REPUBLIC OF TURKEY
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GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES

KRA CANAL PROJECT AND ITS INFLUENCE ON WORLD MARITIME TRADE

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June, 2018

Achmad ZUHDI

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LIST OF SYMBOLS

c	Constant
∇	Displacement of the ship
%	Percent
r_F	Ship fuel oil consumed per day
V	Speed

LIST OF ABBREVIATIONS

ACFTA	ASEAN – China Free Trade Area
AIS	Automatic Identification System
ASEAN	Association of South East Asian Nations
bbl/d	Barrels Per Day
B. C.	Before Christ (calendar years in the period before Christ was born)
DWT	Dead Weight Tonnage
EIA	Energy Information Administration
EU	Europe Union
GDP	Gross Domestic Product
GIS	Global Information System
GT	Gross Tonnage
ICC	International Chamber of Commerce
IFO	Intermediate Fuel Oil
IMO	International Maritime Operation
kW	Kilo Watt
LOA	Length of All
LPP	Length Between Perpendicular
MY PKG	Malaysia Port Klang
NM	Nautical Miles
NSR	Northern Sea Route
OECD	Organization for Economic Co-Operation and Development
PESTLES	Political, Economic, Social, Technological, Legal, Environmental, and Safety
RPM	Rotation per Minute
RT	Register Tonnage
(S)ECA	(Sulphur) Emission Control Area
SFOC	Specific Fuel Oil Consumption
TEUs	Twenty-Foot Equivalent Units
ULCC	Ultra Large Crude Carrier
UNCTAD	United Nations Conference on Trade and Development
US	United States
USD	United States Dollar
VLCC	Very Large Crude Carrier
VTS	Vessel Traffic Service
STRAITREP	Ship Reporting System in the Straits of Malacca and Singapore

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ABSTRACT

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Suez Canal and Panama Canal are two successful inventions in maritime trade that built in order to abridge ship line from one port to another port. Effectiveness is given by these canals for problem solving such as faster than without passing them on.

There are also too many problems take place as before existing canals were built: too long voyage, piracy, and limited dimension. Currently, Malacca Strait is one of the busiest straits in the world with this congestion and pirates attack. Vessels who are sailing from Indian Ocean to South China Sea, *vice versa*, should pass Malacca Strait (known also as Singapore Strait) for the shortest voyage. Unfortunately, this strait is overcapacity and lack of safety.

Kra Canal is one of the invention to solve Strait of Malacca problems that has already been discussed since 1863. Kra Canal is an idea of constructing the canal planned for the shortcut of the voyage to shorten without passing the Strait of Malacca anymore. Its location is in Southern Thailand and will connect directly with the Andaman Sea. Its length is about 102 km, 400 meters wide with a depth of more than 20 meters.

Processing of this canal is required approximately 8-10 years with predicted that will shorten the journey about 1,200 km between the Indian Ocean and the Pacific Ocean.

Our objective on this thesis is simulating the voyage through Kra Canal and Malacca Strait using Netpass Distance program to know the voyage distance and time changes and ARENA simulation software to simulate the voyage. It is estimated that the Kra Canal will shorten the voyage between two to five days. It is foreseen that construction of this canal will affect the world economy, maritime transportation and the countries close to this canal.

Keywords: Kra Canal, Malacca Strait, Netpass Distance, ARENA Simulation

ÖZET

KRA KANALI PROJESİ VE DÜNYA DENİZ TİCARETİ ÜZERİNE ETKİLERİ

Achmad ZUHDI

Gemi İnşaatı ve Gemi Makineleri Mühendisliği Anabilim Dalı

Yüksek Lisans Tezi

Tez Danışmanı: Dr. Öğr. Üyesi Eda TURAN

Süveyş Kanalı ve Panama Kanalı, bir limandan diğer limana gemi hattını sağlamak için inşa edilen iki başarılı deniz ticareti icatlarıdır. Verimlilik, bu kanalları kullanmamaya göre daha hızlı olmak amacıyla problem çözümü olarak verilmektedir.

Mevcut kanallar kurulmadan önce de çok fazla sorun yaşanmıştır: çok uzun yolculuklar, korsanlık ve sınırlı boyut. Şu anda Malacca Boğazı, gemi trafiği ve korsan saldırısı ile dünyanın en yoğun boğazlarından birisidir. Hint Okyanusu'ndan Güney Çin Denizi'ne giden gemiler, tam tersi olarak, en kısa sefer için Malacca Boğazı'ndan (Singapur Boğazı olarak da bilinir) geçmelidir. Maalesef, bu boğazda kapasite fazlası ve güvenlik eksikliği bulunmaktadır.

Kra Kanalı, 1863'ten beri tartışılan Malacca Boğazı sorunlarının çözümü için önerilen buluşlardan biridir. Kra Kanalı, artık Malacca Boğazı'nı geçmeden yolculuğu kısaltmak amacıyla planlamış bir kanal inşa etmenin fikridir. Konumu Güney Tayland'dadır ve doğrudan Andaman Denizi ile bağlantı kuracaktır. Uzunluğu 102 km, genişliği 400 metre ve derinliği 20 metreden fazladır.

Bu kanal sürecinin yaklaşık 8-10 yıl gerektiği tahmininde Hint Okyanusu ile Pasifik Okyanusu arasındaki 1,200 km'lik yolculuğun kısalacağı öngörülmektedir.

Bu tez konusundaki hedefimiz, yolculuk mesafesini ve zaman değişimlerini bilmek için Netpas Distance programı ve yolculuğu simüle etmek için ise ARENA Simülasyon yazılımı kullanarak, Kra Canal ve Malacca Boğazı'yla gerçekleştirilen sefer simülasyonunu yapmaktır. Kra Canal'ın iki ile beş gün arasında yolculuk süresini kısaltacağı tahmin edilmektir. Bu kanalın yapılmasının dünya ekonomisini, deniz taşımacılığını ve kanala yakın ülkeleri etkileyeceği öngörülmektedir.

Anahtar kelimeler: Kra Kanalı, Malacca Boğazı, Netpass Distance, ARENA Simülasyonu

CHAPTER I

INTRODUCTION

The Kra Canal is the new invention of constructing canal in the isthmus of the southern part of Thailand (see Figure 1.1). It could shorten the world maritime line for the ships which are coming from Andaman Sea to Gulf of Thailand, or *vice versa*. This new shortcut will be constructed in order to avoid the congestion of Malacca/Singapore Straits.

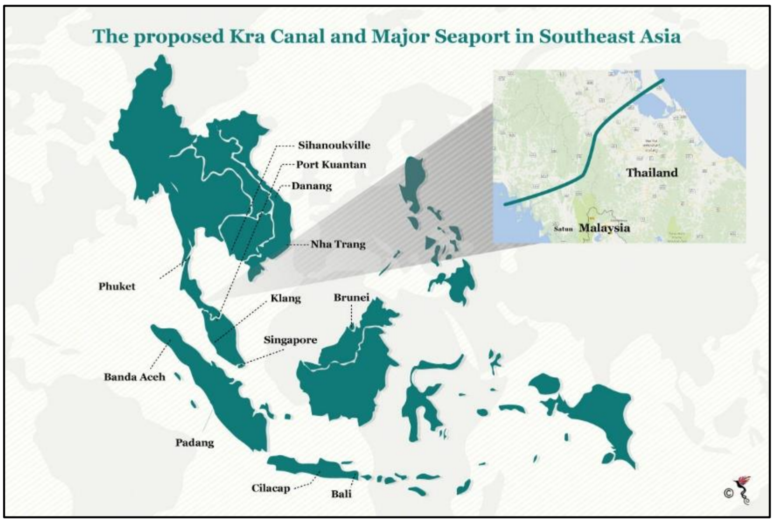

Figure 1.1 Map of Proposed Kra Canal [1]

1.1 Literature Review

Sommart Chulikpongse [2] started to revived discussing the construction of Kra Canal that was interested by policy makers and shipping players, at that time. According to his thesis, he figured out Kra Canal clearly by giving the factors which influenced the canal to be constructed and ended up by giving recommendations for future Songkhla and Satun (Thailand's province) to be ready for the canal, which could reduce the estimation of overcrowd maritime line in Malacca/Singapore Straits. With respect to traffic of Malacca/Singapore Straits, Klang Vessel Traffic Service (VTS) reported in 2017 Malacca/Singapore Straits were passed by 231 ships per day [3] [4]. For figure out the ships in Malacca/Singapore Straits, Figure 1.2 shows Traffic in Malacca/Singapore Straits Captured by Automatic Identification System (AIS). It increased since Abdul Rahman et al. [5] reported that in 2010 was 203 ships per day and he reviewed Kra Canal deeply by point of view of PESTLES (Political, Economic, Social, Technological, Legal, Environmental, and Safety) analysis for maritime business and economy in Malaysia. These seven elements concluded as follows: diversification by maritime business, development of certain part in Malaysia as a bunkering service, and promoting Penang Port to be hub port to overcome Kra Canal. Both Abdul Rahman et al. [5] and Zuhdi & Turan [6] focused on giving recommendations for Malaysia and Indonesia, respectively, while Zuhdi & Turan [6] recommended Sabang port as an international modern economic port and maximizing seaborne cost of Indonesia region. It is because the concern

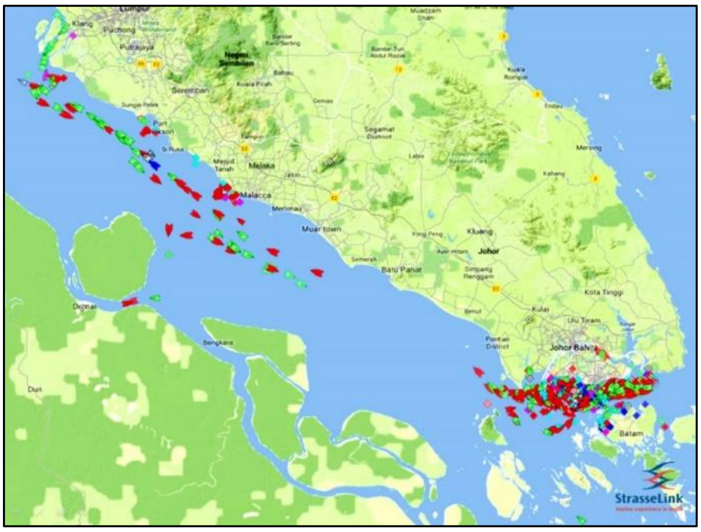

Figure 1.2 Traffic in Malacca/Singapore Straits Captured by Automatic Identification System (AIS) [7]

of Chen and Kumagai [8] that calculated briefly the economic impacts of constructing Kra Canal by simulating the sea port distances among ports using Global Information System (GIS) and World Shipping Lane based on spatial economics. They gave three cases: Kra Canal and Malacca/Singapore Straits are coexisting; only Kra Canal is working; and Kra Canal with Special Economic Zone (SEZ) in the middle of the canal. As a result, Thailand, China, India, Japan, and Europe Union could take highest benefit from canal that could also affect their national gross domestic product (GDP). On the other hand, Indonesia, Malaysia, Singapore, and Brunei gain negatively high for this simulation. At the end of their paper, it was highlighted to be concerned in the future study regarding the existing of Kra Canal in terms of reducing ship operation cost and the powerful of Singapore Port existence.

The history of Kra Canal was also elaborated in sufficient details by Stephen Doobs [9]. Based on British colonial documents and Singapore sources, Kra Canal is started to be proposed since 1850s as a revival. On this paper, Kra Canal seemed very far away to be constructed because of the antithesis from the cost, Thailand political situation and sovereignty. Going along with Doobs [9], Ivica Kinder [10] and Sulong [11] involved debating Kra Canal. Kinder [10] highlighted Kra Canal with some perspective from other countries: Thailand, Malacca/Singapore Straits' littoral countries, China, Japan, South Korea, India, and United States, while Sulong [11] debated in terms of environment, political, economic, and security in national (Thailand) and regional, ASEAN (Association of South East Asian Nations), that passageway could split ASEAN countries into two region physically and economically. It could give the new conflict in international relations although in international law countries are independent for making passageway to connect two seas.

Without neglecting the harmony of ASEAN relation, the shipping players are concerning overcrowd of Malacca/Singapore Straits area in maritime shipping line. Ibrahim & Khalid [12], Abdul Rahman et al. [13], and Cheng Young Lau & Jason Wai Chow Lee [14] dealt with overcapacity of Malacca/Singapore Straits. Ibrahim & Khalid [12] persuaded International Maritime Operation (IMO) to make improvements for safety and pollution prevention around the straits. Abdul Rahman et al. [13] gave solution to reduce the crowd of the straits by utilization of Northern Sea Route (NSR) between Far East and Europe ship line due to reduce operation cost, bunker cost, emissions, and voyage time for maritime sector in Malaysia. But the main threats of this idea are reducing the port profit, countries income, and employment rate, especially increasing the northern sea temperature by ship's exhaust gas. Lee & Kim [15] explained Northern Sea Route from the point of view of shipping companies that compared both risks and opportunities regarding global climate change which causes melting icebergs and glaciers. It was also reported that Korean Shipping Company had tried to navigate through NSR in 2013 but unfortunately it seemed an unfamiliar route that could present many challenges such as risks of moving ice, extreme weather conditions, and lack of consistent cargo flow. In other words, it was not a real solution to reduce overcrowd of Malacca/Singapore Straits. Added by Lee & Song [16] in 2014, the issue of NSR brought it to simulation using Netpas Distance program that could shorten 5,000 nautical miles or 9,260 km in the simulation. In terms of voyage distance and time it resulted positively, however some unpredictable aspect could happen such as a costly passage fee charged by Russia and some rules and regulations should be created related to NSR. Again, some innovation in order to reduce Malacca/Singapore Straits is still under expectation.

Conceptual feasibility study that near to support constructing Kra Canal was conducted by Cheng Young Lau & Jason Wai Chow Lee [14]. It was briefly explained the existence of two canal before: Suez Canal and Panama Canal, as a comparison for constructing the new one. Even though, Kra Canal was expected to stuck at least in a couple of years in the future because Doobs [9] stated it must be simulate by shipping players in future for knowing from the point of view of ship liners or academician.

