Dissertation for the degree of Doctor of Engineering

A Study on the Development of Real Time Supporting System (RTSS) for VTS Officers

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Contents

List of Tables

List of Figures

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A Study on the Development of Real Time Supporting System (RTSS) for VTS Officers

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Abstract

In coastal countries like Vietnam, sea transportation has always contributed greatly to the development of the national economy. The development of sea transportation depends on many factors. Among these factors marine traffic safety in ports and adjacent waterways is one which directly influences this development.

The launch of the Vessel Traffic Service (VTS) has contributed significantly to improving safety in waterways such as harbor waters, fairways and straits which have high traffic density. After six months of official operation, the Vung Tau VTS Center in Vietnam has helped to reduce the number of accidents in the VTS area by 60%, compared to the same period in the previous year, 2012.

However, the rate of accidents related to traffic in the Vung Tau VTS area is still high, about 70% of total accidents. It is because of the “dis-order” traffic in the waterway.

Navigation assistance and traffic organization are two of the main functions of a VTS system. So that improving the effectiveness of the Vung Tau VTS Center in these two functions is one of the feasible and effective solutions to solve this problem.

After studying the work of VTS officers (VTSO), it was found that the key factor in deciding the performance of a VTSO is his/her ability to assess the risk of vessels. In fact, at all VTS centers this process totally depends on the assessment of the VTSO. These assessment results greatly depend on human factors such as working experience, working conditions, human error, etc. An effective solution for this problem is the application of a quantitative risk assessment model to evaluate the risk of a vessel's traffic safety.

For this reason this dissertation researches and develops the Real Time Supporting System (RTSS) for VTS officers. It is able to help VTSOs determine the collision risk of vessels quantitatively and alert vessels which have un-acceptable risk of collision. In addition, the RTSS is also able to alert vessels which have the possibility of going aground or being off-route or over-speed.

This RTSS was designed for application in the Vung Tau VTS Center to improve marine traffic safety in the three main fairways in the Vung Tau Waterway. It will contribute to the economic development of the Important Triangular Economic Zone in the southern part of Vietnam (Ho Chi Minh City, Dong Nai Province, and Ba Ria-Vung Tau Province).

For the purpose of this research a survey of traffic in the Vung Tau Waterway was conducted. Traffic environment factors were studied and statistical data of marine traffic and marine accidents in the waterway were collected. To find the assessment model most appropriate for the Vung Tau Waterway, this data was then analyzed, evaluated, and compared using various methods such as evaluation based on experts' surveys or based on assessment models, comparison evaluation results with statistical data, etc. Results showed that the PARK model (Potential Assessment of Risk model, developed in Korea) is the most appropriate model for the Vung Tau Waterway.

This RTSS was developed based on this model. Its functions and user interface were designed according to survey responses of VTSOs in the Vung Tau VTS Center.

After development this RTSS has gone into trial operation at the Vung Tau VTS Center where it obtainned data about traffic through the AIS (Automatic Identification System) receiver device. Then the feedback of VTS officers was collected and analyzed for further study on improving the RTSS.

The findings of the dissertation are summarized as follows:

1. The affects of marine environment factors such as winds, currents, tides, waves, fog, rain, width and depth of waterway on marine traffic safety were analyzed. It was found that they have a small negative affect on traffic safety in the Vung Tau Waterway
2. Through traffic survey and quantitative assessment by the IWRAP model, it was found that the "dis-order" movement of traffic in this area by ocean vessels, barges, tug boats, fishing boats, etc. is the main factor which affects traffic safety in this waterway. This problem can be looked into by many ways. However, an effective and feasible solution is improving the effectiveness of the Vung Tau VTS Center
3. The effectiveness of the Vung Tau VTS Center is still restricted because of lack of sea and working experience of VTS officers. So a supporting system to support VTS officers for improving their competency and the Vung Tau VTS Center's efficiency needs to be established. The supporting system should be able to help VTS officers to assess collision risks of vessels quantitatively in real time. It must be built based on an assessment model that takes into account the risk of human factors
4. Through analysis it was found that some models other than the ES model and the PARK model use statistical measures or the opinions of experts,

but they do not take into account the risks of human factors. So these models cannot be used to assess collision risks of vessels in real time. By qualitative analysis and assessment of VTS officers about the ES model and the PARK model, it was shown that the PARK model is the most appropriate model for evaluating risks of collision in the Vung Tau Waterway in real time

5. The Real Time Supporting System (RTSS) for VTS officers was developed. It is able to evaluate collision risks of vessels based on the PARK model in real time and alert vessels that run a risk of collision. In addition, it can alert officers about vessels' going aground, being off-route and over-speed vessels. The RTSS was put in trial operation in the Vung Tau VTS Center. Most VTS officers have given the same feedback, i.e., that it is a useful tool and should be improved to become an indispensable part of the VTS system

From these results this dissertation recommends to the Maritime Administration of Ho Chi Minh City, which manages the Vung Tau VTS Center, to give permission for connecting the RTSS with the VTS system to enable complete traffic data gathering for implementing the subsequent trial operation steps. In this way the RTSS will continue to be assessed, modified, and then put into official operation.

Chapter 1. Introduction

1.1 Scope of Research

This study researches and develops a Real Time Supporting System (RTSS) for VTS officers and applies it in the Vung Tau VTS Center in Vietnam for the purpose of improving maritime traffic safety in the Vung Tau VTS area (Vung Tau Waterway).

The RTSS is able to alert VTS officers to monitor vessels that run a risk of collision, running aground, or sailing off-route or over-speed.

The benefits of the VTS's improving maritime traffic safety in a waterway are undeniable. This was clearly stated in Regulation 12 of SOLAS, Chapter 5 as follows:

"Vessel traffic services (VTS) contribute to safety of life at sea, safety and efficiency of navigation and protection of the marine environment, adjacent shore areas, work sites and offshore installations from possible adverse effects of maritime traffic." (IMO, 2010b)

The supporting efficiency of a VTS system depends on two main factors as below:

(1) the system's capacity
(2) the competency of the VTS officers

To improve the efficiency of the system, we can:

(1) upgrade the system by expanding the radar surveillance range; apply new technology in data communication; or add more functions that support VTS officers, etc.

(2) or improve VTS officers' competency by improving the management system, training, and evaluating regularly, etc.

This study approaches the goal of improving the efficiency of a VTS center by developing a supporting system that is able to alert vessels that run a risk of collision, running aground, or sailing off-route or over-speed. The supporting system will help to reduce the work load of VTS officers and prevent human errors such as misjudging vessel risk and failing to observe dangerous traffic situations and/or off-route vessels or over-speed vessels.

The VTS officers have many considerations to properly do their duties, such as a reduced work load, improved efficiency of communication between the VTS officers and ship-handlers (captains and/or pilots), enhanced visual observation of the actual image of ships, etc. After analyzing the accidents in the Vung Tau Waterway from 2008 to 2012 and collecting ideas from VTS officers at the Vung Tau VTS Center, this study focuses on the imperative need of an alert system to avoid the risk of collision and the grounding of vessels. Additionally, there is need for an alert system for off-route and over-speed vessels.

According to statistical data of the Maritime Administration of Vung Tau, from 2008 to 2012, there were twenty-two accidents inside the Vung Tau Waterway, one caused by technical fault (5%); three caused by crew errors on cargo stowage, cargo operation and anchoring (14%); and eighteen (groundings: two; collisions: sixteen) caused by crew errors in navigation (81%).

In addition, based on the results of a traffic survey by the AIS from October to December 2012, about 20% of vessels did not follow the fairway in parts of the traffic routes and about 25% of vessels violated the safe speed regulations.

The waterway which is supported by the RTSS system is the Vung Tau VTS area. In this study it is abbreviated to the Vung Tau Waterway. The Vung Tau VTS Center is responsible for the VTS Sector 1 and Sector 2 of the Sai Gon–

Vung Tau VTS System. It is about twenty-four nautical miles (nms) in width and twenty-three nautical miles in length, as shown in Figure 1.1.

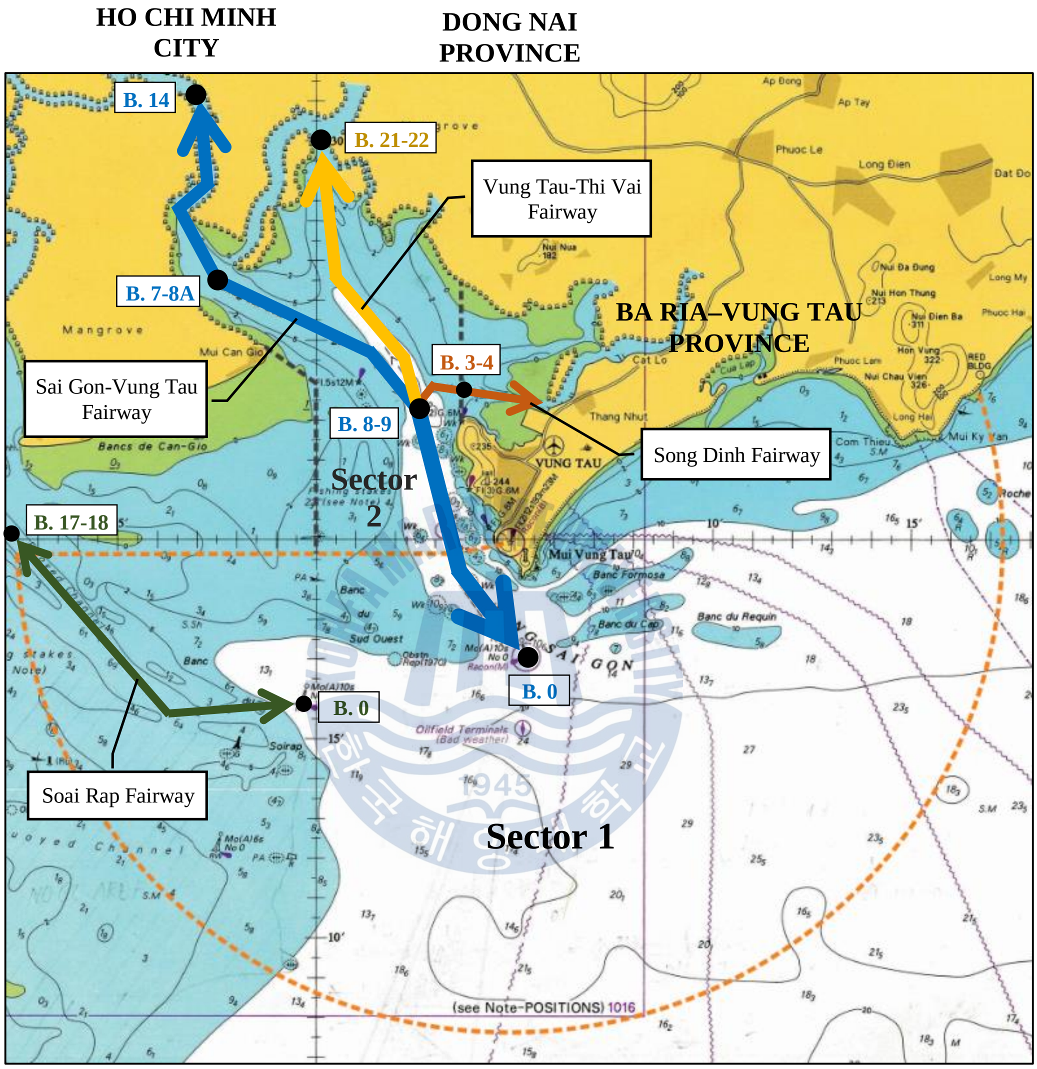


Figure 1.1 The Vung Tau Waterway on the British Admiralty (BA) Chart No.1261

The Vung Tau Waterway is the approach area of the four fairways which connect the Important Triangular Economic Zone in the southern part of Vietnam (Ho Chi Minh City, Dong Nai Province, and Ba Ria-Vung Tau Province) with other parts of Vietnam and other countries in the world.

