

SAFETY ON NAVIGATION IN THE STRAITS OF MALACCA USING
AUTOMATIC IDENTIFICATION SYSTEM (AIS) DATA

AMIRRUDIN BIN YAACOB

UNIVERSITI TEKNOLOGI MALAYSIA

SAFETY ON NAVIGATION IN THE STRAITS OF MALACCA USING
AUTOMATIC IDENTIFICATION SYSTEM (AIS) DATA

AMIRRUDIN BIN YAACOB

A project report submitted in partial fulfilment of the
requirements for the award of the degree of
Master of Engineering (Marine Technology)

Faculty of Mechanical Engineering
Universiti Teknologi Malaysia

JANUARY 2014

Special dedication to my beloved family

*My parents Mr. Yaacob & Mrs. Jamaliah, My wife Mrs. Siti Norfatihah, My
siblings, Mrs. Norrita, Ms. Norhanizah, Ms. Noridah, Ms Norizan, Ms Noraini
and the last one Ms Noraishah*

Thanks for your valuable sacrifice

Love you all...

ACKNOWLEDGEMENT

“In the name of God, the most gracious, the most compassionate”

First and foremost, all praises and thanks to Allah (S.W.T) to give me strength and ability to complete this project.

I would like to take this opportunity to express my highest appreciation to Dr. Jaswar Koto my respectful thesis supervisor to provide better guidance, encouragement, ideas, comment, recommendation and advice that lead me for the successful completion of this project. My special appreciation to my lovely and understanding wife, Mrs. Siti Norfatihah her unlimited effort in term of encouragement, guidance, critics and suggestions.

To my mother and father that always pray for my successes, what you have done cannot be paid by anything. My special thanks also to my fellow postgraduate friends. Special thanks to Surhan, Syafwan, Adib for their willingness to help and suggest means a lot to me. In addition, my thanks to My Brain 15, Ministry of Higher Education of Malaysia who have supported my scholarship to do master degree in UTM Malaysia. Special thanks to all the people who are contribute directly or indirectly, thousand thanks to all supported of financial and moral.

Above this all, my highest praises and thanks to Almighty ALLAH S.W.T, the most gracious the most merciful, who gave me the knowledge, courage and patience to accomplish this project. May the peace and blessings of ALLAH be upon Prophet Muhammad (PBUH).

ABSTRACT

Safety on navigation has become one of the important issues to the entire world shipping community. The result from the ship collisions has been contributing to the issues of security, the loss of lives and property also the environmental may occur. This study focuses on the Strait of Malacca area because it is one of the world's most congested straits used for international shipping which is located on the border among the three countries of Indonesia, Malaysia and Singapore. The study is to extract and record the data of ships which is passing through The Strait of Malacca using Automatic Identification System (AIS) in Marine Technology Center, Universiti Teknologi Malaysia, Skudai, Johor. The main scope is to develop the program that can reduce the numbers of collision between the vessels during the navigation in the Straits of Malacca. The data from Automatic Identification System (AIS) will be analyzed using the program that will be developed. The effectiveness of the developing program will be determined by using the data analyses and determination of the particular vessel which is in danger condition which is using safety distance calculation.

ABSTRAK

Keselamatan pelayaran telah menjadi salah satu isu penting kepada masyarakat dunia keseluruhan. Hasil daripada pelanggaran kapal itu telah menyumbang kepada isu-isu keselamatan, kehilangan nyawa dan harta benda juga alam sekitar boleh berlaku. Kajian ini memberi tumpuan kepada kawasan Selat Melaka kerana ia adalah salah satu selat yang paling sesak di dunia yang digunakan untuk penghantaran antarabangsa yang terletak di sempadan antara tiga negara Indonesia, Malaysia dan Singapura. Kajian ini adalah untuk mengeluarkan dan merekodkan data kapal yang melalui Selat Melaka menggunakan Automatik Identifikasi Sistem (AIS) di Pusat Marin Teknologi, Universiti Teknologi Malaysia, Skudai, Johor. Skop utama adalah untuk membangunkan program yang boleh mengurangkan bilangan pelanggaran antara kapal semasa pelayaran di Selat Melaka. Kemudian data dari Sistem Pengenal Automatik (AIS) yang diperolehi dianalisis menggunakan program yang akan dibangunkan. Keberkesanan program yang dibangunkan akan ditentukan dengan menggunakan data analisis kepada kapal tertentu yang berada dalam keadaan bahaya dengan menggunakan kaedah jarak selamat.