1. 2 Objective of the Thesis

The purpose of this thesis is to simulate a ship passing Kra Canal using Netpas Distance software for estimating the distance for shipping line and ARENA Rockwell simulation software. The condition of this simulation is using a ship from Rotterdam Port in Netherland to Shanghai Port in China by passing the new canal and Malacca Strait. Comparing the voyage and congestion will give the result of the shortcut voyage by distance and time. Then, the calculation for ship operation cost will be calculated. At the end of this thesis will also give the writer's view point of constructing this canal for one of the new invention in maritime trade or other recommendations instead of continuing to construct the canal which are more efficient and viable.

1. 3 Hypothesis

The hypothesis of this thesis is the Kra Canal, as the suitable new invention due to solve the Malacca Strait problems, will decrease the sailing time of the vessels which sail from Europe to East Asia/Middle East. This simulation could reduce ship voyage time and ship operation cost in term of experimental simulation.

CHAPTER II

GENERAL INFORMATION

2. 1 Overview of Maritime Transportation in Asia

Discussing maritime transportation is affected by performance of developments economic growth and trade among countries. The growth of world economy was going down in 2016 by 2.2% of GDP (gross domestic product) while in 2015 it was 2.5% and worse than average GDP percentage between 2001 – 2008 growth rate by 3.2%, as shown in table 2.1. Slowing down of the economic growth occurred also in developed countries (Europe Union, United States, and Japan) from 2.2% in 2015 to 1.7% in 2016. China and India became strong in economic growth last decades have dropped to 6.7 and 7.0, respectively, while Asia as a developing economic region had 7.3% in 2001 – 2008 average economic growth, 5.2% change in 2015, and 5.1% economic growth in 2016.

Table 2.1 World Economic Development, 2015-2017 (Annually, in percent). Source: Organization for Economic Co-Operation and Development (OECD) [17]

Region/Country	**2001-2008**	**2015**	**2016**	**2017**
Developed Countries	2.2	2.2	1.7	1.8
EU (28 Countries)	2.2	2.3	1.9	1.9
Japan	1.2	1.2	1.0	1.5
United States	2.5	2.6	1.6	2.1
Developing Economies				
Asia	7.3	5.2	5.1	5.2
China	10.9	6.9	6.7	6.7
India	7.6	7.2	7.0	6.7
World	3.2	2.6	2.2	2.6

Table 2.2 shows annual percentage change of merchandise trade by volume. By merchandise trade by volume, investment, economic growth and trade generated trade among countries became poor. But in 2016 both export and import for the world was

rising from 1.4 to 1.7 (export) and from 1.9 to 2.1 (import). This increment was caused by the improvement of oil price in 2016 that support countries' trading company to increase the volume of merchandise trade.

Table 2.2 Annual Percentage Change of Merchandise Trade by Volume. Source: UNCTAD [18]

Region/Country	**Imports**				**Exports**			
	2013	**2014**	**2015**	**2016**	**2013**	**2014**	**2015**	**2016**
Developed Countries								
EU(28 Countries)	-1.0	3.2	4.1	2.8	1.9	1.6	3.3	1.1
United States	0.8	4.7	3.7	3.6	2.6	3.3	-1.1	-0.2
Japan	0.3	0.6	-2.8	-0.3	-1.5	0.6	-1.0	0.3
Asia								
Western Asia	6.7	2.2	3.1	-2.4	3.7	-3.2	-0.6	3.5
Southern Asia	-0.4	4.7	7.4	8.9	0.0	1.1	-1.4	18.1
Eastern Asia	7.0	3.4	-1.1	2.2	6.7	4.9	-0.6	0.6
South-East Asia	4.2	2.4	5.7	4.4	5.0	3.7	3.7	3.9
China	9.1	2.9	-1.8	3.1	8.5	5.6	-0.9	0.0
India	-0.3	3.2	10.1	7.3	8.5	3.5	-2.1	6.7
World	2.3	2.5	1.9	2.1	3.1	2.0	1.4	1.7

Increasing in world economy in 2016 affected for world seaborne trade that accelerated 2.6% in 2016 from 1.8% in 2015 with 264 million tons of total volume added (data are shown in table 2.3). This addition was from raising of oil and gas trading, almost half of total volume added, because of China's demand for importing oil and gas and in 2016 China became the biggest oil importer in the world overtook United States of America (USA).

In containerized goods trading, weak condition in the range of 2011 – 2015 occurred continuously after recovery in 2010 from world crisis in 2008 which affected containerized trading in 2009 down, as shown in figure 2.1. In loaded or unloaded trade, in 2016 it increased 2.0% by 7,231.3 million tons for loaded condition and 7,058.3 million tons for unloaded one. Improvement was encouraged by two important condition: increasing of Europe – Asia seaborne trade (oil & gas, main dry bulks, and container) and raising intra-Asian container trade. These reason caused to gain more volume in global containerized trade.

Table 2.3 Seaborne Trade Volume Loaded (million tons) [18]

Year	Container	Bulks	Oil and Gas	Total	Growth Rate (%)
2013	3,762	2,923	2,829	9,514	3.4
2014	4,033	2,985	2,825	9,843	3.4
2015	3,971	3,121	2,932	10,023	1.8
2016	4,095	3,172	3,055	10,287	2.6

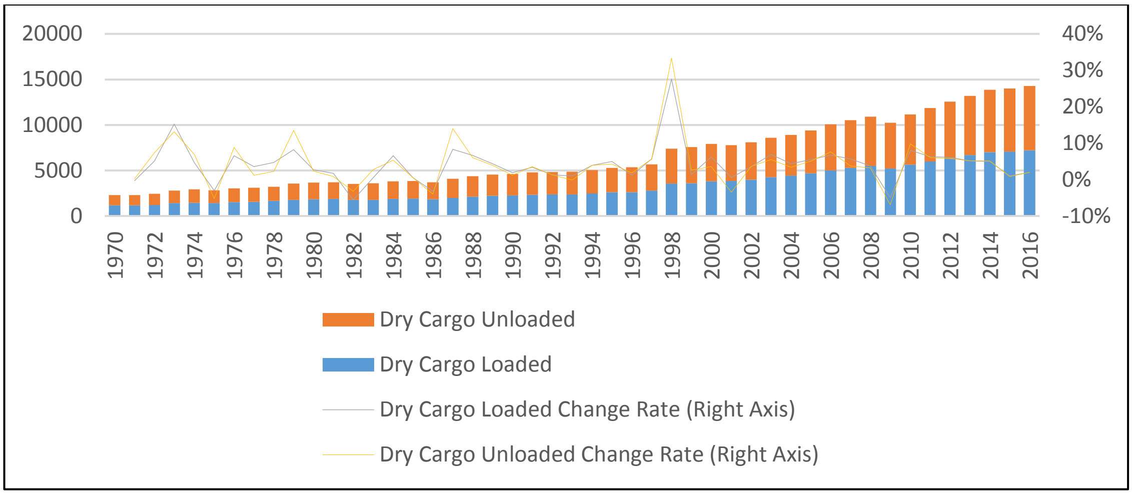

Figure 2.1 Global Containerized Trading – Loaded and Unloaded (Metric tons in millions) [19]

In the perspective of maritime route, the development is presented in table 2.4 within Asia-America-Europe. The volume of Asia-Europe path is positively increase except decline in 2015.

Table 2.4 2014 – 2017 Asia and Europe Containerized Trade Routes in million TEU (annually) [18]

Year	Eastern Asia—North America	Eastern Asia—Northern Europe and Mediterranean	North America—Eastern Asia	Northern Europe and Mediterranean—Eastern Asia
2014	15.8	15.2	7.4	6.8
2015	16.8 (6.6%)	14.9 (-2.4%)	7.2 (-2.9%)	6.8 (0.0%)
2016	17.7 (5.2%)	15.3 (2.8%)	7.7 (7.3%)	7.1 (4.0%)
2017	17.9 (1.0%)	15.5 (1.8%)	8.2 (6.4%)	7.6 (7.3%)

Severe condition for container trading in 2008/2009 affected trade flows were going slower after recovery. Asia-Europe and intra-Asia trade routes became stronger and surplus than other regions and it caused mergers and acquisitions within shipping industries to prevent from bankruptcy as happened on Hanjin on April 22, 2016, which gave up for management control to the Korea Development Bank.

Mergers and acquisitions are constructed for example Hapag-Lloyd – UASC merger and Maersk – Hamburg Süd acquisition to maximize container capacity and reduce ship operation costs around the world. Ships alliances also occurred into three big alliances: 2M Alliance (Maersk & MSC), Ocean Alliance (CMA CGM (with APL), China Shipping, OOCL, Evergreen), and THE Alliance (K Line, Yang Ming, MOL, Hapag-Lloyd and UASC, NYK Line - this group contained Hanjin Shipping prior to its bankruptcy). This condition could influenced container trade by changing ships distribution format. For example the improvement of Panama Canal is supporting higher volume for the ships passing from this canal. As a consequence, “old Panamax” (5,000 TEUs) ships were changed with the ships in range of 8,000 – 12,000 TEUs to support container trade between United States East Coast – Asia volume [18].

2.2 World Ship Oversupply

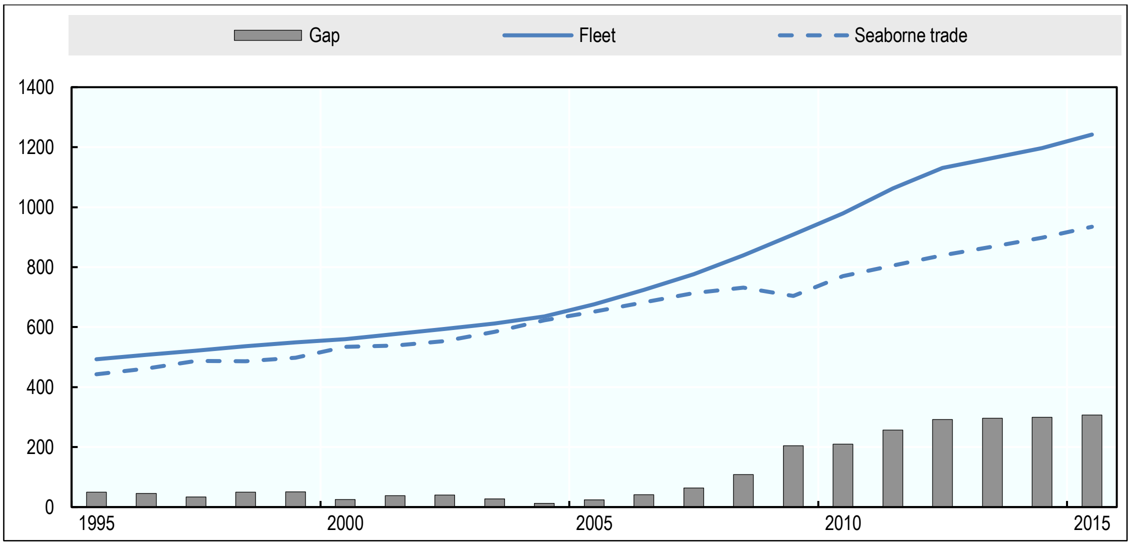

Figure 2.2 Global merchant fleet and seaborne trade, 1995 – 2015 (million GT) [20]

Organization for Economic Co-operation and Development (OECD) explained about the overcapacity of fleet market in the world (especially in the type of tanker, bulk carrier, and container vessels) in gross tonnage (GT) with seaborne trade in figure 2.2. After the global crisis in 2008, the difference between merchant fleet and seaborne trade was starting to become larger. It was claimed that 307 million GT oversupplied in 2017, close to 25% of total world fleet in 2015. This condition was predicted to stick out until 2035 if there is no effort to lower supply of fleet or incisive attempt to increase seaborne trade in containerized goods, general cargo, or liquid (oil and gas production). A small gap on supply and demand started in 2005 added by unpredictable future world economic performance, caused the supply of the ship exceeds demand in seaborne trade (especially in containerized goods) since shipbuilders deliver the order after 2-3 years after agreement with ship owners. Indeed, capacity of shipbuilding is limited, in some cases shipbuilders have unused fleet from cancellation that tends to offer to market by low prices. Governmental policies protection of the shipbuilding industries and labor markets also intensifies oversupply situation [20].

2.3 Seaborne Trade in Future

The outgrowth of e-commerce in Asia, as a 60% homeland for the population in the world, is predicted growing importantly to strong condition. Two China's e-commerce companies: Jingdong (JD.com) and Alibaba Group Holding Ltd. led as the biggest e-commerce companies in Asia followed by Rakuten is the 3rd. Although global e-commerce markets are still held by developed countries, in Asia it accelerated significantly that could defined as opportunities or even challenges in merchandise trade and transportation among countries since it seems to increase shipment or airfreight volume in Asia especially. E-commerce tendency also affects containerized trading and supply chain in the world which for long-lasting product would deliver using maritime model while susceptible goods prefer to deliver by air model.

In the future, until 2022 at least the growth of main commodities and container trade will develop around 5% that expected by the projects such as the China's One Belt, One Road initiative, the Russian Federation-India-Central Asia's International North – South Transport Corridor, and the Japan's Quality for Infrastructure Partnership. All of the projects might increase the volume of merchandise trading to assist projects' sustainability by supply raw materials, machinery, or manufactured goods almost using marine transportation.

Marine transportation is holding over 80% of world merchandise trade however lack of certainty and riskiness should be resolved. Ship capacity, maritime shipping line connectivity, and performance of port in certain country should be improved. On the segment of maritime trade policy, in terms of the Addis Ababa Action Agenda and the 2030 Agenda for Sustainable Development, the World Trade Organization Agreement on Trade Facilitation (February 2017) should be executed effectively and efficiently that could encourage world trade flows and cost reduction in developing countries, especially. Marine policies also should encourage marine activity and trade in order to excite trade and increase maritime transportation markets [20].

