ships will be calculated by using the stopping distance calculation and the actual distance for the particular vessel also will be determined by using the Haversine formulation. After the value of stopping distance and actual distance have been calculated using the programming, the safety distance between the particular vessels can be detected. For the ships that considered in dangerous condition during navigation whether the ship in same direction or different direction, advising and warning can be performed by given the ship particular which is the name of the ship, MMSI Number, IMO Number and also call sign to the Vessel Traffic System Unit, Marine Department of Malaysia for further action.

7. Result and analysis

This chapter contains step description of data processing which taken from AIS, the process of getting additional ships data, database making and safety distance estimation. Furthermore, assessment of the safety distance is calculated and the distribution around the Malacca Strait also considered through usage of visual basic programming. As mentioned earlier, calculation of safety distance is calculated by using stopping distance calculation and also calculation of actual distance by using Harversine formula. The actual distance can be calculated by using the data of latitude and also longitude of the particular vessel which is provided in the automatic identification system (AIS) data. After the value of stopping distance and also actual distance are determined, the safety distance of the particular vessel can be determined.

6.1 Investigation number of ship from AIS data

Primary data of ships which obtained from an AIS receiver in the study are MMSI of the ship, IMO number, receive time, position of the ship (longitude and latitude), speed of ground (SOG) and course of ground (COG). These all the data obtained from an AIS receiver installed in Marine Technology Laboratory (Marine Technology Center (MTC)), Faculty of Mechanical Engineering, Universiti Teknologi Malaysia (UTM). The raw data of the AIS which taken from AIS receiver is from December 2012 until November 2013. The raw data form AIS computer seems to be incomplete data. So the raw data of the AIS are taken from September 2013 until November 2013. The raw data of AIS have been extracted to Microsoft excel in order to find the highest traffic in September 2013 until November 2013. Finally got the highest traffic during November 2013. In order to get the highest traffic for the vessel in the Straits of Malacca, the raw data of AIS from November 2013 will be extracted again to find which day can be considered as the highest traffic per day in November 2013 and 15 November 2013 is the busiest in the particular month. After that the raw data of AIS have been extracted once again to find the highest traffic in hour from 8.00pm until 9.00 pm, 15 November 2013 The file format of AIS data is in the form of CSV (Comma delimited). The AIS data are recorded by the computer in Marine Technology Center (MTC) in hour for every day. In the file of AIS raw data consist of every second updated with the information of the vessel in the Straits of Malacca. In order to investigate and manipulate all the data using Microsoft Excel, the AIS raw data have been combined into a month by using Command Prompt program.

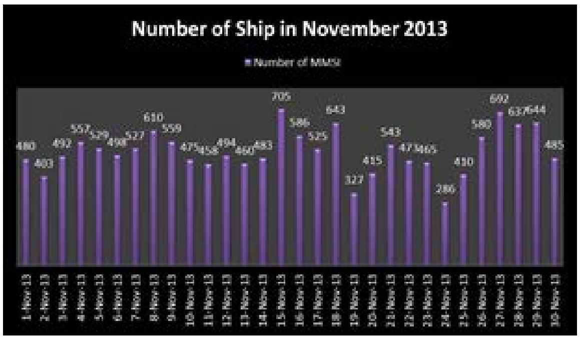

Figure 5. Number of ship in November 2013

Table 4. Total of MMSI or vessels for November 2013

NOVEMBER 2013	
Date	**Number of MMSI**
1-Nov-13	480
2-Nov-13	403
3-Nov-13	492
4-Nov-13	557
5-Nov-13	529
6-Nov-13	498
7-Nov-13	527
8-Nov-13	610
9-Nov-13	559
10-Nov-13	475
11-Nov-13	458
12-Nov-13	494
13-Nov-13	460
14-Nov-13	483
15-Nov-13	705
16-Nov-13	586
17-Nov-13	525
18-Nov-13	643
19-Nov-13	327
20-Nov-13	415
21-Nov-13	543
22-Nov-13	473
23-Nov-13	465
24-Nov-13	286
25-Nov-13	410
26-Nov-13	580
27-Nov-13	692
28-Nov-13	637
29-Nov-13	644
30-Nov-13	485

Based on the graph shown in Figure 6, the highest traffic density of ships in the Strait of Malacca occurs on the 15 of September 2011at hour from 8.00 pm until 9.00 pm. The total number of ships at the time is 295 ships. Information of ships based on AIS is not complete to use as the basis for calculation. AIS only provides several initial data such as MMSI, IMO number, position of ships (longitude and latitude), Speed Over Ground (SOG), Centre of Gratify (COG) and true heading of the ship.