According to data of the Vung Tau VTS Center, from July 2013 to September 2013, the number of passing vessels in this area was approximately sixty vessels per day. In the coming years the forecast for Vietnam's economic growth is about 5% per year. This means the number of crossings will continue to increase in the next few years. However, the type of vessels increased will be mainly container vessels whose length exceeds 150 meters (m) due to the on-going operation of deep-water container terminals along the Thi Vai River (Dong Nai Province).

Ensuring the safety of vessel traffic in the Vung Tau Waterway plays a very important role in the economic development of southern Vietnam both at present and in the future.

1.2 Literature Review

The Sai Gon–Vung Tau VTS System is the first VTS system of Vietnam. Its official operation began on April 3, 2013 (VMS South, 2013). Up to then there had not been any research conducted relating to VTS and maritime traffic safety in Vietnam.

Nguyen (Nguyen Huu Ly, 2012), did research on the human factors in the accidents that happened in the Sai Gon–Vung Tau Fairway. According to his research, the errors of ship-handlers accounted for a large proportion of these accidents.

Le (Le Van Ty, 2012a) researched the requirements for a Traffic Separation Scheme (TSS) for the Vung Tau Waterway. His research concluded that it is necessary to have a TSS for the Vung Tau Waterway to solve the existing dis-order traffic problem for improving maritime traffic safety.

Nguyen (Nguyen Xuan Thanh et al., 2012) did a quantitative marine traffic safety assessment of this area by using the IWRAP model (IALA Waterway Risk Assessment Program model). His results showed that the intersection area of the three fairways: Sai Gon–Vung Tau, Thi Vai and Song Dinh (adjacent to Buoys No.8 and No.9 of the Sai Gon–Vung Tau Fairway) has the highest risk of collision followed by the adjacent areas from Buoy No.0 to Buoys No.8-9 and from Buoys No.8-9 to Buoys No.7-8A along the Sai Gon–Vung Tau Fairway.

Lee (Lee Hyong Ki, 2011) researched and developed a supporting system for VTS officers based on the ES model (Environment Stress). The system was integrated into ECDIS (Electronic Chart and Display Information System). It calculates the environment stress on the ship-handlers quantitatively and alerts VTS officers via colored vessel symbols on the ECDIS screen.

1.3 Research Review and Flow-chart

Chapter 1 of this dissertation describes its scope, gives a review of literature and presents a research layout. The first part of Chapter 2 is a general introduction to the Vung Tau Waterway; marine environment factors such as winds, currents, tides, waves, fog, rain, width and depth of waterway, and the affects of these factors on the safe navigation of passing vessels according to the evaluations of pilots are discussed. The next section presents the results of the marine traffic survey and traffic safety assessment in the waterway by the IWRAP model. In the last part of the Chapter 2 the marine traffic management and the organization and operation of the Sai Gon-Vung Tau VTS System and the Vung Tau VTS Center are presented. The beginning of Chapter 3 reviews features of some popular waterway risk assessment models and presents the ES (Environment Stress) model and the PARK (Potential Assessment of Risk) model in detail. Chapter 3 finishes by describing the analysis of selecting the best appropriate assessment model to be used to evaluate the risk of maritime traffic safety in the Vung Tau Waterway. The selected model will be applied in the RTSS. Here the statistical data of marine traffic accidents from 2008 to 2012 are used as one of the bases to compare the results of proposed assessment models. Chapter 4 presents details regarding the Real Time Supporting System for VTS officers. The first part presents the process of developing the RTSS, from conceptual design to testing procedure. The last part shows how the RTSS was implemented in the Vung Tau VTS Center and analyzes the feedback of the VTS officers. The final chapter, Chapter 6, presents conclusions and makes suggestions for future studies to improve performance of the RTSS.

Figure 1.2 shows the research flow-chart of this study

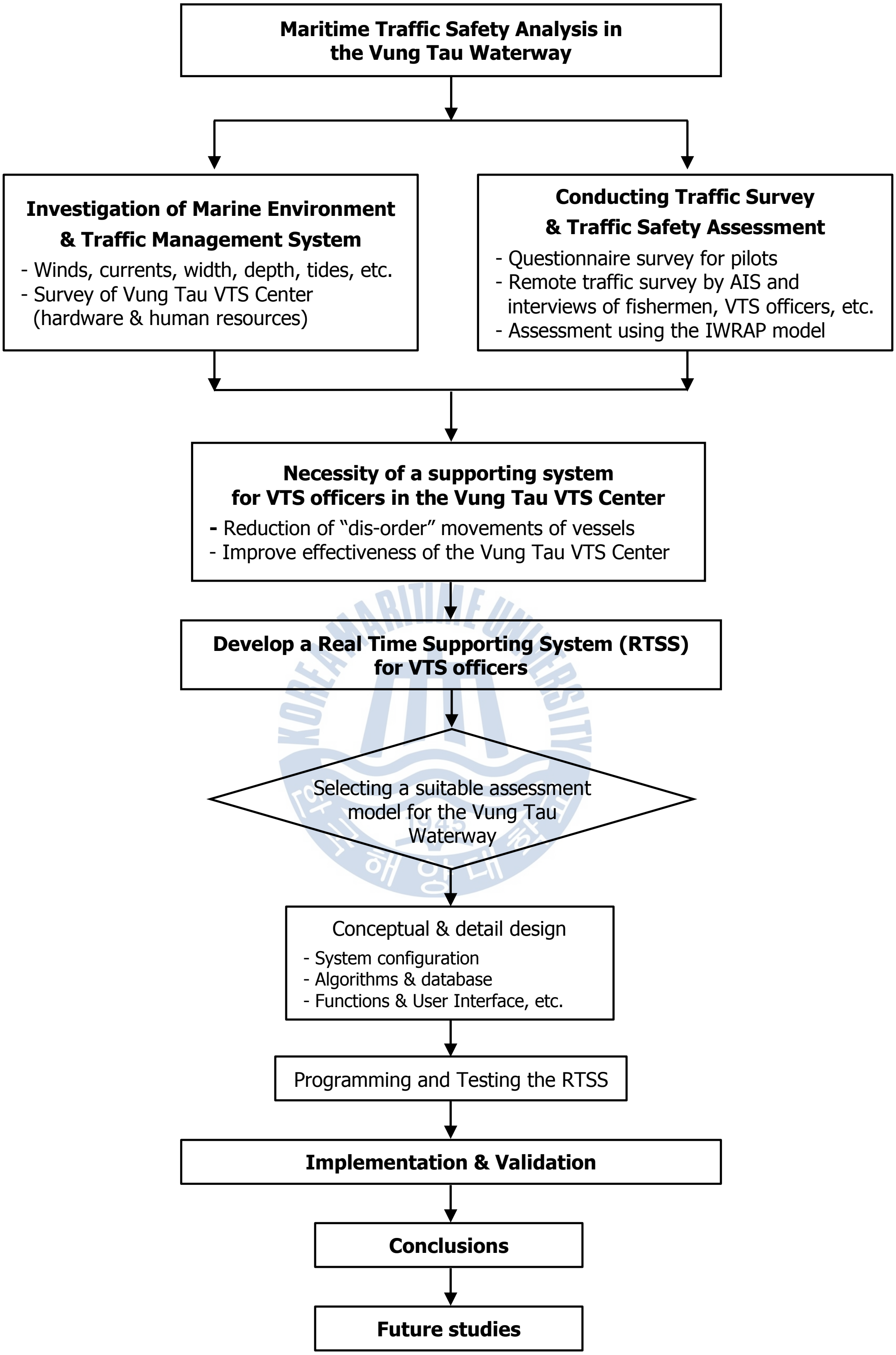


Figure 1.2 Research flow-chart

Chapter 2. Marine Environment, Traffic and Traffic Management in the Vung Tau Waterway

2.1 Introduction to the Vung Tau Waterway

The Vung Tau Waterway is the waterway monitored by the Vung Tau VTS Center. It consists of Sector 1 and Sector 2 in the Sai Gon–Vung Tau VTS System, as shown in Figure 2.1.

Sector 1 is the offshore waters within 12 nautical miles of the Vung Tau Lighthouse. Sector 2 covers the adjacent waterways along the following fairways:

(1) The Sai Gon–Vung Tau Fairway, from Buoys No.4-5 of the Vung Tau–Thi Vai Fairway to Buoy No.14 of the Sai Gon–Vung Tau Fairway
(2) The Vung Tau–Thi Vai Fairway, from Buoys No.4-5 to Buoys No.21-22
(3) The Song Dinh Fairway, from Buoys No.8-9 of the Vung Tau–Thi Vai Fairway to Buoys No.3-4 of the Song Dinh Fairway

The Vung Tau Waterway stretches from 10-08.05N to 10-31.23N latitude and from 106-52.53E to 107-16.80E longitude. It is approximately twenty-four nautical miles in width and twenty-three nautical miles in length.

It is the approach area of the four fairways described below. These fairways are the main sea routes which connect the Important Triangular Economic Zone in the south of Vietnam with the East Sea (South China Sea).