2.4 Container Vessels and Liners' Overview in Asia

Table 2.5 Ownership of Container-carrying World Fleet in 2017 [18]

Country	Size of Largest Ship (TEUs)	Average Size per ship (TEUs)	Total of Ships	Total of TEUs	Market Share (%)
Germany	14,036	2,277	2,106	4,795,085	21.46
China	19,224	2,409	871	2,098,655	9.39
Greece	14,354	3,224	563	1,815,265	8.13
Denmark	18,270	5,163	300	1,548,865	6.93
Hong Kong (China)	17,859	4,805	288	1,383,720	6.19
Singapore	15,908	3,056	448	1,368,888	6.13
Japan	14,026	3,027	410	1,240,871	5.55
Switzerland	14,000	5,195	236	1,225,932	5.49
Taiwan Province of China	8,626	3,491	280	977,453	4.38
United Kingdom	15,908	2,592	337	873,348	3.91
Republic of Korea	13,100	2,628	254	667,571	2.99
France	17,722	6,239	95	592,738	2.65
Kuwait	18,800	10,903	42	457,918	2.05
United States	9,443	1,708	206	351,895	1.58
Netherlands	3,508	468	646	302,313	1.35
Turkey	9,010	514	512	262,955	1.18
Norway	13,102	628	365	229,220	1.03
Indonesia	2,702	448	410	183,479	0.82
Israel	10,062	4,253	42	178,263	0.80
Cyprus	6,969	1,419	123	174,513	0.78
Sub Total		2,429	8,534	20,729,307	92.79
Rest of World			2,616	1,610,491	7.21
World Total	19,224	2,004	11,150	22,339,798	100.00

As seen in table 2.5 for ownership of container-carrying world fleet in 2017, although Germany became superior in ownership of container vessels with 21.46% of market share in the world, Asian countries hold 37.5% market value from 92.79% total market. China, Hong Kong, and Kuwait also had container ships more than 17,000 TEUs that could serve long maritime route efficiently with biggest container vessels in the world as a development of Asia seaborne trade (containerized goods). Up to May 2017, Danish container ship liner company, Maersk Line, led in the top 50 companies in terms of container capacity in TEUs by 3.2 million TEUs with 16.0% market value in the world.

Liner shipping companies could own the ships by their companies or by charter from shipping operator so that the best liner companies were not correspond directly became the biggest container vessels owner by country.

2.5 Container Ship Freight Rates and Maritime Transport Costs

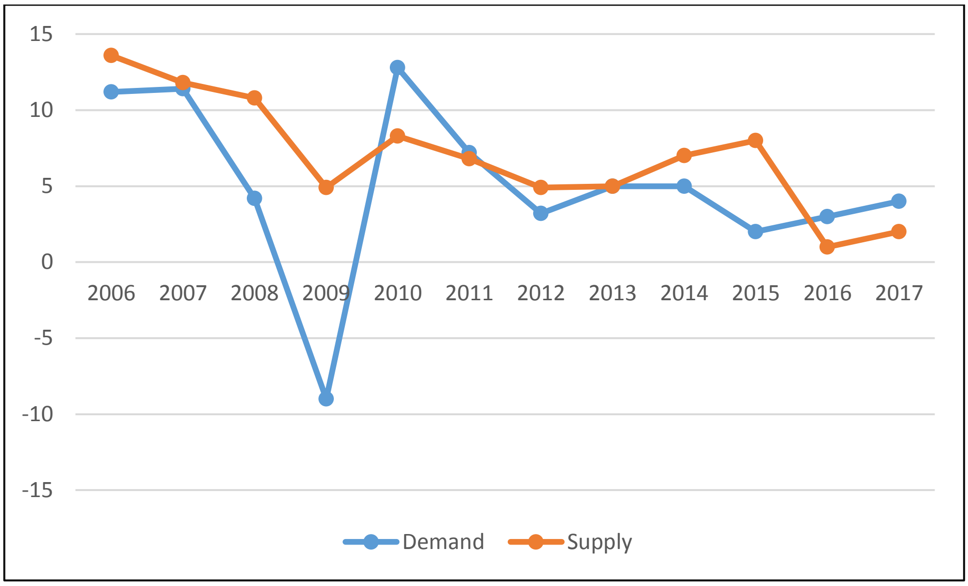

Figure 2.3 Containerized Merchandise Demand and Container Shipping Supply Annual Change Rate (%) Based on TEUs [18]

In a year of 2016 was the difficult situation for container fleet. In the figure2.3 explains that in 2016, demand of the containerized goods was raising 3%, greater than in 2015 by 2%. The problem was the container vessels supplied down in 2016 with 1% declined from 8% in 2015. Demand in containerized goods in global trade increased positively which mostly caused by increasing the volume of Far East Asia – Europe trade and intra – Asian trade connections while container vessels dropped because of demolition and slowing down of container ships fleet growth. Table 2.6 explains freight rates between two main connections, Far East Asia-Europe and intra-Asia that affected by supply and demand condition in container ships market. Shanghai-Northern Europe voyage lightly improved 8.6% in 2016 or $683 per TEU from $629 per TEU, which the lowest price since 2009. An excessive supply of container also affected China to Mediterranean freight rate added with faint China’s export goods that made these condition occurred. In 2016 the most severe falling condition freight rate was Shanghai – South East Asia (Singapore) that dropped from $187 per TEU to $70 per TEU. These harsh condition made ship liners managed doing demolition of vessels, idling the fleets, or in special case performing slow steaming which operate the ships below maximum speed to save money on fuel. This condition happened in order to face the global uncertainty of freight rates and to heal from unpleasant ship operation cost in some area [18].

Table 2.6 Freight Market and Rates of Container Fleet by Main Connections (Dollars per TEU) [18]

Routes	2009	2010	2011	2012	2013	2014	2015	2016
Shanghai–South East Asia (Singapore)		318	210	256	231	233	187	70
Percentage change			-34.0	21.8	-9.7	0.9	-19.7	-62.6
Shanghai–Northern Europe	1,395	1,789	881	1,353	1,084	1,161	629	683
Percentage change		28.2	-50.8	53.6	-19.9	7.10	-45.8	8.6
Shanghai–East Japan		316	337	345	346	273	146	185
Percentage change			6.7	2.4	0.3	-21.1	-46.5	26.7
Shanghai–Mediterranean	1,397	1,739	973	1,336	1,151	1,253	739	676
Percentage change		24.5	-44.1	37.3	-13.9	8.9	-41.0	-8.6
Shanghai–Persian Gulf (Dubai)	639	922	838	981	771	820	525	399
Percentage change		44.33	-9.1	17.1	-21.4	6.4	-36.0	-24.0

2.6 Port Overview in Asia

In the year of 2016, most of ports in the world suffered from low global economic performance, poor growth in world seaborne trade by volume, uncertainty of freight market rate, and lessen merchandise trade. These harsh condition affected container port in the world. As data seen in table 2.7, in 2015 and 2016 global container port handled 686.6 million TEUs and 699.7 million TEUs respectively, gained 1.9% in 2016 which increased less than in 2014 by 5.7%. Asia region handled around 64% of world container port by TEUs mainly concentrated on Eastern and South East Asia. Europe (16%), North America (8%), Developing America (6%), Africa (4%), Oceania (2%) are the rest.

Table 2.7 Global Container Port Handle Volume (in TEUs) [18]

Continent	2014	2015	2016
Asia	429,641,660	439,573,985	446,813,796
Europe	109,018,957	108,359,396	113,831,821
North America	51,659,185	53,689,663	54,120,207
Developing America	45,615,876	45,804,387	45,915,853
Africa	28,027,967	28,122,893	27,909,132
Oceania	11,017,084	11,139,239	11,112,739
Total	674,980,729	686,689,563	699,703,546
World Annual Percentage Change	5.7%	1.7%	1.9%

In the table 2.8, there are 40 big container ports in the world handling by volume of the container in TEUs in 2015 and 2016. Totally, these port serviced 60% of global container trade and the top 10 shared around 33.3% from the total trade. Piraeus Port, Kelang Port, Colombo Port, and Cat Lai Port increased TEUs handling by more than 10% in 2016. Moreover, Kelang Port overstepped Rotterdam Port in 2016, which in 2015 Rotterdam Port handled more volume than Kelang Port. China still dominated the biggest handling TEUs that 7 ports from 10 top ports are from China and also ports in China almost handled 50% volume from the top 40 ports. From these top 40 ports in the world by TEUs handling, Asia contributed 26 ports as the highest including 7 ports from South East Asia, followed by European Union by 8 ports, and America by 6 ports.

Table 2.8 Container Port Volumes Service in 2015 and 2016 [18]

Rank	**Port**	**Country**	**2015 (TEU)**	**2016 (TEU)**	**Rate**
1	Shanghai	China	36,537,000	37,135,000	1.6%
2	Singapore	Singapore	30,962,000	30,930,000	-0.1%
3	Shenzhen	China	24,204,000	21,565,000	-0.9%
4	Ningbo	China	20,593,000	19,580,000	4.7%
5	Hong Kong	China	20,114,000	19,378,000	-2.7%
6	Guangzhou	China	17,457,000	18,859,000	0.4%
7	Busan	Republic of Korea	19,296,000	18,859,000	8.0%
8	Qingdao	China	17,465,000	18,050,000	3.3%
9	Dubai	United Arab Emirates	15,592,000	14,772,000	-5.3
10	Tianjin	China	14,109,000	14,523,000	2.9
11	Port Kelang	Malaysia	11,891,000	13,167,000	10.7
12	Rotterdam	Netherlands	12,235,000	12,385,000	1.2
13	Kaohsiung	Taiwan Province of China	10,264,000	10,460,000	1.9
14	Antwerp	Belgium	9,650,000	10,037,000	4.0
15	Xiamen	China	9,179,000	9,614,000	4.7
16	Dalian	China	9,449,000	9,584,000	1.4
17	Hamburg	Germany	8,825,000	8,900,000	0.8
18	Los Angeles	United States	8,160,000	8,857,000	8.5
19	Tanjung Pelepas	Malaysia	8,799,000	8,029,000	-8.8
20	Cat Lai	Viet Nam	6,863,000	7,547,000	10.0
21	Laem Chabang	Thailand	6,821,000	7,227,000	6.0
22	Long Beach	United States	7,192,000	6,775,000	-5.8
23	New York	United States	6,372,000	6,250,000	-1.9
24	Yingkou	China	5,921,000	6,087,000	2.8
25	Colombo	Sri Lanka	5,185,000	5,735,000	10.6
26	Tanjung Priok	Indonesia	5,201,000	5,515,000	6.0
27	Bremerhaven	Germany	5,546,000	5,489,000	-1.0
28	Suzhou	China	5,102,000	5,479,000	7.4
29	Lianyungang	China	5,009,000	4,829,000	-3.6

Table 2.8 Container Port Volumes Service in 2015 and 2016 (cont'd)

30	Algeciras	Spain	4,511,000	4,745,000	5.2
31	Valencia	Spain	4,668,000	4,660,000	-0.2
32	Tokyo	Japan	4,623,000	4,653,000	0.6
33	Jawaharlal Nehru	India	4,468,000	4,475,000	0.2
34	Manila	Philippines	4,135,000	4,427,000	7.1
35	Jeddah	Saudi Arabia	4,188,000	3,997,000	-4.6
36	Piraeus	Greece	3,287,000	3,750,000	14.1
37	Felixstowe	United Kingdom	4,043,000	3,745,000	-7.4
38	Savannah	United States	3,737,000	3,645,000	-2.5
39	Seattle	United States	3,529,000	3,529,000	0.0
40	Santos	Brazil	3,774,000	3,564,000	-5.6
	Total		408,956,000	415,928,000	1.7

2.7 Geography and Overview of Malacca/Singapore Straits

Malacca/Singapore Straits are one of the important straits in the international navigation with long and busy pathway connecting the voyage between Andaman Sea and South China Sea, vary on width and depth. This is also one of the chokepoints of the world that in 2017 around 84,456 vessels passed per year, as shown in table 2.9, and predicted will become more crowded in 10-15 years. Avoiding the congestion of Malacca/Singapore Straits is considered by shipping players for example new route alternatives e. g. Sunda Strait and Lombok Strait, both are in Indonesian territory. Nevertheless, these two route alternatives extend the voyage in time and distance. Together with shipping companies, reducing fuel and the operation cost is a must instead of using Sunda Strait and/or Lombok Strait [6].

Table 2.9 Numbers of Ships Reporting Under STRAITREP until January 2018 [21]

Type of Ships	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018***
VLCC / Deep Draft	4333	4539	4732	4825	4993	5324	5418	6711	613
Tanker Vessel	16247	16223	17345	18296	18765	18470	17799	20629	1711
LNG & LPG Carrier	3579	3830	4014	4248	4173	3936	3685	4137	425
Cargo Vessel	8445	7996	7950	7613	6989	7144	6595	7090	580
Container Vessel	24806	25552	24639	24658	25071	25389	23625	24446	2143
Bulk Carrier	11642	10851	11678	12658	13454	15168	14307	15411	1410

Table 2.9 Numbers of Ships Reporting Under STRAITREP until January 2018 (cont'd)

Ro-Ro	2624	2545	2980	2998	3146	3117	2622	2629	208
Passenger Vessel	1071	877	861	1063	1041	925	1125	1776	206
Livestock Carrier	45	47	38	55	59	76	67	50	4
Tug / Tow	545	414	529	563	676	467	536	533	57
Government Vessel	37	57	50	58	96	87	46	54	10
Fishing Vessel	20	20	52	27	51	53	23	28	3
Others	739	577	609	911	830	803	714	962	95
Total	74133	73528	75477	77973	79344	80959	76562	84456	7465

Piracy on the shipping companies' point of view is one of a loss of profit while the cost of insurance also higher if the probability of piracy soars with the same condition. This increasing could be happened also by political situation around the world maritime shipping line. It was cited from International Chamber of Commerce (ICC) International Maritime Bureau that in the range of 2009–2013 there was increasing for pirate attacks around Malacca/Singapore Straits in amount of 42, 63, 74, 101, and 125, respectively. Moreover, on the table 2.10 is shown the improvement attempted to reduce the piracy [22].