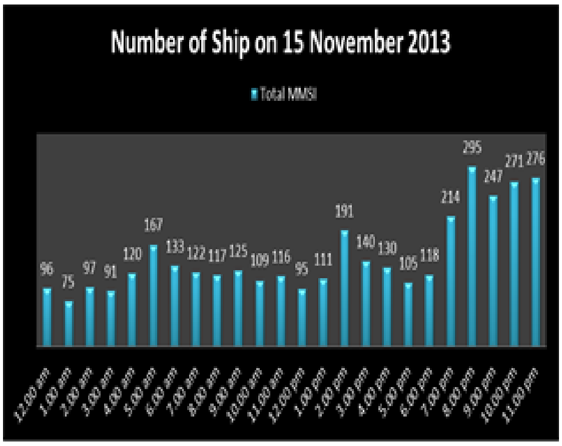

Figure 6. Number of ship in 15 November 2013

The ship particular such as length, breadth and also draught is obtained from other references (free ship database). To get the ship particular data by using several websites that provide free of ship database such as marinetraffic.com, maritime-connector.com, equasis.org, vesseltracker.com and Equasis.org. Figure 7 shown the ship data by input the MMSI or IMO number to the website through the search feature.

Figure 7. Ship particular data from websites such as *www.marine traffic.com*

The ship database for vessel have been developed. From the program, the stopping distance and also actual distance of the ship are calculated. So by using the database which is stored in the program, it can show the particular ship, the information, IMO number, call sign and so on. The ship database need to always updated because if lack of information, the program cannot show what kind of ship which is in the dangerous condition.

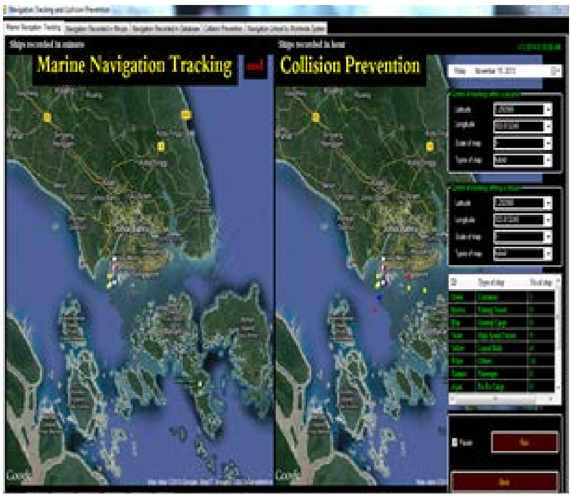

Figure 8. Mode operational pattern of the ships using Visual Basic 2010

6.2 Safety distance calculation procedure

Calculation of safety distance is estimated for every ship which is recorded by AIS on 15 November, 2013 at 8.00 pm until 9.00 pm. There were 295 total number of ships are counted. Calculation of stopping distance based on the stopping distance calculation and also actual distance calculation using Haversine formula. The calculations by considering several factors are:

i. Length of Ship
ii. Longitude of Ship
iii. Latitude of Ship
iv. Type of Ship
v. Speed of Ship

6.3 Calculation by programming

Calculation of safety distance will generate a huge number of calculations and result. This happens because of the calculation involved the ship movement in minute. So by using a program which is Microsoft Visual Studio 2010 (Visual Basic 2010) program. Figure 8 show the appearance of the programming. Navigation tracking, often with a map "picture" in the background, but showing where the vessel have been and allowing "routes" to be preprogrammed, giving a line that can follow on the screen. In this programming, under the marine navigation tracking shows the track of the ship using the AIS raw data that have been put in the program. The marine navigation tracking will show the position of the ship and denoted with different color based on the type of the ship. This kind of information can be detected by the program using the ship database that have been develop before. That is the reason why the ship database is really important because of this matter. If the information in the database in not complete, perhaps the program cannot calculate at all the safety distance of the particular ship. The information that is very important such as the length of the ship.