TABLE OF CONTENT

CHAPTER	TITLE	PAGE
	DECLARATION	ii
	DEDICATION	iii
	ACKNOWLEDGEMENT	iv
	ABSTRACT	v
	ABSTRAK	vi
	TABLE OF CONTENT	vii
	LIST OF TABLES	x
	LIST OF FIGURES	xii
	LIST OF ABBREVIATION	xiii
	LIST OF SYMBOLS	xiv
	LIST OF APPENDICES	xv
1	INTRODUCTION	1
	1.1 Background	1
	1.2 Problem Statements	3
	1.3 Objective	4
	1.4 Scope of Study	4
2	STUDY LITERATURE	6
	2.1 Safety on Navigation	6
	2.2 The Straits of Malacca	10
	2.2.1 Geography of the Straits of Malacca	11
	2.2.2 Port, trade and Navigation	12

2.3.	Automatic Identification System (AIS)	13
2.3.1	Ideal Case for AIS	21
2.3.2	AIS Setup	22
2.3.3	Software, Design, Tools and Methods	22
2.4	Navigational Risk assessment using AIS	23
2.5	Ship Inertial Stopping Distance	26
3	METHODOLOGY	27
3.1	Introduction	27
3.2	Identification Problem	27
3.3	Data Processing	28
3.3.1	AIS Data Collection	28
3.3.2	Ship Database Collection	28
3.4	Safety Navigation Assessment	29
3.5	Safety Distance Determination Using Programming	30
3.6	Flow Chart	31
3.7	Master Schedule	32
4	RESULT AND ANALYSIS	33
4.1	Overview	33
4.2	Investigation Number of Ship from AIS Data	33
4.2.1	Investigation Using Command Prompt Program	35
4.2.2	Investigation Using Microsoft Excel Program	38
4.3	Analysis Procedure	49
4.3.1	Safety Distance Calculation Procedure	49
4.3.2	Calculation by Programming	49
4.4	Results of Safety on Navigation	59
5	CONCLUSION	61
5.1	Conclusions	61
5.2	Recommendations and Future Work	62
	REFERENCES	63
	APPENDIX A	65

LIST OF TABLES

TABLE NO.	TITLE	PAGE
2.1	The opinion of navigators, the main hazards to navigation in the Straits of Malacca	7
2.2	Information updates rates for AIS dynamic information	16
2.3	Identifiers to be used by ships to report their type on AIS	16
2.4	Details and dimensions of the subject vessel	24
4.1	Total of MMSI or vessels from September 2013 – November 2013	38
4.2	Total of MMSI or vessels for November 2013	41
4.3	Total of MMSI or vessels for 15 November 2013	42
4.4	The example of ship database	44
4.5	The example of ship database	45
4.6	The example of ship database	45
4.7	The example of ship database	45
4.8	The number of ships by Type of Ship	46
4.9	The number of ships by Port of Registry	47