Table 2.10 South East Asia's Actual and Attempted Attacks. Source: ICC International Maritime Bureau [22]

Region	**2013**	**2014**	**2015**	**2016**	**2017**
Indonesia	106	100	108	49	43
Malacca Straits	1	1	5	0	0
Malaysia	9	24	13	7	7
Philippines	3	6	11	10	22
Singapore Straits	9	8	9	2	4
Thailand	0	2	1	0	0

In 2016 United States (US) Energy Information Administration (EIA) claimed that at that year, Strait of Malacca is the second prominent chokepoint by the volume of carried oil after Strait of Hormuz. Passed by 16.0 million barrels per day (bbl/d), Malacca/Singapore

Straits was less 2.5 million bbl/d than the Strait of Hormuz which passed by 18.5 million bbl/d from world total oil supply around 97.2 bbl/d carried by ship oil tanker [21]. For more details, see figure 2.4 and table 2.11.

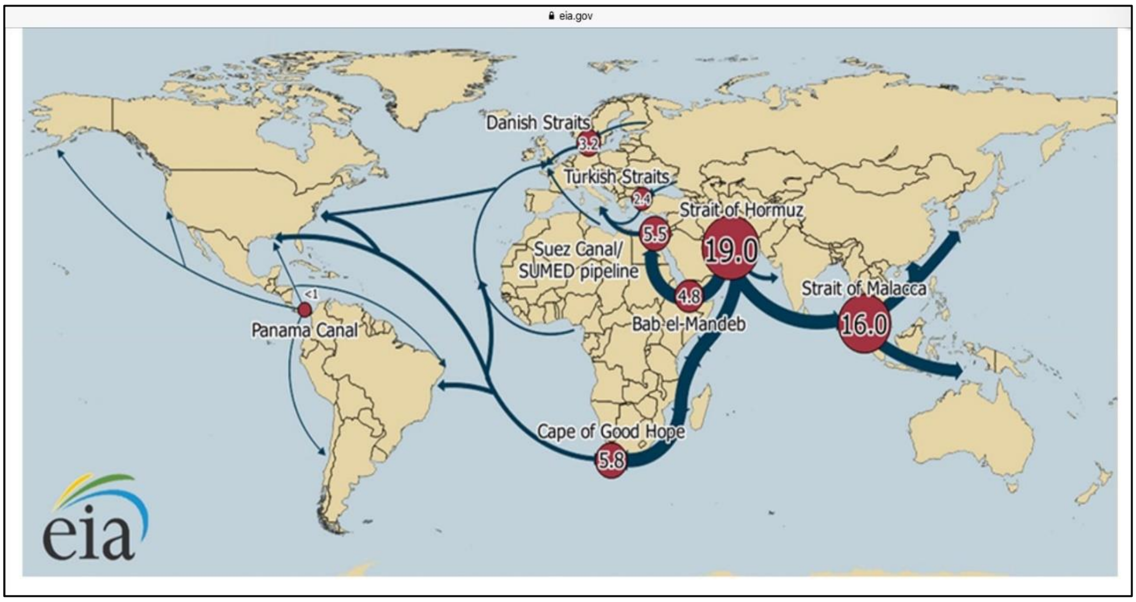

Fig. 2.4 Transit Volumes bypassing World Maritime Oil Chokepoints in a Day [23]

Table 2.11 Crude Oil and Petroleum Volume Transported in World Chokepoints from 2011 to 2016 (in millions bbl/d) [23]

Location	2011	2012	2013	2014	2015	2016
Strait of Hormuz	17.0	16.8	16.6	16.9	17.0	18.5
Strait of Malacca	14.5	15.1	15.4	15.5	15.5	16.0
Cape of Good Hope	4.7	5.4	5.1	4.9	5.1	5.8
Suez Canal and SUMED Pipeline	3.8	4.5	4.6	5.2	5.4	5.5
Bab el-Mandeb	3.3	3.6	3.8	4.3	4.7	4.8
Danish Strait	3.0	3.3	3.1	3.0	3.2	3.2
Turkish Strait	2.9	2.7	2.6	2.6	2.4	2.4
Panama Canal	0.8	0.8	0.8	0.9	1.0	0.9
World Maritime Oil Trade	55.5	56.4	56.5	56.4	58.9	n/a
World Total Oil Supply	88.8	90.8	91.3	93.8	96.7	97.2

2.8 World Maritime Chokepoints

Table 2.12 World Maritime Chokepoints and Countries Authority [24]

Chokepoints	**Littoral State(s)**	**Linked Bodies of Water**	**Width at the narrowest point (km)**
Strait of Hormuz	Oman, UAE, Iran	Arabian Sea – Persian Gulf	48
Strait of Bab-el-Mandeb	Djibouti, Eritrea, Yemen	Red Sea – Arabian Sea	32
Straits of Malacca	Indonesia, Singapore, Malaysia	Indian Ocean – South China Sea	2.5
Panama Canal	Panama	Pacific Ocean – Atlantic Ocean	0.3
Turkish Straits	Turkey	Mediterranean Sea – Black Sea	1
Strait of Gilbraltar	Spain, Morocco	Atlantic Ocean – Mediterranean Sea	13
Suez Canal	Egypt	Mediterranean Sea – Red Sea	0.2

Malaccamax is the maximum and suitable size of the vessel which could pass through Malacca/Singapore Straits without any trouble in term of dimension of the strait. Malaccamax has general requirement in dimension: 400 m in length and 60 m for width, and 14.5 for depth or 300,000 DWT (dead weight tonnage) capacity and maximum speed of 19 knots [25]. By this restricted area in dimension and congestion, vessels bigger than Malaccamax should voyage to Sumatra route as second possibility and absolutely gains the cost and delivery time more than before because of distance. Those facts are driven the shipping players in whole world to figure out the solutions for optimizing maritime trade. Other world maritime chokepoints are shown in table 2.12.

2.9 Existing Canals in the World

Suez Canal and Panama Canal are the successful project for invention in maritime trade which also cause the limited area. Canal projects could shorten the voyage, reduce shipping cost, and cut the delivery time than before. The successful canals in the world are:

2.9.1. Suez Canal

To creating the new canal for maritime trade, it should be known the existing canal that have already built and succeeded before. The first canal in the world was Suez Canal. Egypt was the first country who made the canal by humans. This canal is crossing from the Mediterranean Sea with the Gulf of Suez to the Red Sea by River Nile's branches to activate world trade since this is the shortest connection between the west and east.

In 1874 B. C., the canal was dredged by Pharoh of Egypt linking the river Nile and the Red Sea. To build the modern canal was initiated by Egypt expedition of Napoleon Bonaparte. This canal was expected to make a devastating trade problem for the British since it would controlled by French and British would have to pay to France or continue sending goods to the southern part of Africa by land. Charles Le Pere started to create in 1799 but unfortunately he miscalculated the sea level of Mediterranean Sea and the Red Sea that, in fact, the Red Sea was more than 30 feet higher than the Mediterranean that the canal would sweep away the Nile Delta.

Shortly, after getting little interest from Mohammed Ali in 1833 and case study of the canal in 1846, the French engineer Vicomte Ferdinand Marie de Lesseps made Said Pasha enthusiastic on project. Then Lesseps created *La Compagnie Universelle du Canal Maritime de Suez* (Universal Company of the Maritime of Suez Canal) in 1858 that estimated that around 2,613 million cubic feet of land could be moved with 200 million francs at that time. This company would have the right to create and operate for 99 years before Egyptian government could take over the canal.

From April 25, 1859 to November 17, 1869 the Suez Canal, by 101 mile (163 km long), was built with the cost $100 million. In sea borne trade, Suez Canal was the one for saving time from 7 to 10 days and reducing voyage by approximately 7,000 km/4,300 nautical miles to sail around Africa or transshipping freight or passengers that stunned entrepreneurs to build canals. Nowadays Suez Canal is very important transport connection that hugely reducing the transit time and distance as shown in figure 2.5 that supported almost 8% of shipping traffic [26] [27].

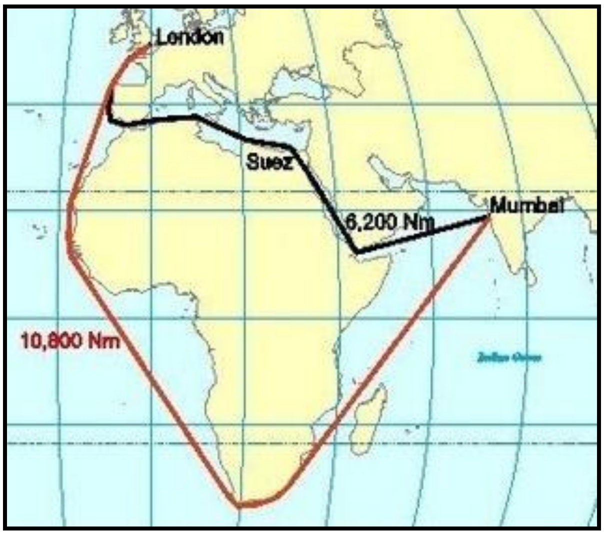

Figure 2.5 Saved distances using Suez Canal [28]

2.9.2. Panama Canal

Maritime sector and canal has been two important sectors for the Panama nationals' economy [29]. Ferdinand de Lesseps is known as a chairman of Panama Canal, after succeeded in Suez Canal. In 1876, he made a company called *Societé Civile Internationale du Canal Interocéanique de Darién* which benefit to complete a survey in Central America to find out the suitable place for construct the canal. In 1879 Lesseps offered this project to the public at the International Geographic Congress of Paris. His tender was not easy, at least two famed engineers Alexandre Gustave Eiffel and Baron Godin de Lépinay disagreed with him, but latter they evolved his project. Lesseps created Compagnie Universalle du Canal Interocéanique de Panama on 1st January 1880 and announced officially the project at the Mouth of Río Grande opposite the Bay of Panama. Because of the falling of employment rate and the corruption accusations, the company was bankrupt and de Lesseps felt guilty and was sent to the jail. He was unsuccessfully to build the Panama Canal. After that on 4 March 1904 USA took the project over. Until 1913 almost 32,000 people worked and on 15th August 1914 the Canal for the first time was passed by the steamship Ancón. Around ten years by spending 387 million dollars and hiring more than 6,000 people. By the length of 82.4 km, Panama Canal became prominent for maritime transportation due to saving 2,740 nautical miles (see figure 2.6) from the east coast of Colombia to Hong Kong, 2,846 nautical miles from Kobe to New York, and up to 7,400 from Guayaquil to New York. In 2003, 92% of the world fleet is served by Panama Canal with around 11,725 vessels (191.3 million metric tons, approximately 4% of world maritime trade) [29]. Recently, Panama Canal is following these dimension: 77 km of length, 55 m of width, and 18.3 m [30].

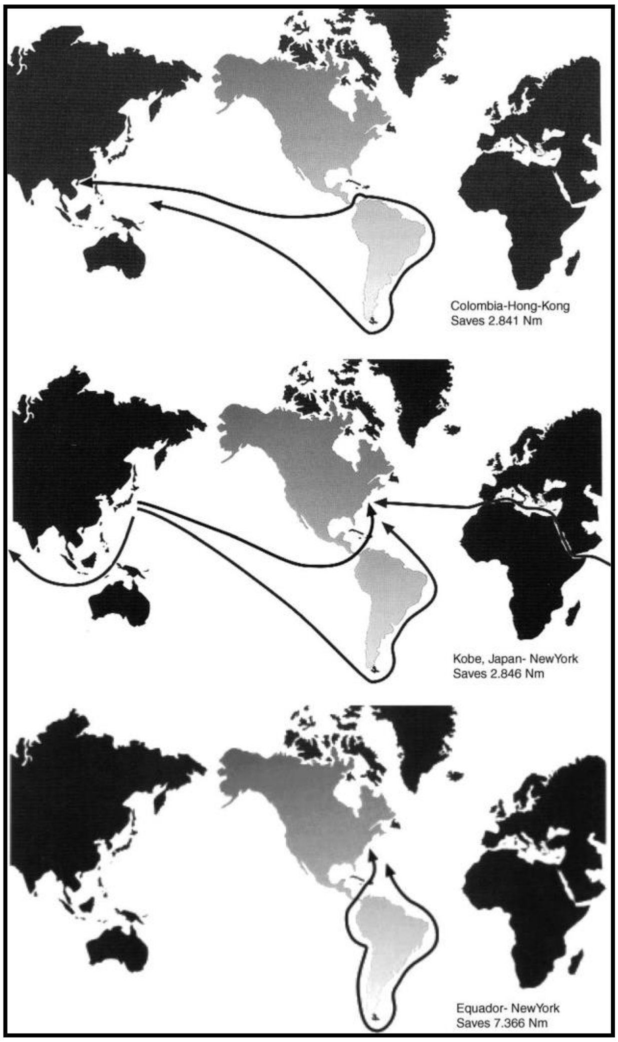

Fig. 2.6 Saved distances using Panama Canal [29]

From the review of existing canals, creating the Kra Canal would possibly benefit for countries that passing Malacca/Singapore Straits as a route of the ship in trading, such as China and Europe Union, to transport goods or oil. Kra Canal as a revival is one of the innovation in maritime trade. It assists shipping company as an alternative route because of the problems in Malacca Strait in world seaborne trade. Outlook of Suez Canal and Panama Canal could be reflected to help related stakeholders constructing Kra Canal.

2.10 The Overview of Kra Canal

The Kra Canal (commonly known as Thai Canal or the Kra Isthmus Canal) will take place in southern area in Thailand. Figure 2.7 explain its geography that this canal could cut the voyage distance among the South China Sea and Indian Ocean. Kra Canal is one of the innovation in maritime trade to solve the heavy congestion in Malacca/Singapore Straits. Marine Department Malaysia in 2018 stated that this strait was passed by 231 vessels per day in 2017 [21].