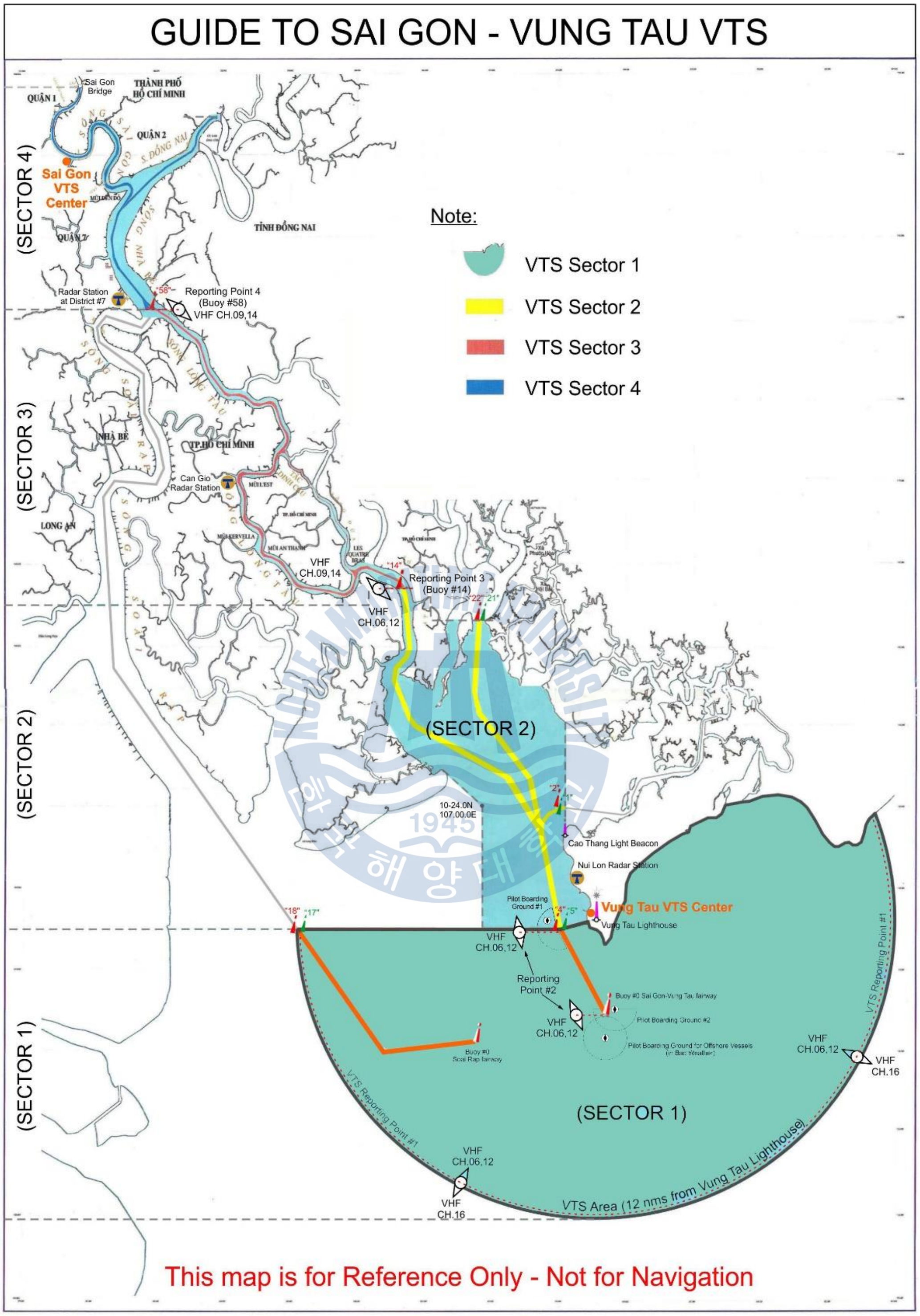


Figure 2.1 The Sai Gon–Vung Tau VTS System

(1) The Sai Gon–Vung Tau Fairway connects Ho Chi Minh City and Dong Nai Province with the East Sea (South China Sea)

(2) The Vung Tau–Thi Vai Fairway connects Dong Nai Province with the East Sea

(3) The Song Dinh Fairway connects Vung Tau City with the East Sea

(4) The Soai Rap fairway connects Ho Chi Minh City and Dong Nai Province with the East Sea

Figure 2.2 shows details of the Vung Tau Waterway

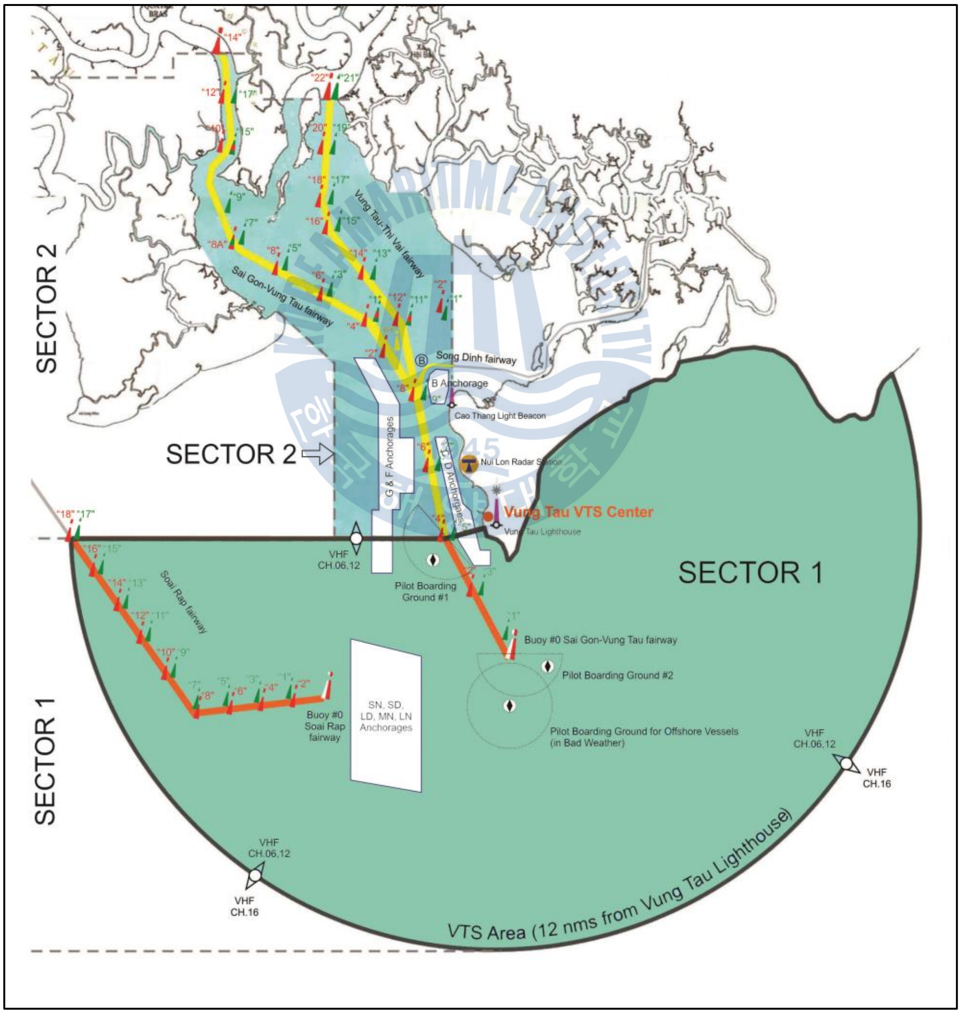


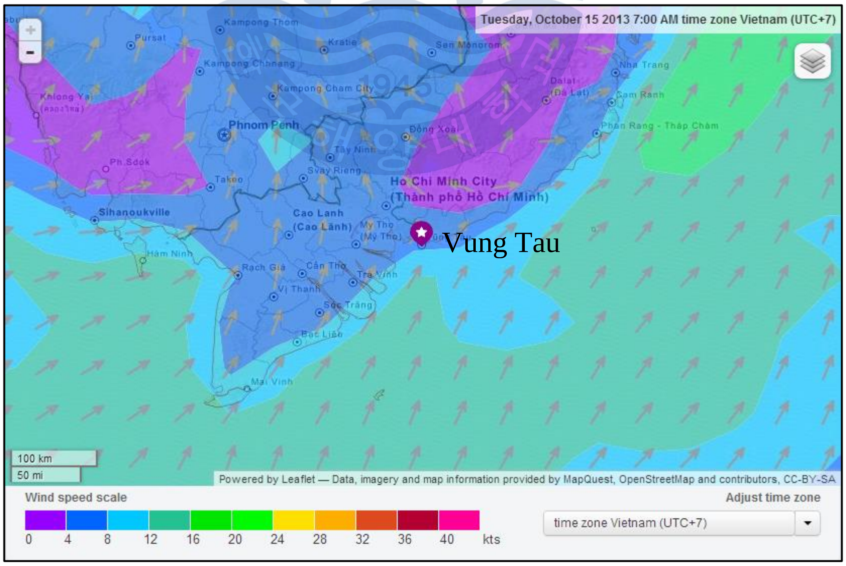
Figure 2.2 The Vung Tau Waterway

2.2 Marine Environment in the Vung Tau Waterway

2.2.1 Winds

The Vung Tau Waterway is located in an area affected by monsoons. The waterway in Sector 1 is clearly influenced by both the northeast monsoon (from November to May) and the southwest monsoon (from June to October). Normal wind speed is less than seven knots. Sometimes gusts can reach sixty knots, but the maximum probability of a wind force of more than 4 (on the Beaufort Scale) is only 7% (World Weather, 2012). The waterway in Sector 2 is sheltered by Vung Tau and the Can Gio Peninsula, so the wind in this area is characterized by low wind speed and unstable wind direction.

Figure 2.3 shows a day-time wind forecast map of winds in the south of Vietnam during the southwest monsoon season. At sea the wind speed is from twelve to sixteen knots (Force 4); however, in the Vung Tau Waterway it is less than eight knots (Force 2).