LIST OF FIGURES

FIGURE NO.	TITLE	PAGE
2.1	The aspects associated with safe ship operation	8
2.2	Map of The Straits of Malacca	12
2.3	Average daily shipping traffic thorough Straits of Malacca	13
2.4	Automatic Identification System (AIS) operation view	17
2.5	Automatic Identification System (AIS) system in MTC, UTM	18
2.6	AIS antenna installed in Marine Technology Center, Universiti Teknologi Malaysia, Malaysia	18
2.7	AIS Installation in Marine Technology Center,UTM Skudai	19
2.8	Example data of ships from AIS is stored in the computer	19
2.9	Database of ships collected around the world	20
2.10	Distribution of ships in the straits of Malacca and Singapore at 7.00 am on September 2, 2011	20
2.11	Distribution of liquid cargo ships in the straits of Malacca and Singapore at 7.00 am on September 2, 2011	21
2.12	Encounter types according to COLREG	25
3.1	The process of the study	31
3.2	The master schedule of the study	32
4.1	The example of AIS raw data from 15 November 2013	34
4.2	The CSV files of AIS raw data in the same folder	35
4.3	The command Promp program in the program menu	36
4.4	The Command Prompt program	37
4.5	The process of merged files of AIS raw data	37
4.6	The merged AIS raw data from 15 November 2013	38
4.7	Number of ships in September 2013 until November 2013	39

4.8	Number of ship in September 2013	40
4.9	Number of ship in October 2013	40
4.10	Number of ship in November 2013	40
4.11	Number of ship in November 2013	42
4.12	Number of ship in 15 November 2013	43
4.13	Ship particular data from websites such as <i>www.marine traffic.com</i>	44
4.14	The number of ships by Type of Ship	47
4.15	The number of ships by Port of Registry	48
4.16	Mode operational pattern of the ships using Visual Basic 2010	48
4.17	The marine navigation tracking	50
4.18	Marine navigation tracking in a minute	50
4.19	Marine navigation tracking in hour	51
4.20	The features in marine navigation tracking	51
4.21	The navigation recorded in a minute	53
4.22	The navigation recoded in a minute (continue from figure 4.21)	53
4.23	The navigation recoded in a minute (continue from figure 4.22)	55
4.24	The ship recorded in database	55
4.25	The ship recorded in database (continue from the figure 4.24)	56
4.26	The collision prevention data (continue from the figure 4.25)	57
4.27	The collision prevention data (continue from figure 4.26)	57
4.28	The collision prevention data (continue from figure 4.27)	58
4.29	The collision prevention data (continue from figure 4.28)	59
4.30	Safety on navigation result	60

LIST OF ABBREVIATION

AIS	-	Automatic Identification System
IMO	-	International Maritime Organization
SOLAS	-	Safety of Life at Sea
MMSI		Maritime Mobile Service Identity
VTS		Vessel Traffic System
TSS		Traffic Separation Scheme
ALAM		Akademi Laut Malaysia
STCW		Standards of Training, Certification and Watchkeeping
MSC		Merchant Shipping Committee
ETA		Estimated Time Arrive
NOAA		National Oceanic and Atmospheric Administration
UTM		Universiti Teknologi Malaysia
MTC		Marine Technology Center
COG		Course over Ground
SOG		Speed over Ground
ROT		Rate of Turn
HDG		True Heading
AIVTIS		AIS-based Vessel Traffic Information System
NTOU		National Taiwan Ocean University
ALE		Arbitrary Lagrangian Eulerian

LIST OF SYMBOL

$\%$	-	Percent
N_m	-	Number of ship using channel
D_c	-	Length of the channel
W_c	-	Width of the channel
N_A	-	number of vessel encounter in a time period
P_c	-	the probability of failing to avoid a collision
N_{coll}	-	Number of Collision
P_s	-	Traffic Density
L	-	Length of the subject (Vessel)
B	-	Beam of the subject (Vessel)
T	-	Period of passage
S	-	Speed of Vessel
P_i	-	Probability of Collision
N_a	-	Collision per year
D	-	Stopping Distance
Lon	-	Longitude
Lat	-	Latitude
R	-	<i>Radius of the Earth</i>

LIST OF APPENDICES

APPENDIX	TITLE	PAGE
A	Ship Database and Ship Identified	65

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Safety on navigation between the vessel 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 strait. This number can show the possibility of the accident that can occur between the vessels are very high. For centuries, concern 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 in term of 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 (IMO, 2001).