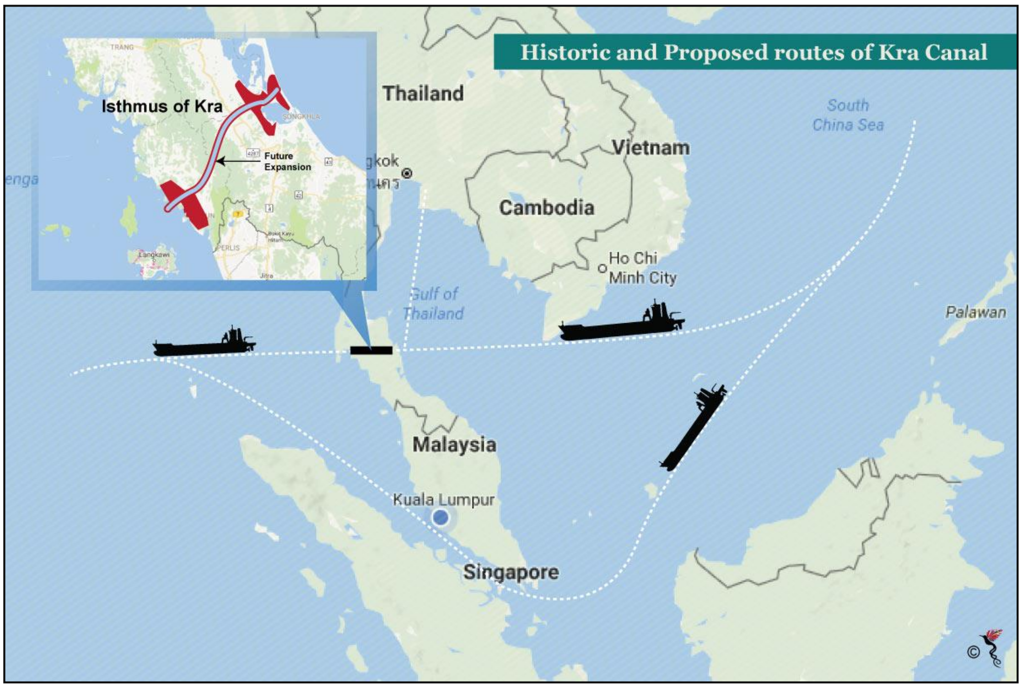

Figure 2.7 Kra Canal Map and Route Change [1]

2.11 History and Development of Kra Canal

Being debated since 1981 at least until 2014, it was issued that China take over this project but conversely not China nor Thailand government admitted the report [31] [32]. United Nations Conference on Trade and Development (UNCTAD) on the Review of Maritime Transport in 2015 and 2016 expected that Kra Canal need cost around USD28 billion [33] [34].

The canal is proposed on 102 km in length or 55 nautical miles, 400 m in width, and 30 m in depth dimension, as shown in Figure 2.8 by 2 corridors roughly taking 10 years to be constructed. Avoiding the Malacca/Singapore Straits' bottleneck and strongly dangerous by the pirates could decrease voyage distance to 1,200 km (650 nautical mile). Moreover, reducing voyage time until five days faster was predicted. Simon Su, Bambang Muryanto, and Maierbrugger analyzed the Kra Canal could reduce voyage time from two to five days in certain route and could minimize ship fuel oil cost. Bottleneck situation could also raise the probability for ship collision. It is susceptible to get accidents which in the year of 2015-2016 raised 25% by 60 accidents happened [35] [36] [37].

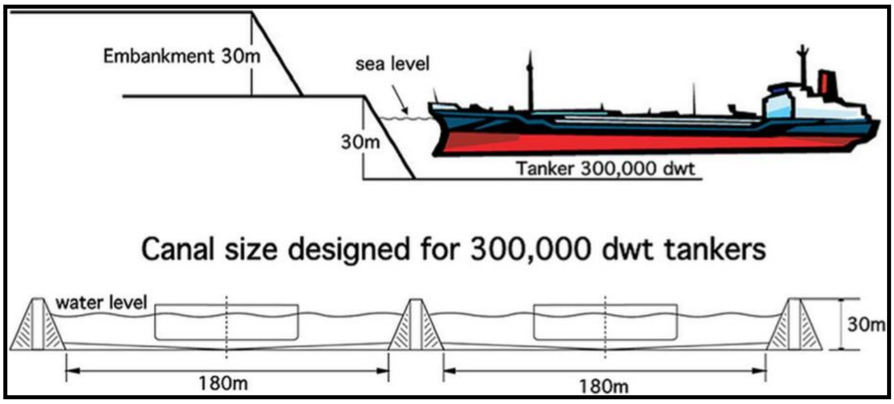

Figure 2.8 Kra Canal Dimension [5]

To sum up Kra Canal information is shown in Table 2.13. ASEAN – China Free Trade Area (ACFTA), an agreement signed on November 6, 2001 in Brunei Darussalam that create to make free trade area to eliminate and decrease barriers to non-tariff barriers, enriched trade service, investment policy, due to develop the prosperity within ASEAN and China, could affect for enhancing cooperation in constructing Kra Canal supporting China's "One Belt, One Road" and "Maritime Silk Road" initiatives. These two strategies are about increasing the connectivity and cooperation between China (Asia) to global merchant trade especially Europe, Africa, and Mediterranean.

Table 2.13 Effects of Kra Canal [5]

Factor	Information
Voyage	1.200 km shorter than Malacca Strait
Voyage time	Two to five days earlier
Safety and security	Avoid piracy from Malacca Strait
Saving on cost	More than USD350,000
Traffic	Avoid Malacca Strait's congestion
Business prospect	Open to direct investment
Accidents and collision	Effective to reduce accidents
Size	2 ways, 102 km of length, 400 m of width, and 30 m of depth
Vessel size	Up to Ultra Large Crude Carrier (ULCC)

Table 2.13 Effects of Kra Canal (cont’d)

Tanker activity	80% of China’s oil passed from Malacca Strait
Singapore’s future status	Could decrease the transhipment activity
Beneficial ports	Ports in Hong Kong and China

CHAPTER III

STATISTICAL AND EVALUATION DATA FROM PORT KLANG

3.1 Handling Ship in Klang Port 2015 – 2018

Klang Port (known also Kelang Port/MY PKG) is the biggest port in Malaysia that located at the western part of Sabah Island with total area up to 573 km2 (see Figure 3.1). Based on UNCTAD review of maritime transportation, Klang Port took over Rotterdam Port (126.43 km2 wide) [38] by servicing TEUs with 13 million TEUs in 2016, around 3% of total TEUs handled in all port of Asia, grew up 10.7% from 2015-2016 while its nearest competitor, Singapore Port (totally around 91.18 km2 wide) [39] grew negatively 0.1%. Klang Port was the 11st busiest port in the world by TEUs handled in 2016.

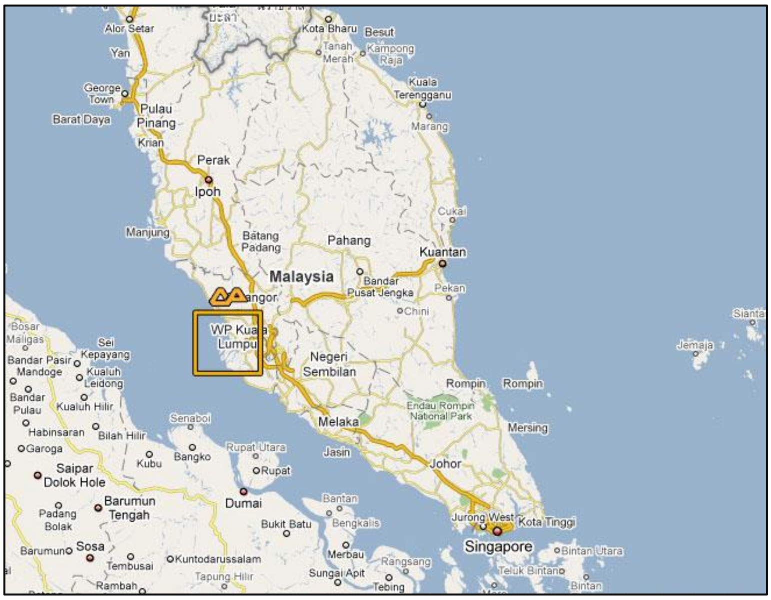

Figure 3.1 Port of Klang Map [40]

Table 3.1 shows that the ships handled in Klang Port from January 1st, 2015 until April 13rd, 2018 and the growth for 2016 and 2017. Containerized merchant trade was handled more than a half from the total in every year unfortunately the rate decreased 10.6% which almost twice from total reduction in 2016. In total ships handled as shown in Figure 3.2, container vessel led by 54%, followed by General Cargo (11%), Tanker (11%), Tug (10%), Bulk Carrier (5%), Passenger (5%), Vehicles Carrier (2%), and the rest Government Navy, Supply Vessel, Heavy Load Carrier, and Hospital Vessel (2%). Tanker, Bulk Carrier, and Vehicles Carrier types raised positive in the year of 2016 and 2017. Tanker activity become greater in Southeast Asia because the demand of using private transportation and also petrol which also increase Vehicles Carrier ship handled in Klang Port. Moreover, in the total per year Klang Port also gain negatively from 2015-2018 which decrease 1.1% and 6.0% in 2016 and 2017. In term of total ship handled in Klang Port, average traffic in one day in Klang Port obviously reduced from 54 in 2015 ships per day to 50 ships in a day in 2017. It was recorded in the first quarter of 2018 that average of the ships handled was 47 ships per day. It is also recorded that the average total time in anchorage area needs 4.53 hours and average time at Klang Port was around 1 hour 53 minutes from all type of ships handled [41].

Table 3.1 Ships Handled in Klang Port [28] & [29]

Type of Ship	**2015**	**2016**	**2017**	**2018***	**Total**
Tanker	1957	2115	2177	552	6801
Growth Rate		8.1%	2.9%		
Bulk Carrier	949	977	1062	269	3257
Growth Rate		3.0%	8.7%		
Cargo	2329	2044	2058	572	7003
Growth Rate		-12.2%	0.7%		
Container	10509	10949	9793	2585	33836
Growth Rate		4.2%	-10.6%		
Passenger	916	942	814	237	2909
Growth Rate		2.8%	-13.6%		
Vehicles Carrier	298	307	349	98	1052
Growth Rate		3.0%	13.7%		

Table 3.1 Ships Handled in Klang Port (cont'd)

Others**	2719	2129	2047	532	7427
Growth Rate		-21.7%	-3.9%		
Total	19677	19463	18300	4845	62285
Growth Rate		-1.1%	-6.0%		
Average Traffic Per Day	54	53	50	47	

*) in 2018 only until April 13rd, 2018
**) Others are Government Ship, Heavy Load Carrier, Hospital Vessel, Landing Craft, Dredger Ship, Drill Ship, Research Vessel, Supply Ship, Tug, Barge, and other Special Purpose Ship.

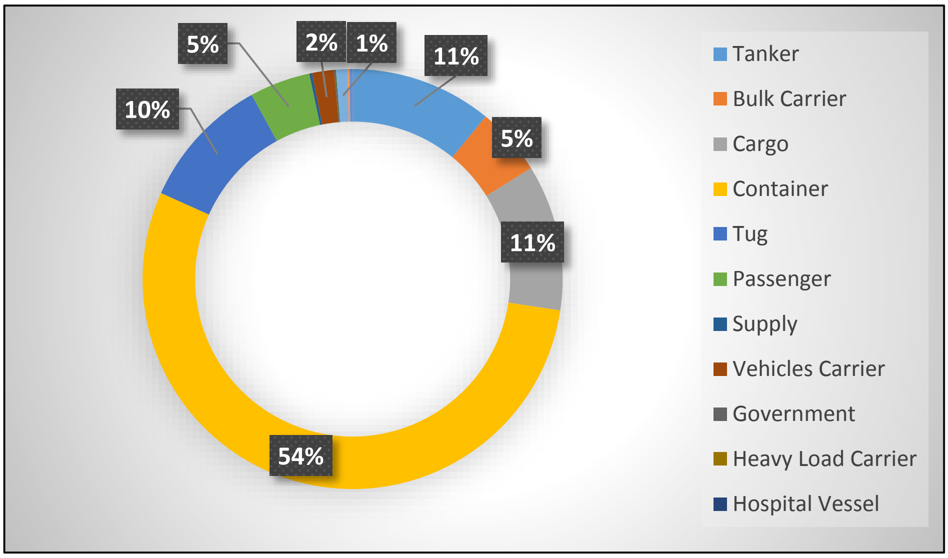

Figure 3.2 Total Ships Handled by Types

3.2 Malacca/Singapore Straits' Ships Movement

Table 3.2 shows the recorded of the movement of the ships in Malacca/Singapore Straits from any direction that collected from Marine Department Malaysia in 2018. Again, most of seaborne trade which passing Malacca/Singapore Straits were using container vessels by 31.8% followed by Tanker (23.10%), Bulk Carrier (16.9%), Cargo (9.61%), VLCC (6.57%), LNG/LPG carrier (5.8%), and the rest for 6.9%. From 2016 to 2017 increase by 10.3% after rose down minus 5.4%. From the total ships recorded in VTS Klang Port, in range of 2010 to 2017, only in the year of 2011 and 2016 had negative growth by -0.8% and -5.4% respectively.