Source: Wind Finder, 2013

Figure 2.3 A sample of a wind forecast map for the southern part of Vietnam

2.2.2 Currents

Currents in this area are mostly created by tidal streams (Nguyen Vinh Phuc, 2012). The details of the tidal streams are:

(1) During twenty-four hours the current's direction and maximum speed changes four times. The speed of the tidal stream at ebb tide is often higher than during high tide. Maximum current speed can reach 4.0 knots because of the wide tide range

(2) Among the three rivers in the area, Long Tau, Thi Vai and Dinh, the tidal stream in Long Tau is considered the strongest

(3) Because of the combination of the tidal stream in ebb tide and the offshore current, there is a current which flows from west to east in an area from Buoy No.1 to Buoy No.5 of the Sai Gon–Vung Tau Fairway, especially in the area between Buoys No.3 and No.5

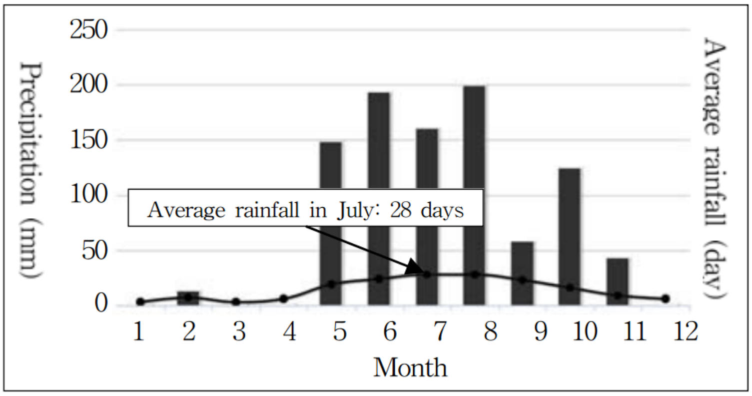
(4) From Buoy No.0 to the limit of the VTS area (twelve nautical miles seaward from the Vung Tau Lighthouse), the current speed is slow due to its distance from the mouth of the river.

2.2.3 Rain and Fog

Vietnam is located in the tropical monsoon region. There are only two seasons throughout the year: sunny and rainy. During the rainy season, from May to October, there are about twenty rainy days per month (World Weather, 2012). Rain usually comes as showers and lasts for only one or two hours.

The area averages ten to twelve fog days per year and fog only occurs during a few hours in the morning and/or afternoon.

Figure 2.4 shows yearly average rainfall in the Vung Tau area



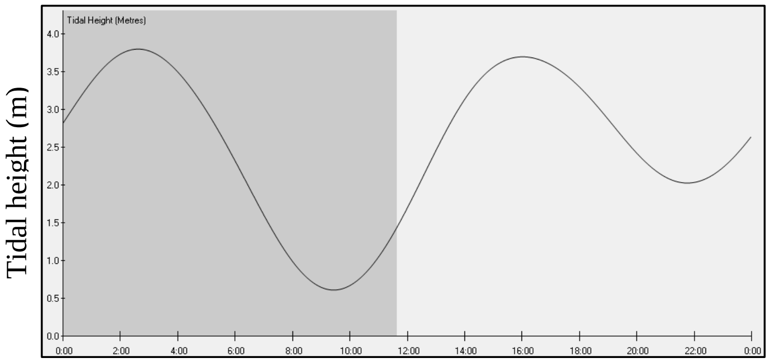
Source: World Weather, 2012

Figure 2.4 Average rainfall in Vung Tau

2.2.4 Waves and Tides

Waves in the area are mostly surface waves caused by wind so that the wave height in Sector 1 is usually higher than in Sector 2. However, due to the usual wind speed of less than Force 4, the wave height generally does not exceed 3.0 meters.

Tides in this area are generally semi-diurnal. During twenty-four hours there are two periods of high water and two periods of low water, as shown in Figure 2.5. The average tide range is about 2.5 meters, but sometimes it can reach 4.0 meters. However, the duration time of the high tide is normally less than thirty minutes because the tide is semi-diurnal.



Time of day

Figure 2.5 A sample of tides in the Vung Tau Waterway

For the above reasons waves and tides in this area do not greatly increase difficulty for captains and/or pilots but they should have precise arrangement on arrival and departure times.

2.2.5 Width and Depth

Figures 2.6 and 2.7 show the two parts (Sector 1 and Sector 2) of the Vung Tau Waterway on the BA Chart No.1016. This BA Chart of the area has the largest scale and is commonly used by ocean-going vessels when approaching the Vung Tau Waterway.

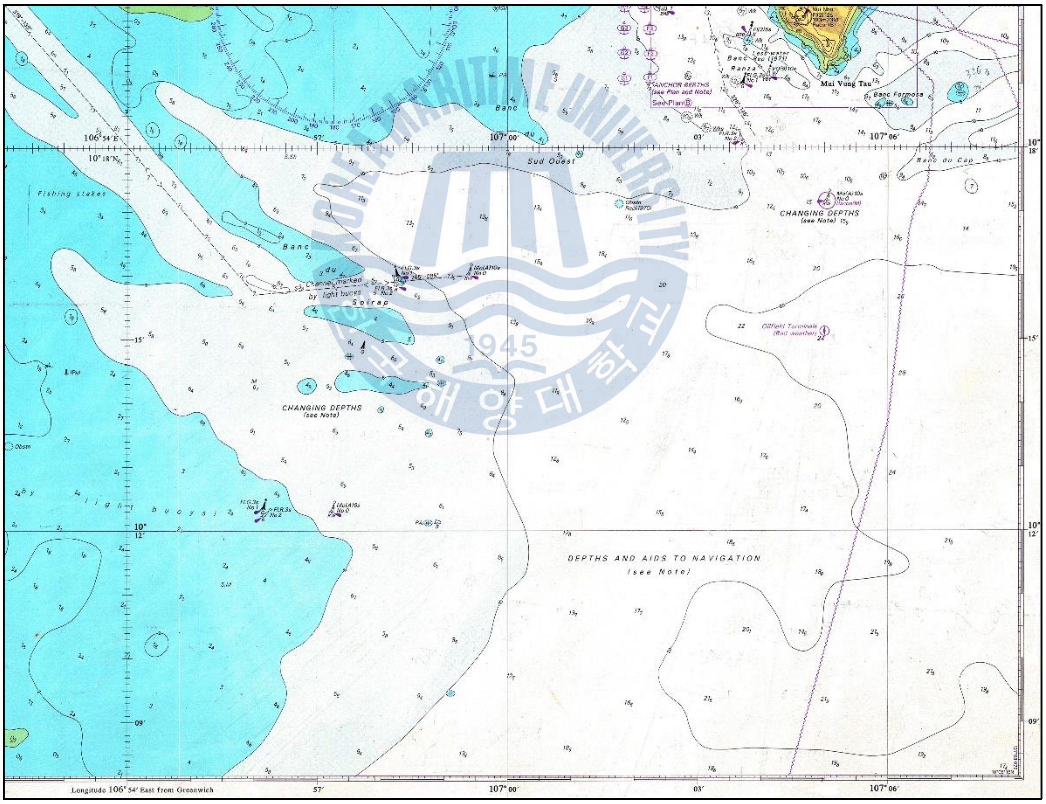


Figure 2.6 Sector 1 of the Vung Tau Waterway (BA Chart No. 1016)

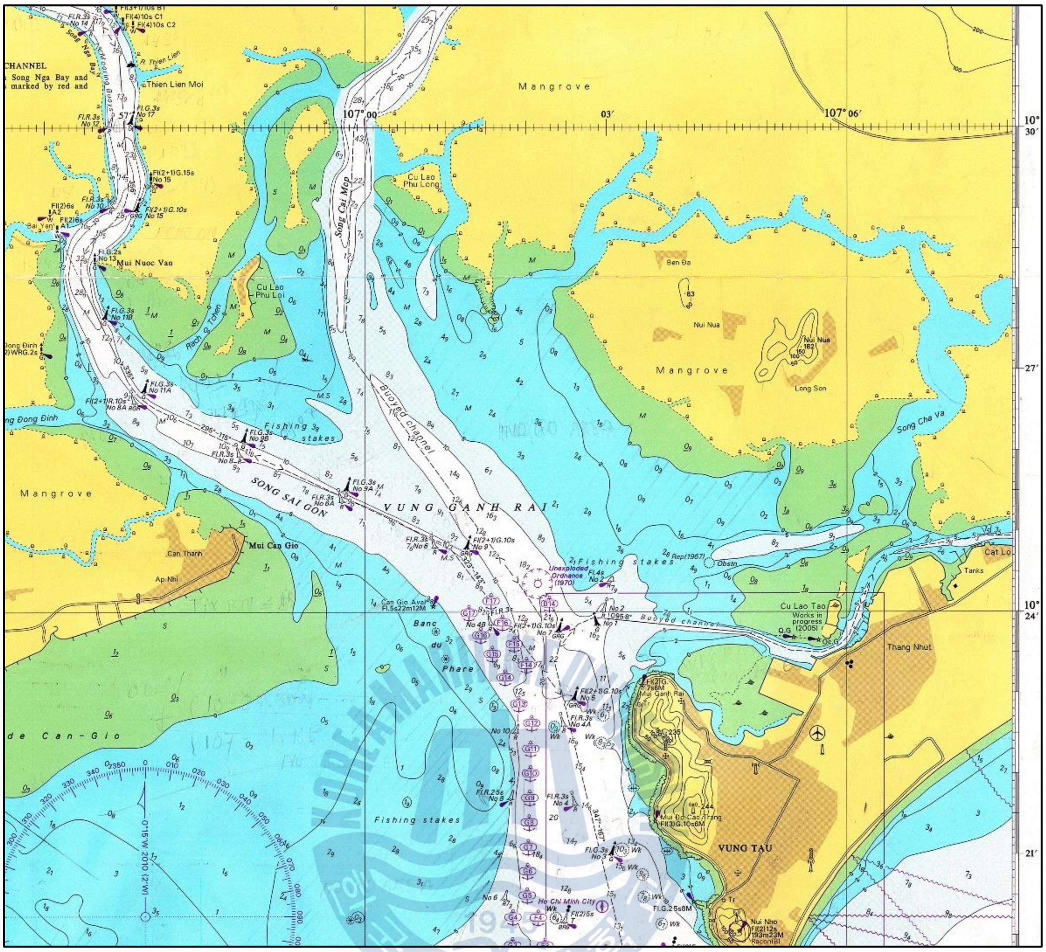


Figure 2.7 Sector 2 of the Vung Tau Waterway (BA Chart No. 1016)

The following presents the minimum requirements of depths and widths according to the PIANC (Permanent International Association of Navigation Congresses) guidelines (PIANC Rules) in accordance with the maximum allowed DWT (Deadweight Tonnage) of the four fairways.