The Strait 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 Strait remains as one of the world's most congested straits used for international shipping. Approximately over 60,000 vessels pass through The

Strait annually (Mihmanli, 2011). 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 Strait of Singapore at its southeast end. Approximately 990 kilometers long and 2.7 kilometers wide, the Strait of Malacca connects to the Indian and Pacific Ocean and it is 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 strait 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 system no later than the first safety equipment survey after 1st July 2004 or by 31st December 2004 (IMO, 2002). 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:

- 1) In a ship-to-ship mode for collision avoidance
- 2) As a means for port authorities or maritime safety bodies to obtain information about a ship and its cargo
- 3) 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 (Eriksen, 2010). Vessels within AIS range can receive information on a dedicated AIS display, a chartplotter or a PC using navigation software. Combined with a shore station such as Marine Technology Center in Universiti Teknologi Malaysia (UTM), this system

can offer port authorities and maritime safety bodies the ability to manage maritime traffics and reduce the hazards of vessel navigation (Adi Maimun, 2010).

The objective of this study is to develop the program that can be used to identify the ship that in high risk condition in term of collision in the Strait of Malacca and Singapore areas using Automatic Identification System (AIS) data. AIS is used as an initial data, it is can identify Maritime Mobil Service Identity (MMSI) of ship, ship speed, initial position and type of ship. 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 use to determine which ship in The Strait of Malacca that can contribute to the collision during navigation.

1.2 PROBLEM STATEMENT

The Strait of Malacca is one of the world's most congested straits used for international shipping, a narrow Strait where major hub to be found and it is one of the heavy marine traffic and in addition, the Strait of Malacca is located on the border among three countries of Indonesia, Malaysia and Singapore. The problem that can be found because of the congested and geographically factor is the collision and fatality of the vessels during navigations. From the result of collision, the issues of security, the loss of lives and property also the environmental may occur.

To reduce this problem, a program will be develop using the data from Automatic Identification System (AIS). The information regarding the ships' identity, position, 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 vessels 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.

1.3 OBJECTIVE

The objectives of this study are:

- i. To extract the data of ships which is passing through the Strait of Malacca and Singapore using Automatic Identification System (AIS) in Marine Technology Center, Universiti Teknologi Malaysia, Skudai, Johor.
- ii. To create the database of ships which is passing through the Strait of Malacca and Singapore using Automatic Identification System (AIS) data in Marine Technology Center, Universiti Teknologi Malaysia, Skudai, Johor
- iii. To develop the program that can identify the vessels which is in danger condition during the navigation in the Straits of Malacca.
- iv. To identify the vessel in high risk condition during navigation using the stopping distance calculation.
- v. To ensure the safety distance program are effective by using the stopping distance calculation by using the reference data of the particular vessel which is in danger condition.

1.4 SCOPE OF STUDY

The scopes of this thesis are:

- i. An analysis of the numbers of ships and its information using AIS data will focuses on the Strait of Malacca area because it is one of the world's most congested straits used for shipping.

- ii. An analysis of actual vessel data will focus only data which are detected by AIS receiver installed in Marine Technology Center, Universiti Teknologi Malaysia (UTM) Skudai, Johor.
- iii. An analysis of the number of the vessel will focuses on one certain day which is occurred the highest traffic in 2013.
- iv. An analysis of the range of the most congested shipping hour of choosing a day that occurs highest traffic in 2013.
- v. An analysis of the safety distance between the ship by using stopping distance calculation for the most congested shipping hour of choosing a day that occurs highest traffic in 2013