Table 3.2 Types of Vessels and Total Vessel Movement Reported to Klang Vessel Traffic Service (VTS) from 2010 to 2017 [21]

Type of Ship	2010	2011	2012	2013	2014	2015	2016	2017	Total	%
VLCC / Deep Draft	4333	4539	4732	4825	4993	5324	5418	6711	40875	6.57
Change Rate		4.8%	4.3%	2.0%	3.5%	6.6%	1.8%	23.9%		
Tanker Vessel	16247	16223	17345	18296	18765	18470	17799	20629	143774	23.10
Change Rate		-0.1%	6.9%	5.5%	2.6%	-1.6%	-3.6%	15.9%		
LNG & LPG Carrier	3579	3830	4014	4248	4173	3936	3685	4137	31602	5.8
Change Rate		7.0%	4.8%	5.8%	-1.8%	-5.7%	-6.4%	12.3%		
Cargo Vessel	8445	7996	7950	7613	6989	7144	6595	7090	59822	9.61
Change Rate		-5.3%	-0.6%	-4.2%	-8.2%	2.2%	-7.7%	7.5%		
Container Vessel	24806	25552	24639	24658	25071	25389	23625	24446	198186	31.84
Change Rate		3.0%	-3.6%	0.1%	1.7%	1.3%	-6.9%	3.5%		
Bulk Carrier	11642	10851	11678	12658	13454	15168	14307	15411	105169	16.90
Change Rate		-6.8%	7.6%	8.4%	6.3%	12.7%	-5.7%	7.7%		
Ro-Ro	2624	2545	2980	2998	3146	3117	2622	2629	22661	3.64
Change Rate		-3.0%	17.1%	0.6%	4.9%	-0.9%	-16%	0.3%		
Passenger Vessel	1071	877	861	1063	1041	925	1125	1776	8739	1.40
Change Rate		-18.1%	-1.8%	23.5%	-2.1%	-11%	21.6%	57.9%		
Livestock Carrier	45	47	38	55	59	76	67	50	437	0.07
Change Rate		4.4%	-19%	44.7%	7.3%	28.8%	-12%	-25.4%		
Tug / Tow	545	414	529	563	676	467	536	533	4263	0.68
Change Rate		-24.0%	27.8%	6.4%	20.1%	-31%	14.8%	-0.6%		
Government Vessel	37	57	50	58	96	87	46	54	485	0.08
Change Rate		54.1%	-12%	16.0%	65.5%	-9.4%	-47%	17.4%		
Fishing Vessel	20	20	52	27	51	53	23	28	274	0.04

Table 3.2 Types of Vessels and Total Vessel Movement Reported to Klang Vessel Traffic Service (VTS) from 2010 to 2017 (cont'd)

Change Rate		0.0%	160%	-48.1%	88.9%	3.9%	-56.6%	21.7%		
Others	739	577	609	911	830	803	714	962	6145	0.99
Change Rate		-21.9%	5.5%	49.6%	-8.9%	-3.3%	-11.1%	34.7%		
Total	74133	73528	75477	77973	79344	80959	76562	84456	622432	100
Change Rate		-0.8%	2.7%	3.3%	1.8%	2.0%	-5.4%	10.3%		
Arrival per day	203	201	206	213	217	221	209	231		

The last information of ships movement recoded in VTS Klang port stated as 231 ships in average passing from any direction around Malacca/Singapore Straits. This overcapacity should be reduce in order not only to maintain the safety to avoid from ship collision, but also to reduce pollution in Singapore, Malaysia, and Indonesia Territory around Malacca/Singapore Straits in order to achieve environmental sustainability. Kra Canal was predicted that could assist to reduce Malacca/Singapore Straits' overcrowd as a new innovation in world shipping line. Distance change and total sailing time as a consequence of passing Kra Canal should be calculated and evaluated to enhance the feasibility study of Kra Canal. Voyage distance and time change will be discussed in the next Chapter (Chapter IV).

CHAPTER IV

CASE STUDY: HOW KRA CANAL AFFECTS WORLD MARITIME ROUTE

4.1 Distance and Time Change

The voyage distance and time from one port as an origin to another port as a destination could be calculated by Netpas Distance 3.4 (Build 3478) trial program that has limited searching for distance within ports maximum five distance until end of 2018 while for paid one has 100 limitation. Netpas Distance program is a useful software to measured distance among 12000 ports in the world. With this program, users easily selected origin and destination ports, after that detects route and distance, as shown in Figure 4.1 and Figure 4.1. Moreover, Netpas Distance software could be re-routed the ship lines and changed to new routes, with an alert for Sulphur Emission Control Area (SECA/ECA), Weather Prediction, Piracy Area and other impressive features in maritime shipping line. It is used for professional business to assist their company so that this software should be paid for the users [42]. Up to now, there were measured 30 important routes that could be affected by constructing Kra Canal, taking advantages by reducing voyage distance or, on the other hand, raising voyage distance. Port selection based on the important ports in Asia, Europe, Mediterranean, Africa, and South East Asian Nations. The results of Netpas Distance utilization is shown in table 4.1.

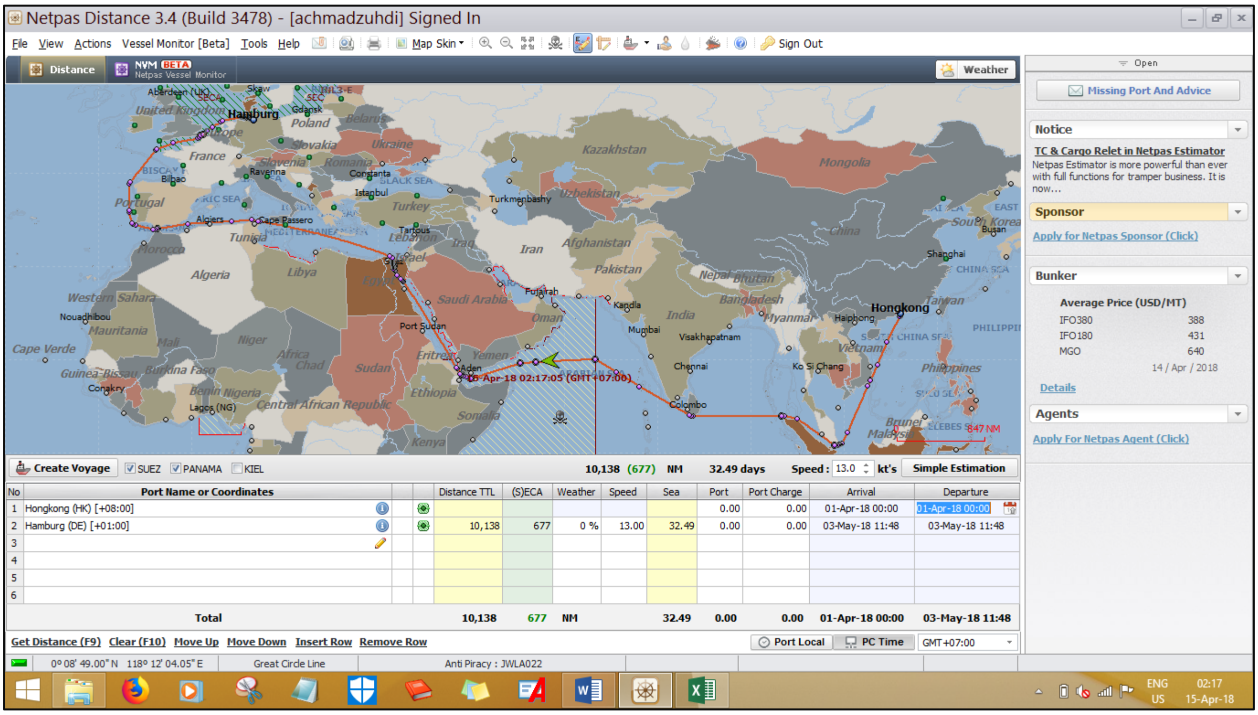

Figure 4.1 Hong Kong Port (Hong Kong) to Hamburg Port (German) Measured Route Bypassing Malacca/Singapore Straits.

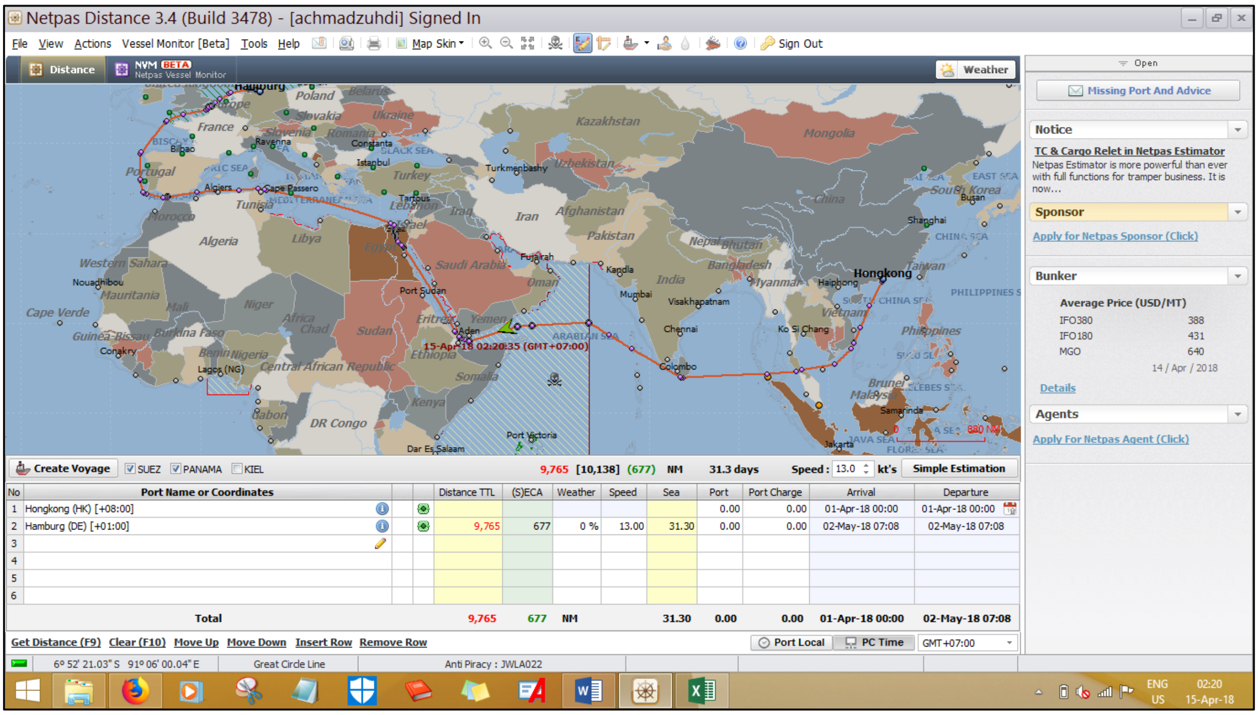

Figure 4.2 Hong Kong Port (Hong Kong) to Hamburg Port (German) Measured re-Route Bypassing Kra Canal.

The most reducing voyage distance is Sihanoukville (Cambodia) – Yangon (Myanmar), with 703 nautical miles (NM) or 1301.96 km saving and decreases sailing time up to two days by average speed (all data in Netpas Distance program are attached constant speed by 13 knots). The voyage between the best ports by TEUs handled in Asia and Europe, Shanghai Port and Rotterdam Port, respectively reduced voyage distance until 323 nautical miles (598,2 km) and reduces voyage time up to one day. Not only reducing voyage distance, without any surprise, there are also some routes increasing sailing distance which maximum raised up to 1,022 NM (1,892.74 km) which is Melbourne Port (Australia) to Rotterdam Port (Netherland) route.

Table 4.1 Origin – Destination Matrix in Certain Countries, Distance in Nautical Miles and Time in Days

Port Origin	Port Destination	Without Kra Canal		With Kra Canal		Distance Changed (NM)	Distance Changed Percentage
		Distance (NM)	Voyage Time (Day)	Distance (NM)	Voyage Time (Day)		
Sihanoukville	Yangon	1692	5.42	989	3.17	-703	-41.55%
Laem Chabang	Bombay	3221	10.32	2529	8.11	-692	-21.48%
Cai Mep	Yangon	1699	5.45	1201	3.85	-498	-29.31%
Hongkong	Hamburg	10138	32.49	9765	31.3	-373	-3.68%
Busan	Rotterdam	10952	35.1	10582	33.92	-370	-3.38%
Bombay	Busan	4911	15.74	4544	14.56	-367	-7.47%
Doha	Kobe	6287	20.15	5937	19.03	-350	-5.57%
San Fransisco	Mumbay	9773	31.32	9431	3023	-342	-3.50%
Shanghai	Rotterdam	10663	34.18	10340	33.14	-323	-3.03%
Izmit	Shanghai	8158	26.15	7838	25.12	-320	-3.92%
Novorossiysk	Shanghai	8577	27.49	8257	26.46	-320	-3.73%
Shanghai	Antwerp	10620	34.04	10304	33.03	-316	-2.98%
Laem Chabang	Port Kelang	999	3.2	707	2.27	-292	29.23%
Kaohsiung	Port Kelang	1812	5.81	1895	6.07	83	4.58%
Port Kelang	Manila	1507	4.83	1618	5.19	111	7.37%

Table 4.1 Origin – Destination Matrix in Certain Countries, Distance in Nautical Miles and Time in Days (cont'd)

Dubai	Singapore	3448	11.05	3667	11.75	219	6.35%
Singapore	Yalova	5941	19.04	6170	19.78	229	3.85%
Rotterdam	Singapore	8471	27.15	8702	27.89	231	2.73%
Brisbane	Bombay	6161	19.75	6430	20.61	269	4.37%
Muara	Port Kelang	925	2.96	1215	3.89	290	31.35%
Shanghai	Cape Town	7712	24.72	8040	25.77	328	4.25%
Tanjung Priok	Izmit	6244	20.01	6658	21.34	414	6.63%
Port of Tanjung Priok	Rotterdam	8749	28.04	9171	29.4	422	4.82%
Rotterdam	Tanjung Priok	8748	28.04	9181	29.43	433	4.95%
Singapore	Shanghai	2199	7.05	2683	8.6	484	22.01%
Port Kelang	Hedland	1890	6.06	2404	7.7	514	27.20%
Tanjung Priok	Port Kelang	874	2.8	1458	4.67	584	66.82%
Hamburg	Port Kelang	8533	27.35	9140	29.29	607	7.11%
Singapore	Tanjung Priok	672	2.15	1548	4.96	876	130.36%
Melbourne	Rotterdam	11526	36.94	12548	40.22	1022	8.87%

4.2 Arena Simulation Software

Arena Rockwell simulation program is discrete-event simulation method based to simulate, model and animate almost any process. Discrete-event simulation is the simulation based on modelling the operation of a system in sequence of event in a certain time in order to see the behavior of the system and process). Arena Version 15 was utilized on this simulation for training and evaluation mode (student version, retrieved from company's website) and made a simulation for one voyage, two busiest port in Asia and Europe connection which is Shanghai Port in China to Rotterdam Port in Netherland regardless the congestion in the route since it is one of the unpredictable aspect in maritime sea route. Based on Maersk Line route, this voyage passes from Shanghai Port – Tanjung Pelepas Port (Malaysia) – and directly goes to Rotterdam Port [43]. Voyage time is measured average 15.5 knots, distance is known from Netpas Distance. Simulation is taken for two conditions, passing Malacca/Singapore Straits and future Kra Canal. Figure 4.3 and Figure 4.4 explain the work modules from Arena Rockwell Simulation software.