Table 2.1 shows typical ship dimensions applied in calculations

Table 2.1 Typical ship dimensions applied in calculations

DWT	Type	LOA	Beam	Draught	Remarks
20,000	Cargo vessel	166	24.8	10.0	(PIANC, 1997)
30,000	Cargo vessel	188	27.7	11.3	
50,000	Container ship	267	32.2	12.5	
70,000	Container ship	280	40.0	14.0	(Hironao Takahashi et al., 2010)
80,000	Container ship	300	40.0	13.5	
100,000	Container ship	304	42.8	14.5	

According to the PIANC, in the conceptual design stage the minimum width of the 2 ways fairway should be calculated as follows (PIANC, 1997):

$$w = 2W_{BM} + 2\sum_{i=1}^{n} W_i + W_{Br} + W_{Bg} + \sum W_p \qquad (1)$$

W_{BM} (W_M), W_{Br}, W_{Bg} and W_p are explained in Figure 2.8. W_i are additional widths that depend on vessel speed, prevailing cross winds, prevailing cross currents, prevailing longitudinal currents, significant wave heights and lengths, aids to navigation, bottom surface, depth of waterway, and cargo hazard level.

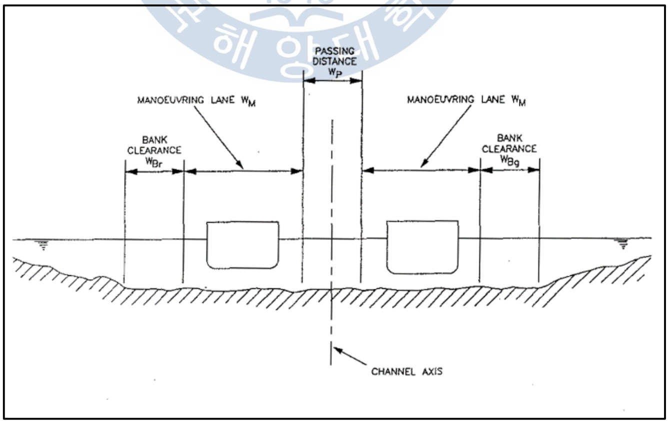


Figure 2.8 Elements of channel widths

Tables 2.2 and 2.3 show detailed calculations of minimum width requirements according to PIANC guidelines with some typical sizes of vessels

Table 2.2 Detailed calculations of minimum required widths of channels

Basic Maneuvering Lane (W_{BM})	1.5 B		
Addition for speed (W_{i1})	0.0 B		
Addition for cross winds (W_{i2})	0.4 B		
Addition for cross currents (W_{i3})	0.0 B		
Addition for longitudinal currents (W_{i4})	0.0 B		
Addition for waves (W_{i5})	0.0 B		
Addition for aids to navigation (W_{i6})	0.2 B		
Addition for bottom surface (W_{i7})	0.1 B		
Addition for waterway depth (W_{i8})	0.2 B		
Addition for cargo hazard (W_{i9})	0.0 B		
Sub total	2.4 B	x 2	4.8 B
Bank clearance on port side (W_{Br})			0.5 B
Bank clearance on starboard side (W_{Bg})			0.5 B
Passing distance (W_p)			1.8 B
		Total	**7.6 B**

Note: B is the breadth of the vessel (m)

Table 2.3 Minimum required widths of channels in accordance with some typical sizes of vessels

DWT	**Type**	**Beam (m)**	**Width of fairway (m)**
20,000	Cargo vessel	24.8	188
30,000	Cargo vessel	27.7	210
50,000	Container ship	32.2	245
70,000	Container ship	40.0	304
80,000	Container ship	40.0	304
100,000	Container ship	42.8	325

Sector 1 of the Vung Tau Waterway is open sea; the minimum depth along the traffic route is 16.5 meters. In addition, the tide height is usually over 1.0 meter so that the depth/draught ratio of a full-load 100,000 DWT vessel is 1.2. Without complications this depth is safe for a full-load 100,000 DWT container vessel passing according to PIANC guidelines (PIANC, 1997).

In Sector 2 of the Vung Tau Waterway the wave height is normally less than 3.0 meters and the vessel speed is limited to 10.0 knots, so that without complications a vessel should be able to pass the waterway safely, if the depth/draught ratio is over 1.1, according to PIANC guidelines (PIANC, 1997).

Table 2.4 shows the minimum depth required for some sizes of vessels with depth/draught ratio is 1.1

Table 2.4 Minimum required depths of channels in accordance with some typical sizes of vessels with depth/draught ratio is 1.1

DWT	**Type**	**Draught (m)**	**Depth of fairway (m)**
20,000	Cargo vessel	10.0	11.0
30,000	Cargo vessel	11.3	12.4
50,000	Container ship	12.5	13.8
70,000	Container ship	14.0	15.4
80,000	Container ship	13.5	14.9
100,000	Container ship	14.5	16.0

Table 2.5 shows a comparison of the width and depth of fairways in the area at present with the requirements of the PIANC guideline

Table 2.5 At present width, depth and maximum allowed DWT of fairways in the Vung Tau Waterway

Area	At present			PIANC required		Remarks
	Min width of channel (m)	**Min depth of channel (m)**	**Max allowed DWT (Ton)**	**Min width of channel (m)**	**Min depth of channel (m)**	
Approaching Area	Open sea	outside traffic route: 13.7 inside traffic route: 16.5	100,000	≅ 325	≅ 16.0	Generally, ships' maneuvering is not restricted by width and depth
Buoy 0 to Buoys 8-9 of the Sai Gon–Vung Tau Fairway	350	14	100,000	≅ 325	≅ 16.0	Ships which have a draft over 12.7m have to consider tides
Buoys 8-9 to Buoy 14 of the Sai Gon–Vung Tau Fairway	350	8.6	30,000	≅ 210	≅ 12.4	Ships which have a draft over 7.8m have to consider tides
Buoys 8-9 to Buoys 21-22 of the Vung Tau–Thi Vai Fairway	400	14	100,000	≅ 325	≅ 16.0	Ships which have a draft over 12.7m have to consider tides
Buoys 8-9 to Buoys 3-4 of the Song Dinh Fairway	220	7	20,000	≅ 188	≅ 11.0	Ships which have a draft over 6.4m have to consider tides
Buoy 0 to Buoys 17-18 of the Soai Rap Fairway	300	5.7	20,000	≅ 188	≅ 11.0	Ships which have a draft over 5.2m have to consider tides

Table 2.5 shows that in Sector 1 of the Vung Tau Waterway a vessel which has a DWT under 100,000 tons can pass this area safely without any restrictions of width and depth.

In the three fairways: Sai Gon-Vung Tau, Vung Tau-Thi Vai, and Song Dinh, vessels which have a DWT under the maximum allowed DWT can pass the fairways without any width restriction. However, some full-load vessels have to consider tide height or lighten before passing the fairways.

An example in Figure 2.9 shows the tide curve of a day in the Vung Tau Waterway. According to the figure the vessel can pass through this area with tide height over 2.5 m from 11:17am to 04:16am the next day (about 17 hours). It also shows that the tide range in this area can reach about 4.0 meters.

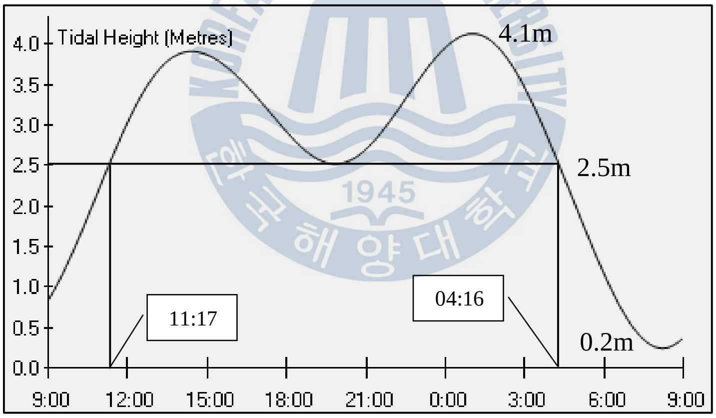


Figure 2.9 Tide curve of a day in the Vung Tau Waterway

In the Soai Rap Fairway the width of the fairway is 300 m and safety depth is 5.7 m, so that vessels passing this fairway have many restrictions of water depth. Almost all vessels which have DWT over 10.000 tons cannot pass this fairway because their light draft is almost about 5.0 m.

Table 2.6 shows the plan of development of the four fairways until 2020 (QD-TTg, 2009), observing the requirements of the PIANC guidelines

Table 2.6 Development plan of fairways in the Vung Tau Waterway until 2020

Area	Plan to 2020			Present		Developing plan	Remarks
	Max allowed DWT	PIANC required		Min channel width (m)	Min channel depth (m)		
		Min width of channel (m)	Min depth of channel (m)				
Approaching Area	100,000	≅ 325	≅ 16.0	Open sea	16.5	N/A	Generally, ships' maneuvering is not restricted by width and depth
Buoy 0 to Buoys 8-9 of the Sai Gon–Vung Tau Fairway	100,000	≅ 325	≅ 16.0	350	14	N/A	Ships which have deep draft have to consider tide height
Buoys 8-9 to Buoy 14 of the Sai Gon–Vung Tau Fairway	30,000	≅ 210	≅ 12.4	350	8.6	N/A	
Buoys 8-9 to Buoys 21-22 of the Vung Tau–Thi Vai Fairway	100,000	≅ 325	≅ 16.0	400	14	Expand width in turning areas	
Buoys 8-9 to Buoys 3-4 of the Song Dinh Fairway	30,000	≅ 210	≅ 12.4	220	7	N/A	
Buoy 0 to Buoys 17-18 of the Soai Rap Fairway	80,000	≅ 300	≅ 14.9	300	5.7	Step 1 to 9.5m Step 2 to 11.0m Step 3 to 12.0m	Able to accept vessels up to 50,000 / 70,000 / 80,000 DWT with the appropriate tide height

Table 2.6 shows that until the year 2020 there is no plan for upgrading the three fairways: Sai Gon–Vung Tau, Vung Tau–Thi Vai, and Song Dinh, so that the maximum allowed DWT vessels which have a deep draft have to consider tides when passing these fairways. The Soai Rap Fairway will be developed in three stages to increase the safety depth to 9.0 m, 11.0 m, and 12.0 m for safe navigation of vessels which have a DWT up to 50,000, 70,000, and 80,000 tons.

Generally at present vessels which have a DWT less than the maximum allowed DWT are able to pass the fairways in the Vung Tau Waterway (except the Soai Rap Fairway) safely in two-way traffic with suitable drafts and/or tides.