REFERENCES

- Aarsaether. K.G., Moan.T.,(2009). Estimating navigation patterns from AIS. *Journal of Navigation*. Vol. 62 pp. 587-607.
- Barrasa, G., M. Soulib, N. Aqueletc and N. Coutyd, 2012. Numerical simulation of underwater explosions using an ALE method: The pulsating Bubble phenomena. *Ocean Eng.*, 41: 53-66.
- Chua, T. E., Natarajan, R. and Ross, S. A. (1998) Analysis of the state of the marine environment of the Straits of Malacca and Singapore. *Singapore Journal of International and Comparative Law* 2, 323 - 349.
- Development and Analysis of AIS Applications as an Efficient Tool for Vessel Traffic Service, 2004
- Graveson. A., (2004). AIS – an inexact science. *Journal of Navigation*. Vol. 57(3) pp. 339-43.
- Gucma. L., Przywarty. M., (2007). The model of oil spills due to ships collisions in southern baltic area. In *Advance in marine navigation and safety of sea transportation, Proceedings from the 7th International symposium on Navigation* (pp. 593-597). Gdynia, Poland.
- Gucma. L., Goryczko. E., (2007). The implementation of oil spill costs model in the southern Baltic sea area to access the possible losses due to ships collisions. In *Advance in marine navigation and safety of sea transportation, Proceedings from the 7th International symposium on Navigation* (pp. 583-585). Gdynia, Poland.
- Hamzah, A. (1997) *The Straits of Malacca: A Pro@le*. In *The Straits of Malacca: International Co-operation in Trade, Funding and Navigational Safety*, ed. A. Hamzah, pp. 3±14. Kuala Lumpur, Pelanduk Publications (M) Sdn. Bhd. and Maritime Institute of Malaysia, 359 pp.
- Harre, "AIS in VTS- the impact on the equipment composition and on day-to-day operations", *Proceedings of ISIS 2002 of DGON*, September 2002.
- Hirt, C., A. Amsden and J. Cook, 1974. An arbitrary lagrangian eulerian computing method for all flow speeds. *J. Comput. Phys.*, 14(3): 227-253.
- IMO Resolution MSC.74 (69). "Recommendation on Performance Standards for A Universal Shipborne Automatic Identification System (AIS)".

- IMO (International Maritime Organization).1998. IMO Resolution MSC.74 (69). "Recommendation on Performance Standards for A Universal Shipborne Automatic Identification System (AIS)".
- IMO (International Maritime Organization. 2003. Guidelines For The Installation Of A Shipborne Automatic Identification System (AIS).
- ITU-R Recommendation M.1371-1, "Technical Characteristics For A Universal Shipborne Automatic Identification System Using Time Division Multiple Access In The Maritime Mobile Band."
- Jing, C., 1984. Theory of Ship Handling. China Communications Press, Beijing.
- Liang, L., P. Xun and C. Wan, 2011. Study on underwater explosion shock characteristic of rudder based on ALE method. Proceeding of the International Conference on System Science, Engineering Design and Manufacturing Informatization, pp: 114-118.
- Mokhtari. A. H., Wall. A., Brooks. P., Wang. J., (2007). Automatic Identification System (AIS): data reliability and human error implications. Journal of Navigation. Vol 60(3) pp. 373-389.
- Navigational Risk Assessment in Restricted Waters by Using AIS Data, 2010
- Usage of Automatic Identification System (Ais) For Evaluation of Marine Traffic Safety In The Malacca Straits, 2010
- Ross, A., Lintu, S. and Hachmoller, B. (1995) Navigational safety in the Malacca Straits. Tropical Coasts 2 (1), 7±10.
- Shaw, K. E. (1973) The Straits of Malacca: in Relation to the Problems of the Indian and Pacific Ocean University Education Press, Singapore, 174 pp.
- Wu, X., 1988. Ship's Maneuverability and Sway. China Communications Press, Beijing.
- Xiaobo. Qu., Qiang. M., Li. S., (2011). Ship collision risk assessment for the Singapore Strait. Accident Analysis and Prevention. Vol. 43 pp. 2030-2063.