Firstly, the model was started with entity (ship, Mary Maersk). Because the simulation only for Mary Maersk, so maximum arrival is one ship (start module). Station module is attached as a first port for starting point (Shanghai Port). In this port, loading and unloading condition occurred in average time 23.52 hours include average of anchoring time. After that ship (entity) made, entity was given attribute, at this condition is giving the speed of ship in knots. The average speed used service speed of the ship, 15.5 knots while distance between ports are known from Netpas Distance program. Ship sailed from Shanghai Port to Tanjung Pelepas Port bypassing Malacca/Singapore Straits giving loading unloading performance in Tanjung Pelepas Port. After finish that performance, the ship sailed to Suez Canal and variable in the simulation is given, tug boat in Suez Canal with limited speed around 6 knots. After passing Suez Canal, entity went to Rotterdam Port. The ships starts from Shanghai Port, loading for merchant goods carried to Tanjung Pelepas or Rotterdam Port. In fact, there are also another option from Shanghai Port goes to other ports inside China, Sri Lanka, Suez Canal and United Kingdom. On this case, Shanghai Port – Tanjung Pelepas Port – and Rotterdam Port will be explained.

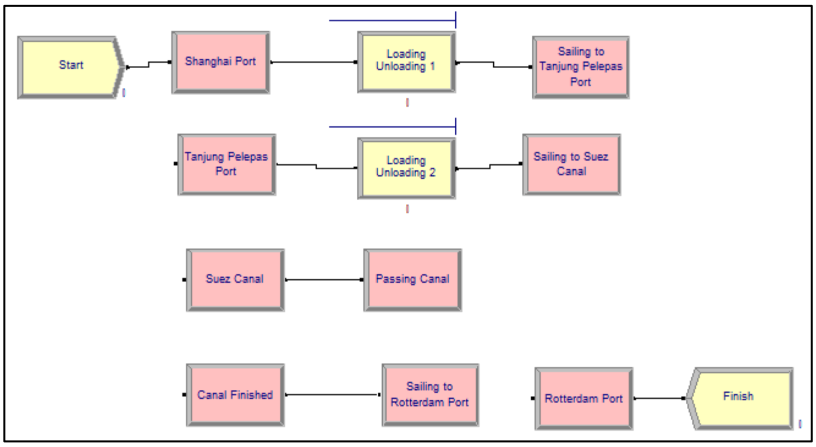

Figure 4.3 Shanghai – Rotterdam Shipping Line Bypassing Malacca/Singapore Straits Modules Selection

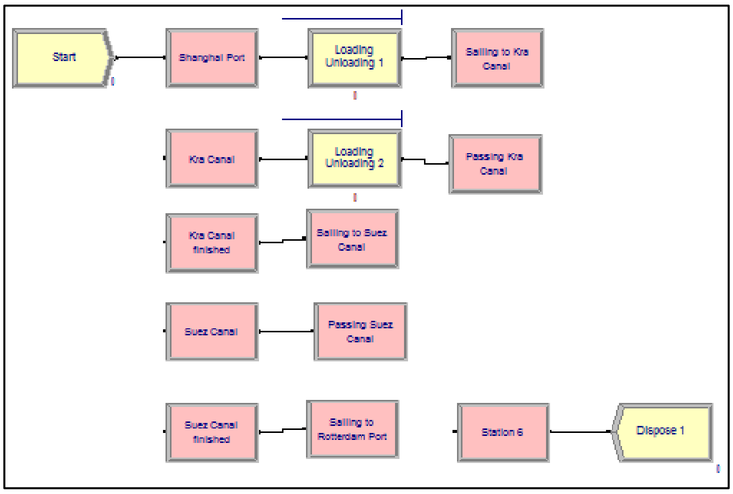

Figure 4.4 Shanghai – Rotterdam Shipping Line Bypassing Future Kra Canal Modules Selection

4.2.1 Shanghai – Rotterdam Shipping Line Bypassing Malacca/Singapore Straits

Firstly, one ship is generated as a beginning in Shanghai Port. Last nine weeks condition is adapted for average time at port, which is 23.52 hours needed. After that sailing through Malacca/Singapore Straits to Tanjung Pelepas Port requires 7.5 days. Loading-unloading condition is attached for average 18.72 hours. After sailing to Suez Canal with 5308 nautical miles distance, passing with restricted speed is required, which is 6 knots with 87 nautical miles [44]. After that continues to sailing to Rotterdam Port for 11 days [45]. The result of simulation is attached on appendix 1.

4.2.2 Shanghai – Rotterdam Shipping Line Bypassing Future Kra Canal

In general, the requirements on Bypassing Kra Canal is same as Bypassing Malacca/Singapore Straits. Restricted speed service passing Kra Canal is adopted from Suez Canal that normally needs 9.2 hours for one voyage. Loading-unloading performance also attached in Kra Canal substituting Singapore, Malaysia, or Indonesia ports. After that ship goes to Rotterdam Port by 24 days sailing time [45]. The results will be discussed in Chapter VI. The result from this simulation is put on appendix 2.

CHAPTER 5

SHIP FUEL OIL COST ANALYSIS FROM REDUCTION OF SEA MILES

The data from Netpas Distance software have two main outputs, reduction of time and voyage distance. On this chapter will be analyzed the reduction of fuel oil consumption from three selected container vessels sailing from certain origin and destination ports. The results also will be compared between passing Kra Canal and Malacca/Singapore Straits.

5.1 General Information of Selected Ships

Before selecting the ships, three important route from origin destination matrix made in Chapter IV. Firstly, from China's port Shanghai to Rotterdam in Netherland route is the most important route in Asia and Europe in the world seaborne trade in 2016. The second route is Sihanoukville Port in Cambodia to Yangon Port in Myanmar (Burma). This route gains the most voyage distance change with 703 nautical miles (1,301.9 km) reduction. The last route is Melbourne Port in Australia to Rotterdam Port in Netherland which gains conversely by increasing the voyage distance and time. This condition is interesting to be calculated because contradict the positive aspects of building Kra Canal.

Reported from Klang Port VTS, container vessels totally moved 31.84% from 2010 to 2017 and berthed in Klang Port 33,836 ships or 54% from total ships handled from January 1st, 2015 to April 13rd, 2018. According to this rate, container fleet was selected to be calculated. Without underestimating other types of vessels, container fleet has unbalance condition between supply of the containership and the demand of containerized seaborne trade. This condition worsened uncertainty of container freight rates which explained mostly grew negatively in some area. Selecting this type of ship is predicted to improve containerized seaborne trade rate, especially for the ships passing

Malacca/Singapore Straits and/or Kra Canal. They are: Shanghai Port (China) – Rotterdam Port (Netherland) Linkage; Sihanoukville Port (Cambodia) – Yangon Port (Myanmar) Linkage; Melbourne Port (Australia) – Rotterdam Port (Netherland) Linkage. In Table 5.1, selected ships that their fuel cost reductions are going to be measured are shown generated from those three routes that affect from the construction of Kra Canal [46].

Table 5.1 Selected Ships General Information [46]

	Mary Maersk (Denmark)	Atout (Liberia)	Margrethe Maersk (Denmark)	
	Shanghai-Rotterdam	Sihanoukville-Yangoon	Melbourne-Rotterdam	
Feature	Value			Unit
LOA	399	182.52	399	m
LPP	379.2	178	379.2	m
B	59	25.2	59	m
H	30.3	14.2	30.3	m
T	12.4	9.8	12.4	m
DWT	194,252	23,978	194,252	tons
Displacement	251,968	39,074	251,968	tons
Container Capacity	18,270	1,702	18,270	TEUs
Service Speed	15.5	11.3	15.5	knots
Maximum Speed	25	21	25	knots
Net Tonnage	223,909.6	n/a	223,909.6	m^3
	79,120	n/a	79,120	RT
Gross Tonnage	551,422.67	51,503.17	551,422.67	m^3
	194,849	18,199	194,849	RT
Total Brake Horse Power	79,602.9	22,341.4	79,602.9	HP
	59,360	16,660	59,360	kW

Table 5.1 Selected Ships General Information (cont'd)

RPM Engine	73.1	105	73.1	RPM
Voyage Bypassing Malacca Straits	10,663	1,692	11,526	NM
	687.9	149.7	743.6	hours
Voyage Bypassing Kra Canal	10,340	989	12,548	NM
	667.1	87.5	809.5	hours

5.2 Daily ships fuel oil consumption

Ships' rate of fuel oil consumption was employed regarding to service speed and displacement especially cargo/containerized merchants weight carried by the ships generated as below [47]:

$$r_F = c_1 . V^{c_2} . \nabla^{c_3} \tag{5.1}$$

From formula 5.1, the ship fuel oil consumed per day (r_F) generated from service speed (V) and displacement of the ship (∇) in a good weather. On the other hand, fuel oil consumption relates to service speed of the vessels and the power of the ships. It is calculated from the mass of fuel oil needed in certain unit time, normally hour.

$$\text{SFOC} = \frac{\text{Mass of fuel oil consumption per hour}}{\text{Total power of the ship}} \tag{5.2}$$

Where SFOC or Specific Fuel Oil Consumption ($\frac{gr}{kWh}$), mass of fuel oil consumption per hour (gr), total power of the ship (kW). The fuel consumed in a selected ship is modified as below:

Fuel oil consumption = SFOC x generated engine power x voyage time (5.3)

From formula 5.2 and 5.3, fuel oil consumption per hour would be measured each from Mary Maersk, Atout, and Margrethe Maersk in Table 5.2. Based on total power gained of the ships that known before, in the catalogue of the main engine used on those ships could be obtained the SFOC of each ships. Since Mary Maersk and Margrethe Maersk are the Maersk's Triple E new generations with total power measured 59,360 kW, they are sistership by two propeller that has same principle of performance and engine. SFOC could be taken from main engine's catalogue which used MAN B&W S80ME-C9.5 (Tier II) type from MAN Diesel & Turbo product (two-stroke propulsion engines) at service speed in 100% and high load condition, which has 166.0 $\frac{gr}{kWh}$ [48]. The bunker price of IFO 380 in Singapore Port at May 2018 will be used in the selected ships for fuel oil consumption estimation which is USD440.50 per metric ton [49]. Atout ship needs total power 16,660 kW in 105 RPM. With the same product of two ships before, MAN Diesel & Turbo engine gives option to MAN B&W S70ME-C8 (Tier II) type product (two-stroke propulsion engines) at service speed in 100% and high load condition [50]. The value of SFOC is 169 $\frac{gr}{kWh}$ [48]. Table 5.2 shows oil consumptions and total costs for one-way voyage in certain route that will be discussed in Chapter VI.

Table 5.2 Selected Ships' Total Oil Consumptions and Costs for One-Trip

Route	**Malacca Strait**		**Kra Canal**		**Fuel Cost Change Rate**
	Total fuel oil consumption (ton)	**Total fuel oil cost (USD)**	**Total fuel oil consumption (ton)**	**Total fuel oil cost (USD)**	
Shanghai – Rotterdam	6778.4	2985885.9	6573.4	2895601.8	-3%
Sihanoukville-Yangon	421.5	185664.7	246.4	108521.5	-41.5%
Melbourne-Rotterdam	7327.25	3227656.2	7976.6	3513700.5	8.86%

CHAPTER 6

RESULT AND DISCUSSION

As mentioned in Chapter 2 and 3 that Malacca/Singapore Straits' congestion in 2017 was passed by 231 ships in a day at average, reported from Klang Port VTS [3] [4]. This condition would be more crowd on several years in the future because recorded from 2010 to 2010 there was increment up to 14% for ship passing Malacca/Singapore Straits. However, seaborne trade as a demand in market increase slightly, less than positive growth of ship (on this case is container fleet, as a supply), other types of vessels passing Malacca/Singapore Straits are making Malacca/Singapore Straits more bottlenecked, for example passenger vessels and tug boats. In addition, shopping lifestyles and trades among countries in South East Asia, China, and India nowadays are shifting to e-commerce between nations that cause increasing of seaborne trade and merchant fleet carrying containerized goods [18]. This situation is predicted would increase the movement of the ships around Malacca/Singapore Straits that gain more congested and lesser service speed while passing Malacca/Singapore Straits. Lesser ships' service speed makes the voyage time increased and affects to seaborne trade activity. In some condition also could occur piracy around Malacca/Singapore Straits as explained in Chapter 2.

It was described in Chapter 2 that world seaborne trade was dominated by container vessels as the largest, followed by bulk carriers and tanker vessels. By ships handled in Klang Port from 2015 to April 2018, reported that container fleet, general cargo ships, tanker vessels, and bulk carrier ships were dominating. Klang Port also surpassed Rotterdam Port by TEUs handling in 2016 and this trend tends to go up and develop the performance not only in Klang Port but also other ports surroundings because increasing of economic growth in ASEAN, contributing the congestion in Malacca/Singapore Straits.