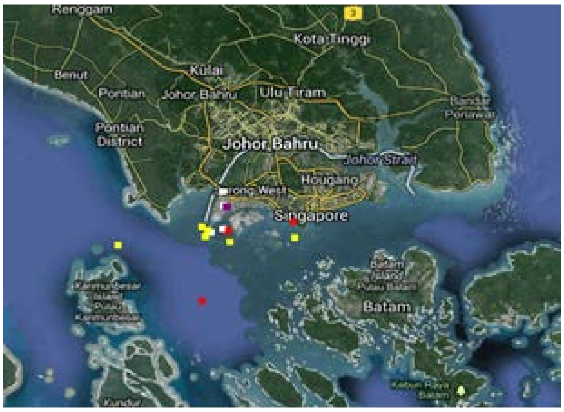

Figure 9. Marine navigation tracking in a minute

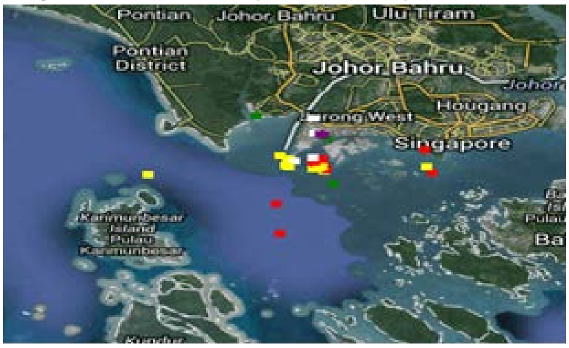

Figure 10. Marine navigation tracking in hour

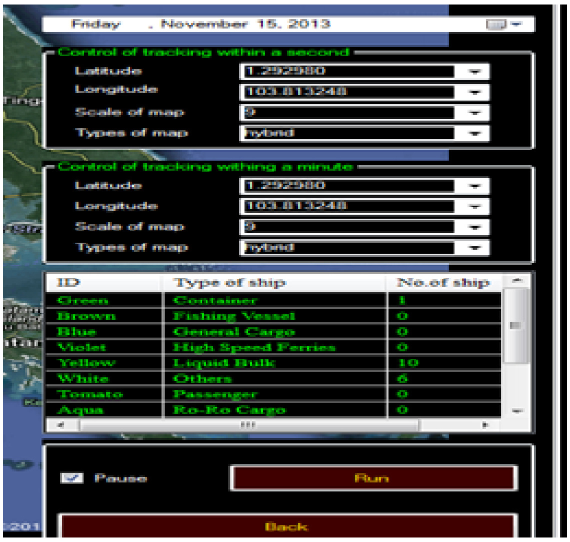

Figure 11. The features in marine navigation tracking

By using the AIS raw data, the actual distance of the ship can be track by using the value of latitude and longitude of the particular vessel. As long as there are this two criteria in the AIS raw data, the actual distance between the ships can be calculated. Figure 9 shows the distribution of the ships with different color based on the different type of ships. The figure shows the position of the ship in a minute. After the program was running for an hour, the position of this ship in in the figure 10. In figure 11 shows some feature in marine navigation tracking. It is provide the information about the date of AIS raw data. There is also the control of tracking within a second and also a minute. In the data of the ship shows that the identity of the ship which is represented with colour, the type of ship and its quantity on that time. From here, the quantity of the ship can be estimated based on minute or hour. There are also the feature of 'Run' and also 'Pause'. If the program need to be run, just click the button run and if want to see another detail information about the ship, the pause button can be used to stop the program for a while. It shows the data for the ship that have been detected by AIS receiver in UTM, Skudai and provide the AIS raw data. By using the longitude and also the latitude of the vessel that can be found in the AIS raw data, the position of the ship can be detected. Another data have been taken by the program from the ship database that have been created and save in the particular program. As mentioned before, the development of the ship database are important in order to detect the ships information. This data also important if occur any cases of collision in the Straits of Malacca. Ship collision is the structural impact between two ships or one ship and a floating or still object such as an iceberg. Ship collisions are of particular importance in marine accidents. Some reasons for the latter are the loss of human life, the environmental impact of oil spills, especially where large tanker ships are involved, financial consequences to local communities close to the accident, the financial consequences to ship owners, due to ship loss or penalties and also the damage to coastal or offshore infrastructure, for example collision with bridges.