2.3 Assessment Affectiveness of the Marine Environment on Marine Traffic Safety

The affects of the marine environment on marine traffic safety is assessed by its affect on ship-handling in the area. In this paper a survey of experts was used to assess this affect. A group of thirty pilots who work in the two pilot companies in this area, Vietnam Maritime Pilot Company No.1 and New Port Pilot Company, were asked to answer a questionnaire, as shown in Annex 1. It consisted of five questions with thirty-six items.

According to Item 2.2 above, only winds, currents and rain/fog have a strong affect on ship-handling. So the questionnaire was designed to focus on the evaluation of the marine environment factors described above.

Figure 2.10 shows a sample question for evaluating the affect of currents. This affect is evaluated and graded in seven levels on the Likert Scale: from "-3: very negative affect" to "+3: very positive affect".

1. Would you please evaluate the affects of CURRENTS on ship handling when a vessel sails FOLLOWING THE CURRENT with the following sizes of vessels. *(-3: very negative affect/ -2: negative affect/ -1: maneuvering ability is worse, drifting/ 0: no affect/ 1: maneuvering ability is better, no drifting/ 2: positive affect/ 3: very positive affect)*

a. Ballast vessel, LOA from 50 to 100 m

negative affect		<---------------------------->				positive affect
(-3)	(-2)	(-1)	(0)	(1)	(2)	(3)

...

h. Full load vessel, LOA over 200 m

negative affect		<---------------------------->				positive affect
(-3)	(-2)	(-1)	(0)	(1)	(2)	(3)

Figure 2.10 A sample question used in the questionnaire survey for pilots

Table 2.7 shows the work experience of pilots who participated in the survey

Table 2.7 Work experience of pilots who participated in the survey

Pilot Company	**Number**	**Experience (years)**
Pilot Company No.1	11	18.6
New Port Pilot Company	19	11.6
Total	**30**	**14.2**

The reliability of the survey is tested by Cronbach's Alpha method, using the SPSS program. The results are presented in Table 2.8

Table 2.8 Reliability statistics

Cronbach's Alpha	Cronbach's Alpha based on Standardized Items	N of Items
.944	.955	36

Figure 2.11 shows that both the NE and SW wind, that have wind force over five, cause a drifting affect on vessels. Especially when a vessel is in a ballast condition this affect will be stronger. If a ballast vessel sails at a slow speed, it is very difficult for her to keep her course.

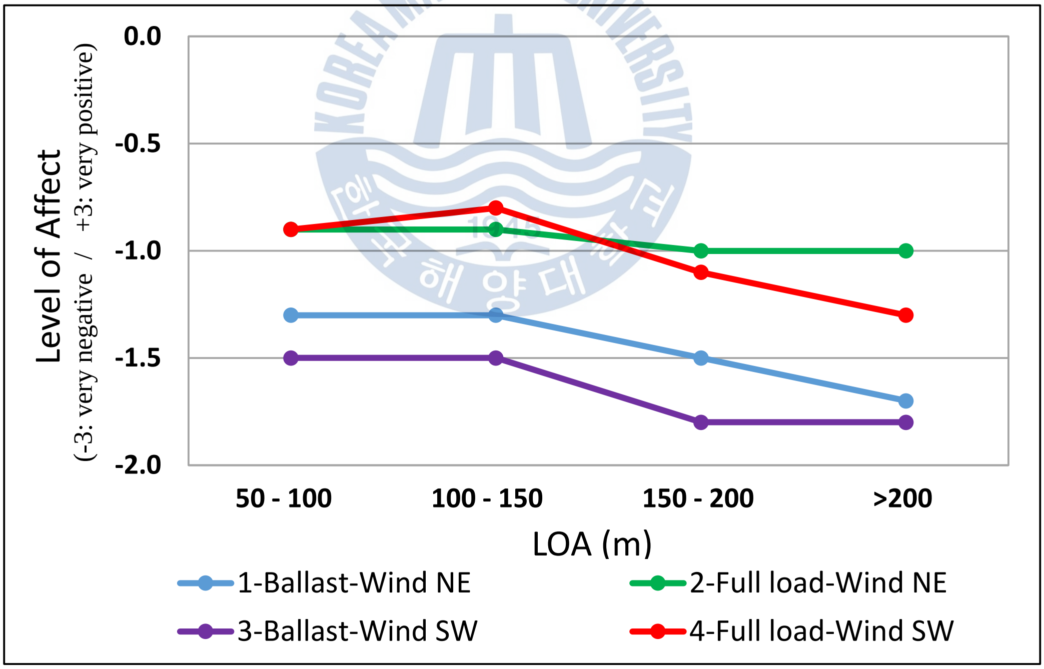


Figure 2.11 Affects of winds on ship-handling

In the case of vessels sailing with the current, their maneuvering ability is very little affected by the current, as in Figure 2.12. When the vessel sails against the current, then the drifting affect starts. With a ballast vessel this affect is almost the same for any size of vessel. But for full-load vessel this affect increases in proportion to the size of the vessel. When the LOA of a vessel is over 150 m, the current will cause strong drifting.

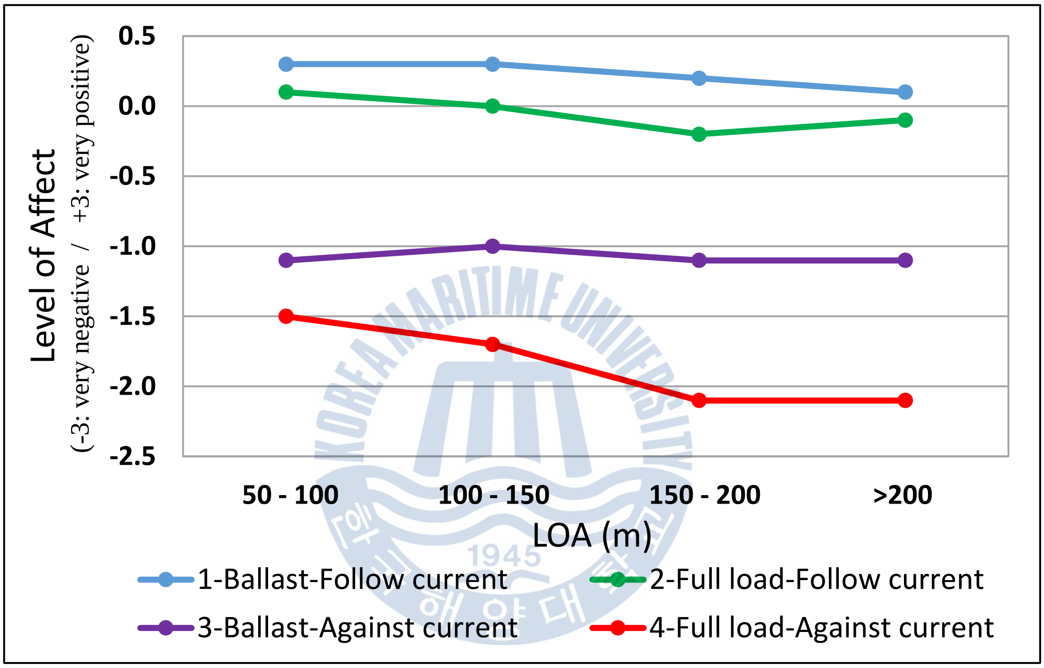


Figure 2.12 Affects of currents on ship-handling

Restricted visibility is one of the most important factors which affect ship-handling. Figure 2.13 shows that rain and fog have a negative affect. This affect increases with the size of the vessel. A small vessel (LOA from 50-100 m) has great trouble sighting nearby target vessels. A large vessel (LOA over 150 m) can sight nearby target vessels only by radar.

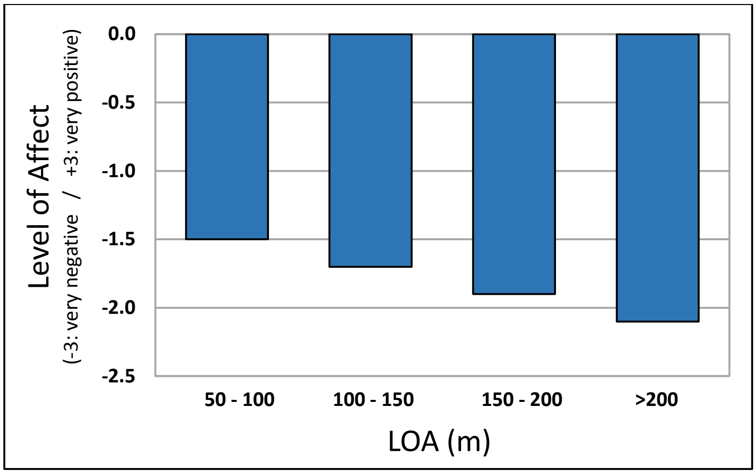


Figure 2.13 Affects of rain and fog on ship-handling

2.4 Traffic Survey in the Vung Tau Waterway

The traffic in the Vung Tau Waterway was surveyed based on the data which were collected from the following sources:

- Vietnam Maritime Administration
- Maritime Administration of Ho Chi Minh City
- Maritime Administration of Dong Nai
- Maritime Administration of Vung Tau
- VTS officers of the Vung Tau VTS Center
- Officers of the Border Guard Department
- Fishermen in Vung Tau City
- AIS data

2.4.1 The Remote Traffic Survey System

Among these data the AIS data is the most important because they give much information related to the traffic of ocean-going vessels, the main traffic in the area.

For the safe operation of the VTS system at the present time only experts from the manufacturer are allowed to access the hardware of the VTS system. Therefore, the remote survey method was applied in this study to obtain AIS data in the Vung Tau Waterway-Vietnam and send them to the Korea Maritime and Ocean University in Korea for analyzing.

Figure 2.14 shows the configuration of the remote traffic survey based on the AIS data.