30 important and significant routes were selected and simulated to measure the voyage distance by using Netpas Distance software. It was reported that Cambodia and Myanmar route increased voyage distance the most with 41.5% decreased. Intra ASEAN trading such as Vietnam – Myanmar and Thailand – Malaysia trade occurred same condition, while Malaysia – Philippines, Brunei Darussalam – Port Klang (Malaysia), Tanjung Priok (Indonesia) – Klang Port (Malaysia), and Tanjung Priok (Indonesia) – Singapore route in opposite situation, increasing voyage distance and time if those routes must pass Kra Cnal and Malacca/Singapore Straits' access is closed. Closing of Malacca/Singapore Straits could harm some South East Asian countries because raising more fuel oil costs that could affect their seaborne trade cost increase. Co-existing between Malacca/Singapore Straits and future Kra Canal is totally recommended. Noted that the decrease of voyage time has not been attached yet by decreasing of sailing service and congestion in Malacca/Singapore Straits, which average were passed by 9 ships per hour in 2017.

Raising in containerized trade predominantly in world seaborne trade by more than four thousand million tons loaded in 2016 (8.85 growth rate from 2013), was greater than oil and gas sector and bulk carrier sector. So that it was tended to simulate container fleet and select at least three routes and obtain one ship each route. The simulations could be feasibility study to assist the issue of constructing of Kra Canal from point of view in maritime ship line.

In the calculation of reducing fuel oil consumption from three selected ships each routes, reported that between Sihanoukville (Cambodia) to Yangon (Myanmar) route gain the most reduction in voyage distance and could save fuel oil cost up to 41.5% each one voyage. Another route between the greatest ports in Asia and Europe by TEUs handled, Shanghai – Rotterdam route, decreased fuel oil cost up to 3% for one voyage. According to Maersk Line website, forecasting of Mary Maersk ship's voyage in 90 days (June 12, 2018 to September 9, 2018) will sail Shanghai – Rotterdam Port twice bypassing Malacca/Singapore Straits. In one year it will be predict to pass Malacca/Singapore Straits eight times [51]. On the other words, Mary Maersk could pass from future Kra Canal instead of Malacca Straits and save up to USD722,272.8 for one ship when fuel oil price (IFO 380) is about USD440.50 per metric tons [49]. Opposite result occurred from utilization of Kra Canal in the Melbourne – Rotterdam route, which this voyage distance gained and loss money around USD286,044.3 for one-way route. This condition could be managed by giving hub connection between Melbourne to future Kra Canal Terminal Port or Sabang Port as the most western port in Indonesia using smaller ship to service Australia – South East Asia countries routes to escape from the cost loss. Reduction in voyage distance not only affects fuel oil cost, but also lubricant oil. This condition would gain more companies' profit.

In terms of Kra Canal tariff and toll charges, the decision should be paid attention carefully. As a comparison, Mary Maersk needs USD343,291.92 to pass Suez Canal exclude of tug, mooring, and pilotage service. It also as a factor for companies to gain the profit [52]. Highly cost of Kra Canal toll charge would affect only a few ships passing from Kra Canal and tend to pass Malacca/Singapore Straits although more crowded. In social finance activity also influences that if the toll charge of Kra Canal in companies' opinion and some ships shift to Kra Canal, Malacca/Singapore Straits would tend to less crowded than years before and more secure from ship collision. Other shipping companies prefer select their ships to pass from Malacca/Singapore Straits. This simulation is hard to be done and required in future research as a review and consideration.

In the simulation made (Chapter 4) using Arena Rockwell simulation program, one ship in Shanghai – Rotterdam route without any congestion passing Malacca/Singapore Straits. There are process loading and unloading in Shanghai Port, Tanjung Pelepas Port, and future Kra Canal Terminal Port from the observation in internet such as time needed travelling from port to port, loading and unloading time consumption, and time needed passing Suez Canal. Total time needed was 811.3 hours or 33.8 days in the sea while passing Malacca/Singapore Straits and 783.4 hours or 32.6 days bypassing Kra Canal.

For sure, the simulations and calculations made for selected ships not only for container fleet, but also can be utilized in oil and gas tanker, general cargo ships, and bulk carriers. In tanker fleet seaborne trade market, increasing in several years in the future would be still occurred because China's consumed energy is tend to increase. At 2014 China was the biggest oil importer in the world by 6.6 million bbl/d overtook United States by 5.5 million bbl/d. 80% of China's oil consumption was passed from Malacca/Singapore Straits and also currently pipeline crude oil transportations from Kazakhstan, Russia, Burma, and Pakistan became important projects crude oil supplier to China [2].

CHAPTER 7

CONCLUSION

Ships movement in Malacca/Singapore Straits reported from Klang VTS and ships handled in Klang VTS are dominated by container ships, tanker fleet, and bulk carriers. These type of vessels contributed more significant than others: passenger ships, vehicles carriers, heavy load carriers, navy ships, tug boats, dredgers, drill ships, and other special purpose ships such as hospital vessels and research vessels. In 2017, Malacca/Singapore Straits passed by 231 ships in a day by any types of ships. This overcrowd is taken into account by maritime players such as shipping liners, shipping policy makers, and ship owners. Kra Canal as a new invention to reduce congestion in Malacca/Singapore Straits needs feasibility study to be known the effects of world maritime shipping line.

Simulations with Netpas Distance program and Arena Rockwell simulation program are implemented, as the results, using Kra Canal could reduce the distance, voyage time, and fuel oil cost. Regarding from simulation utilize Netpas Distance software, 30 origin-destination matrixes from port to port are randomly selected, Sihanoukville (Cambodia) to Yangon (Myanmar) route is the most reducing voyage distance by 703 NM and reducing sailing time from 5.42 days to 3.17 days. It affects the reducing in fuel oil consumption cost from 185664.7 USD to 108521.5 USD, around 41.5% reduction for one voyage. The biggest port in Europe, Rotterdam Port (Netherland), to the biggest port in Asia, Shanghai Port (China) also reduced in voyage distance from 10663 NM to 10340 NM with shorten the sailing time from 34.18 days to 33.14 days. Obviously it took benefit from the reducing fuel oil consumption cost from 2985885.9 USD to 2895601.8 USD, around 3% saving in fuel oil consumption for one voyage. With no surprise, some origin-destination matrixes also gained in voyage time and distance. The biggest increment is Melbourne Port (Australia) to Rotterdam Port (Netherland) that gain from 11526 NM to

12548 NM for distance and 36.94 days to 40.22 days for sailing time. It also increase the fuel oil consumption cost from 3227656.2 USD to 3513700.5 USD.

If this canal seriously will be made, the future tariff and toll charges should be determined. As a comparison, Mary Maersk with 79 thousand GRT and draft 12.4 m with ballast needs 343291.92 USD estimation for one voyage to pass Suez Canal for the first time (it has some discount rate if using more than one) excluding tug, mooring, and pilotage service, around 18.8 USD per TEU). Since the alternative route for the future Kra Canal is not inferior as Suez and Panama Canal, highly cost of Kra Canal's toll charge could happen only a few ships bypass this canal. Mary Maersk in full loaded has 18,270 TEU. Comparing with the profit for one voyage around 90284.1 USD, it is equal condition if the charge is 4.9 USD per TEU and still reasonable avoiding congestion of Malacca/Singapore Straits.

Simulations with Arena Rockwell program bypassing Malacca/Singapore Straits and future Kra Canal were occurred with Shanghai to Rotterdam route. The result without Kra Canal estimated 42 hours 14 minutes 24 second total waiting time in the Shanghai Port, Tanjung Pelepas Port, Suez Canal Economic Zone, and the last one in Rotterdam Port. It also spent 811 hours/33.7 days for the sailing time. In the other hand, with Kra Canal it was estimated 41.5 hours total waiting time in those ports and 783.4 hours/32.6 days in the sea. From this simulation, congestion of Malacca/Singapore Straits was not taken into account since the traffic is one of an unpredictable aspect in maritime trade beside engine failure, weather condition, piracy, and some political situation. These aspects could not be simulated in Arena Rockwell.

Increasing the voyage distance and time also occurred in the simulation, which should be managed well in order to solve from other problems as Kra Canal's effect. Making some port hub in Malaysia, Singapore, and Indonesia countries could be attached as a result of opening Kra Canal to make maintain the harmony of South East Asia countries. ASEAN could help Thailand to communicate with separatist in southern part of Thailand that could threat Thailand's security and sovereignty. Other solution besides Kra Canal is also needed to getting win-win solution within ASEAN and maritime players. Constructing pipeline to reduce movement of tanker in Malacca/Singapore Straits is highly needed not only to reduce the traffic but also to prevent the environment around Malacca/Singapore Straits' Littoral countries (Singapore, Malaysia, and Indonesia) from ship collision that could harm marine ecosystem. Another future study overcoming the traffic in

Malacca/Singapore Straits is highway or container train in Songkhla – Satun area, which are becoming proposed starting and ending point of future Kra Canal. By making this project, overcrowd in Malacca/Singapore Straits would be decreased. Those future study should be paid attention by maritime players, policy makers, and academicians.

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APPENDIX-A

SIMULATION RESULT THROUGH MALACCA/SINGAPORE STRAITS

23:23:44 **Category Overview** June 22, 2018

Unnamed Project

Replications: 1 Time Units: Hours

Key Performance Indicators

System	Average
Number Out	1

Model Filename: E:\arena for thesis\Shanghai-Malacca-Suez-Rotterdam Page 1 of 3

Unnamed Project

Replications: 1 Time Units: Hours

Entity

Time

VA Time	Average	Half Width	Minimum Value	Maximum Value
Entity 1	42.2400	(Insufficient)	42.2400	42.2400

NVA Time	Average	Half Width	Minimum Value	Maximum Value
Entity 1	0.00	(Insufficient)	0.00	0.00

Wait Time	Average	Half Width	Minimum Value	Maximum Value
Entity 1	0.00	(Insufficient)	0.00	0.00

Transfer Time	Average	Half Width	Minimum Value	Maximum Value
Entity 1	811.30	(Insufficient)	811.30	811.30

Other Time	Average	Half Width	Minimum Value	Maximum Value
Entity 1	0.00	(Insufficient)	0.00	0.00

Total Time	Average	Half Width	Minimum Value	Maximum Value
Entity 1	853.54	(Insufficient)	853.54	853.54

Other

Number In	Value
Entity 1	1.0000

Number Out	Value
Entity 1	1.0000

WIP	Average	Half Width	Minimum Value	Maximum Value
Entity 1	0.5690	(Insufficient)	0.00	1.0000

Unnamed Project

Replications: 1 Time Units: Hours

Queue

Time

Waiting Time	Average	Half Width	Minimum Value	Maximum Value
Loading Unloading 1.Queue	0.00	(Insufficient)	0.00	0.00
Loading Unloading 2.Queue	0.00	(Insufficient)	0.00	0.00

Other

Number Waiting	Average	Half Width	Minimum Value	Maximum Value
Loading Unloading 1.Queue	0.00	(Insufficient)	0.00	0.00
Loading Unloading 2.Queue	0.00	(Insufficient)	0.00	0.00

Resource

Usage

Instantaneous Utilization	Average	Half Width	Minimum Value	Maximum Value
Resource 1	0.02816000	(Insufficient)	0.00	1.0000

Number Busy	Average	Half Width	Minimum Value	Maximum Value
Resource 1	0.02816000	(Insufficient)	0.00	1.0000

Number Scheduled	Average	Half Width	Minimum Value	Maximum Value
Resource 1	1.0000	(Insufficient)	1.0000	1.0000

Scheduled Utilization	Value
Resource 1	0.02816000

Total Number Seized	Value
Resource 1	2.0000

APPENDIX-B

SIMULATION RESULT THROUGH KRA CANAL

00:14:59 **Category Overview** June 23, 2018

Unnamed Project

Replications: 1 Time Units: Hours

Key Performance Indicators

System	Average
Number Out	1

Model Filename: E:\arena for thesis\kra canal Page 1 of 3

Unnamed Project

Replications: 1 Time Units: Hours

Entity

Time

VA Time	Average	Half Width	Minimum Value	Maximum Value
Entity 1	41.5200	(Insufficient)	41.5200	41.5200

NVA Time	Average	Half Width	Minimum Value	Maximum Value
Entity 1	0.00	(Insufficient)	0.00	0.00

Wait Time	Average	Half Width	Minimum Value	Maximum Value
Entity 1	0.00	(Insufficient)	0.00	0.00

Transfer Time	Average	Half Width	Minimum Value	Maximum Value
Entity 1	783.40	(Insufficient)	783.40	783.40

Other Time	Average	Half Width	Minimum Value	Maximum Value
Entity 1	0.00	(Insufficient)	0.00	0.00

Total Time	Average	Half Width	Minimum Value	Maximum Value
Entity 1	824.92	(Insufficient)	824.92	824.92

Other

Number In	Value
Entity 1	1.0000

Number Out	Value
Entity 1	1.0000

WIP	Average	Half Width	Minimum Value	Maximum Value
Entity 1	0.5499	(Insufficient)	0.00	1.0000

Unnamed Project

Replications: 1 Time Units: Hours

Queue

Time

Waiting Time	Average	Half Width	Minimum Value	Maximum Value
Loading Unloading 1.Queue	0.00	(Insufficient)	0.00	0.00
Loading Unloading 2.Queue	0.00	(Insufficient)	0.00	0.00

Other

Number Waiting	Average	Half Width	Minimum Value	Maximum Value
Loading Unloading 1.Queue	0.00	(Insufficient)	0.00	0.00
Loading Unloading 2.Queue	0.00	(Insufficient)	0.00	0.00

Resource

Usage

Instantaneous Utilization	Average	Half Width	Minimum Value	Maximum Value
Resource 1	0.02768000	(Insufficient)	0.00	1.0000

Number Busy	Average	Half Width	Minimum Value	Maximum Value
Resource 1	0.02768000	(Insufficient)	0.00	1.0000

Number Scheduled	Average	Half Width	Minimum Value	Maximum Value
Resource 1	1.0000	(Insufficient)	1.0000	1.0000

Scheduled Utilization	Value
Resource 1	0.02768000

Total Number Seized	Value
Resource 1	2.0000

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AWARDS

Outstanding Student of Indonesia Classification & Royal Institute of Naval Architect