Figure 12. The collision prevention data - Target ship

From the Figure 12 shows that, for example the target ship which is Ocean America completed with its sailing time with MMSI Number and also the longitude and latitude of that particular ship. In this section, Ocean America is identified as a target ship. After that the program will show the closest ship near Ocean America.

Closest Ship Name	MMSI (closest ship)	Longitude (Closest ship)	Latitude (closest ship)
CHANG BAI SAN	566430000	103.5932	1.2373
PACIFIC PALLADIUM	565175000	103.6364	1.3103
MERMAID ACHIEVER	572365210	103.6502	1.3048
SWIBER KAIZEN 4000	357978000	103.6348	1.2358
SEMAC 1	308646000	103.6453	1.3077
PACIFIC SUPERIOR	566581000	103.6362	1.3107
SWIBER KAIZEN 4000	357978000	103.6348	1.2358
LADY D	319912000	103.6333	1.3431
UE SAPPHIRE	566385000	103.5845	1.2388
SWIBER KAIZEN 4000	357978000	103.6348	1.2358
SEMAC 1	308646000	103.6453	1.3077
LADY D	319912000	103.6333	1.3431
NS SPIRIT	636012801	103.5986	1.2355

Figure 13. The collision prevention data - Closed ship

From the figure 13 shows that the collision prevention data for the closest ship with the target ships. For example here, the target ship before is Ocean America and from the figure can conclude that there have 13 ships near the Ocean America. The information of MMSI Number, the longitude and also the latitude of the closest ship can be identified. All this information have been extracted from the ship database from the previous section.

Safety Distance (m)	Distance between Ships (m)
1117	1665
7186	315
6659	201
1429	780
6944	943
7230	380
1429	780
10802	245
1615	500
1429	780
6944	943
10802	245
1233	910

Figure 14. The distance between ships

From the Figure 14 show that the collision prevention data for safety distance for the closest ship and also the actual distance of the closest ship with target ship. The status of the ship whether it is in danger or not is depend on the distance between ships. If the actual distance between the closest ship and the target ship less that the safety distance of the closest ship, the ship can be consider in the dangerous condition. But it is depend on the situation also. That is why there are the reference from the website in order to consider what type of the vessel they are. For example if the closest ship is tug boat, it does not matter because the tug boat maybe in process of assisting the target ship. In other words, if confirmed that the vessel is in danger condition, the information of that particular vessel can be forwarded to enforcement agency such as Marine Department of Malaysia (MARDEP) or Malaysian Maritime Enforcement Agency (MMEA). The information that can be forwarded to them such as IMO number, call sign and so on.

8. Conclusion

Estimation of safety on navigation by using safety distance formulation of sea transport is possible with by using data from the Automatic Identification System (AIS). Based on AIS data can be calculated the safety distance and actual distance of the target ship and also closest ship Calculation of safety distance and actual distance of the ship using AIS data closer to the real condition because AIS data provide ship data (time and location) as real-time. This study showed that calculation of safety distance is able to cover all speed more than 5 knots. The results show several ships from 295 total numbers of ships through the Strait of Malacca on 15th November 2013, 8.00 pm until 9.00 pm in danger condition but need to refer to the type of the ship also by using the information from the references website. The ships under the Singapore flag contribute the highest values from the total quantity of the marine traffic on 15th November 2013, 8.00 pm until 9.00 pm follow by Panama, Liberia and Marshall Island. The most high-risk time which danger to the marine transportation and shipping traffic in the Strait of Malacca is on 15th November 2013, 8.00 pm until 9.00 pm.

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