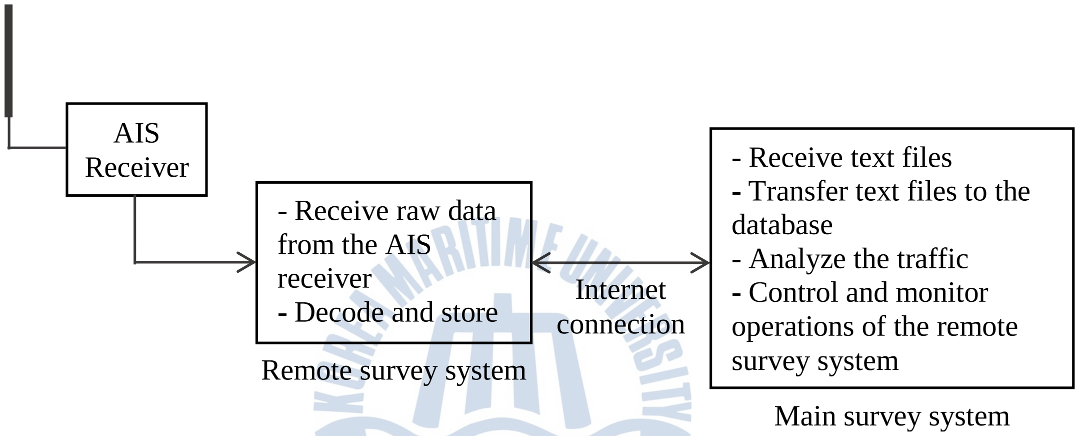


Figure 2.14 Configuration of the remote traffic survey based on the AIS data

In the remote survey system the following programs were installed:

– ShipPlotter Program, developed by Centro de Observação Astronómica no Algarve (COAA, 2013), for communicating with the AIS receiver, obtaining raw data, and then decoding and storing the data to text files. The static information of the vessel such as MMSI (Maritime Mobile Service Identification), ship's name, length, width, etc. are stored to one text file and named as shipinfo.txt. The dynamic and voyage information such as position, course, speed, draft, destination, etc. are stored to many files, one file for one day, and named as shipplotterYYMMDD.log (YYMMDD is an abbreviation of the date when the file is created).

- Teamviewer Program, developed by TeamViewer GmbH (Teamviewer, 2013), for connecting with the main survey system through an internet connection.

The main survey system is installed with the following programs:

- Teamviewer for connecting with the remote survey system through an internet connection. From the main survey system we can monitor, control, and obtain text files from the remote survey system by using this program
- TOAIS-1 for transferring the text files that are received from the remote survey system to the database file
- TOAIS-2 for analyzing the traffic based on the collected AIS data. This program is able to:
    - Plot vessels' tracks
    - Plot traffic density in the waterway
    - Identify traffic routes in the waterway based on the traffic density map
    - Analyze traffic at gates that are created by users to obtain the following information:
        - number of vessels passing the gate classified by size and type
        - calculation of average speed and draft of vessels classified by size and type when passing the gate
        - statistical data of passing vessels by date, time, type, and size
        - lateral distribution of traffic

Figures 2.15 to 2.18 are some pictures of the remote traffic survey which was implemented to survey traffic in the Vung Tau Waterway.

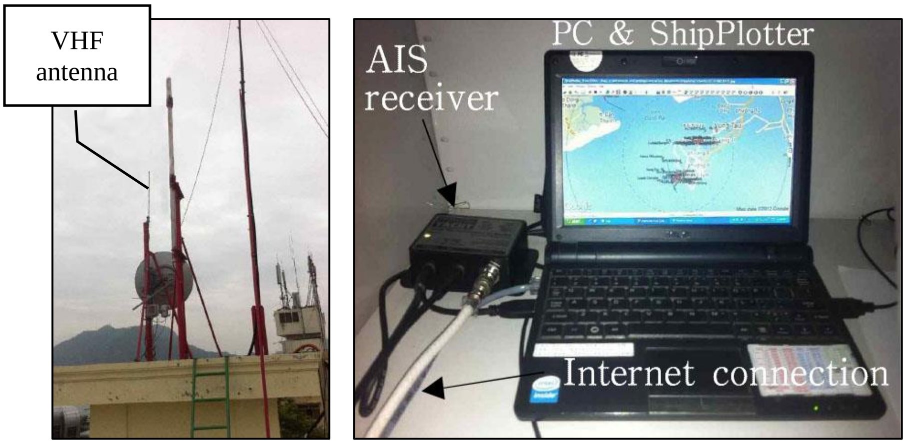


Figure 2.15 The AIS data acquisition system in the Vung Tau VTS Center

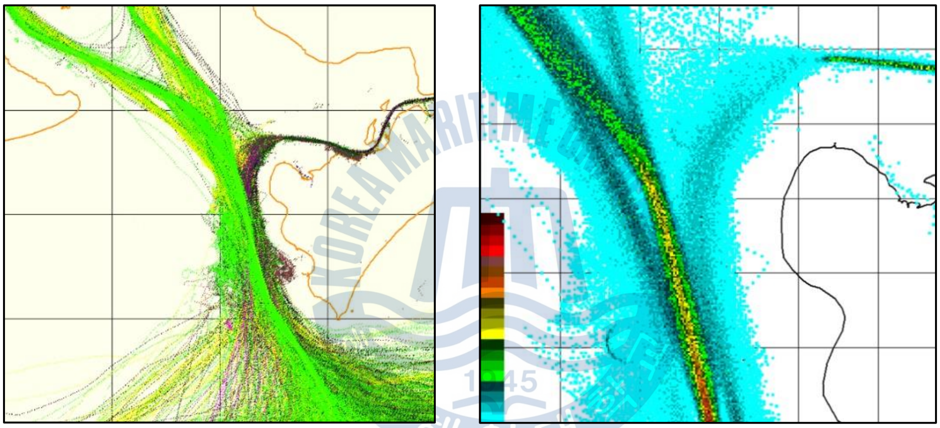


Figure 2.16 Screens of vessels' tracks and traffic density in the TOAIS-2

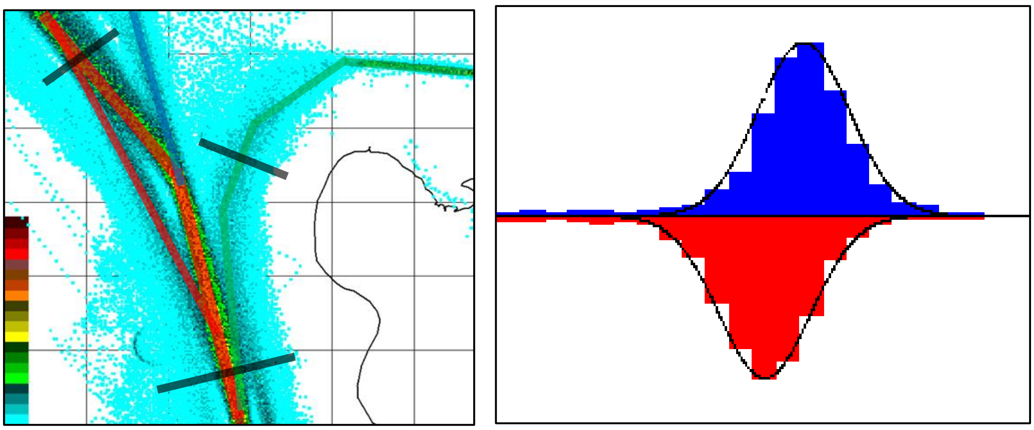
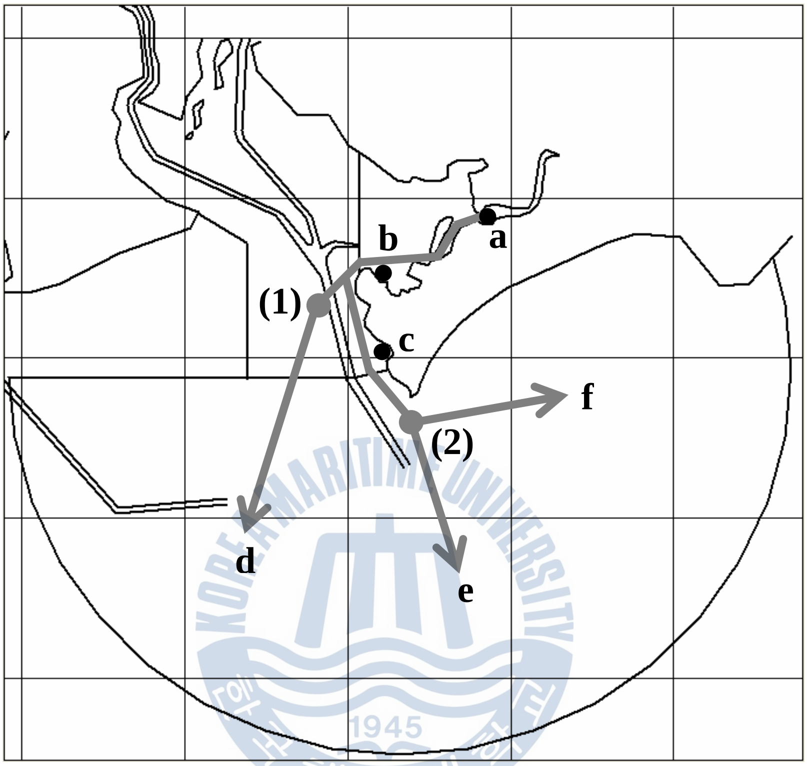


Figure 2.17 Screens of traffic routes, gates, and distribution in the TOAIS-2

2.4.2 Traffic of Off-shore Fishing Boats

Off-shore fishing boats often pass through the Vung Tau Waterway via the two routes, as shown in Figure 2.18.



Notes:

a: Cat Lo Fishing Port located in the Song Dinh Fairway

b: Sao Mai–Ben Dinh Fishing Port located in the Ben Dinh River

c: fishing boat anchorage located at Bai Truoc in Ba Ria-Vung Tau Province

d: to fishing grounds in Con Dao Island-Vietnam, Thailand, Malaysia, etc.

e: to fishing grounds in the Philippines, Indonesia, etc.

f: to fishing grounds in the middle part of Vietnam

Figure 2.18 Traffic of off-shore fishing boats

(1) Route 1: from (a), (b) vessels sail to point (1) at the position (10-22.5N, 107-22.5E) and alter their course to (d) for the fishing grounds. They sail on the opposite route on return.

(2) Route 2: from (a), (b), (c) vessels sail along the coast to point (2) and alter their course to (e) or (f) for the fishing grounds. They follow the same route on return.

Fishing boats usually operate on a monthly cycle. They depart from the 16th to the 19th every month and return between the 9th and the 13th of the next month, according to the lunar calendar. During this period there are about 300~500 crossings of fishing boats per day.

Figures 2.19, 2.20, and 2.21 show the Cat Lo and Sao Mai-Ben Dinh Fishing Ports and the fishing boat anchorage in the Ba Ria-Vung Tau Province

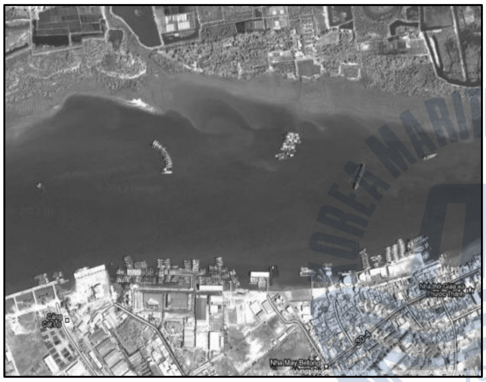


Figure 2.19 Cat Lo Port

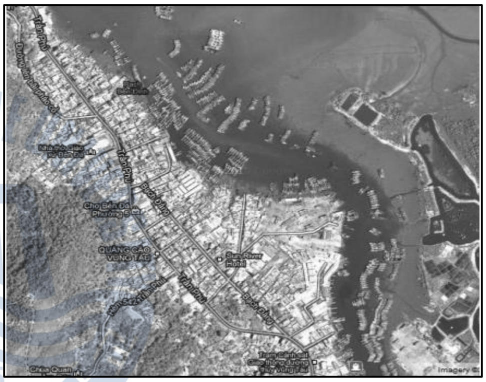


Figure 2.20 Sai Mai-Ben Dinh Port

Figure 2.21 Fishing boat anchorage
(views from satellite and from the Vung Tau Pilot Station)

2.4.3 Traffic of Fishing Boats that Operate inside the Vung Tau Waterway

There are some fishing activities that operate inside the Vung Tau Waterway, as follows:

(1) By using fishing nets tied to fixed pillars, as shown in Figure 2.22. These types of fishing activities have existed in the research area for many years, so their positions are well known

(2) By trawling and drift netting from Buoy No.3 to outside of the VTS area. Because trawling vessels move in the fairway with a very slow speed and the position of drift nettings changes day by day, they have a strong affect on maritime traffic safety in this area

Figure 2.22 Fish trapping in Vung Tau area

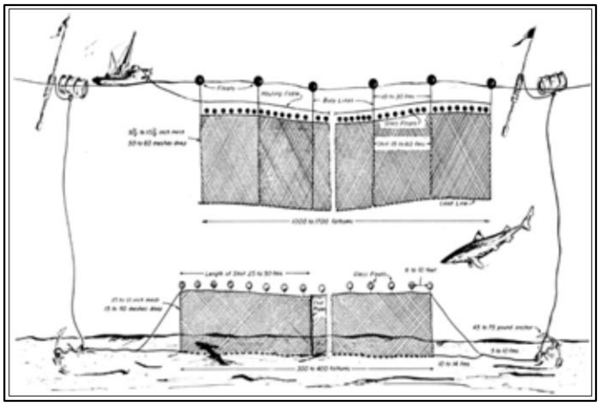


Figure 2.23 Drift netting

2.4.4 Traffic of Inland Waterway Vessels (vessels less than 300 GT, barges, wooden boats, etc.)

According to information from the Vung Tau VTS officers, the number of inland waterway vessels that pass the Vung Tau Waterway is small. Most of them are bunker barges, dredging barges, pilot boats, and small passenger boats, especially hydrofoil passenger vessels that operate between Ho Chi Minh City and Vung Tau City with a frequency of about forty passages per day.

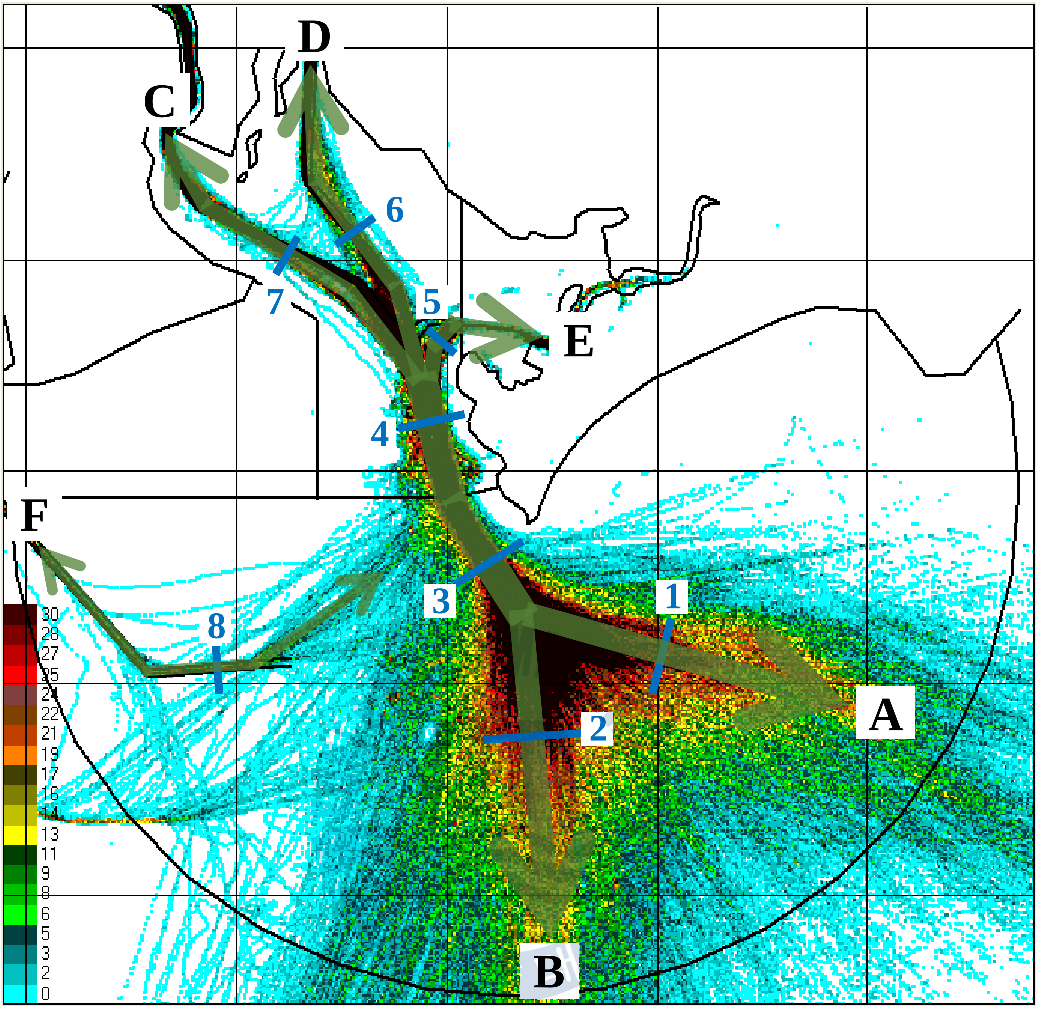
2.4.5 Traffic of Ocean-going Vessels (vessels which operate on domestic ocean routes, international ocean routes, supply base-offshore platform routes, etc.)

According to statistics of the Vietnam Maritime Administration (Vinamarine, 2012) most ocean-going vessels passing the Vung Tau Waterway are over 300 GT, so they are installed with AIS devices according to IMO requirements.

Figure 2.24 shows the traffic density of ocean-going vessels passing the area during three months from November 2012 to February 2013.

Based on this figure and information from the Maritime Administration of Vung Tau, ocean-going vessels usually pass this waterway through 6 main routes, as follows:

(1) Route 1: from A to C and back through the Sai Gon–Vung Tau Fairway
(2) Route 2: from B to C and back through the Sai Gon–Vung Tau Fairway
(3) Route 3: from A to D and back through the Thi Vai Fairway
(4) Route 4: from B to D and back through the Thi Vai Fairway
(5) Route 5: from A to E and back through the Song Dinh Fairway
(6) Route 6: from A and B to F and back through the Soai Rap Fairway (vessels have to move to Pilot Boarding Ground No.1 for embarking and de-embarking pilots)



Notes:

A: to ports located in the middle and northern parts of Vietnam, China, Hong Kong, Taiwan, Korea, Japan, America, etc.

B: to ports located in Thailand, Cambodia, Singapore, Malaysia, Indonesia, Australia, India, Middle East, and Europe, etc.

C: to ports located in Ho Chi Minh City and Dong Nai Province

D: to ports located in Dong Nai Province

E: to ports located in Ba Ria-Vung Tau Province along the Song Dinh Fairway

F: to ports located in Ho Chi Minh City

Figure 2.24 Traffic of ocean-going vessels

Figure 2.25 shows the frequency of crossings on the above routes from 2008 to 2012 based on statistical data of the three Maritime Administration Offices in the area: Ho Chi Minh City, Dong Nai, and Vung Tau. Because of the depth restriction, at present the number of crossings on the Sai Rap Fairway is very small (less than 5 crossings a day, based on AIS data). Therefore, traffic on this route is ignored.

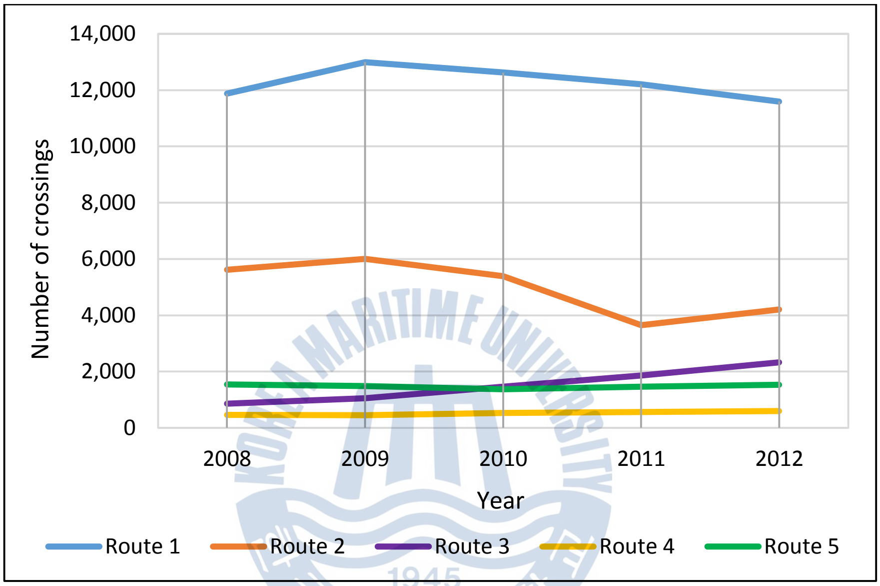


Figure 2.25 The number of crossings on routes in recent years

Figure 2.25 shows that the traffic volume of Route No.1 is the highest. There are about thirty eight in/out-bound crossings per day on average. From 2008 to 2012 traffic volume on Route No.3 increased about 130% per year. On average, there were about sixty vessels passing this area per day in 2012.

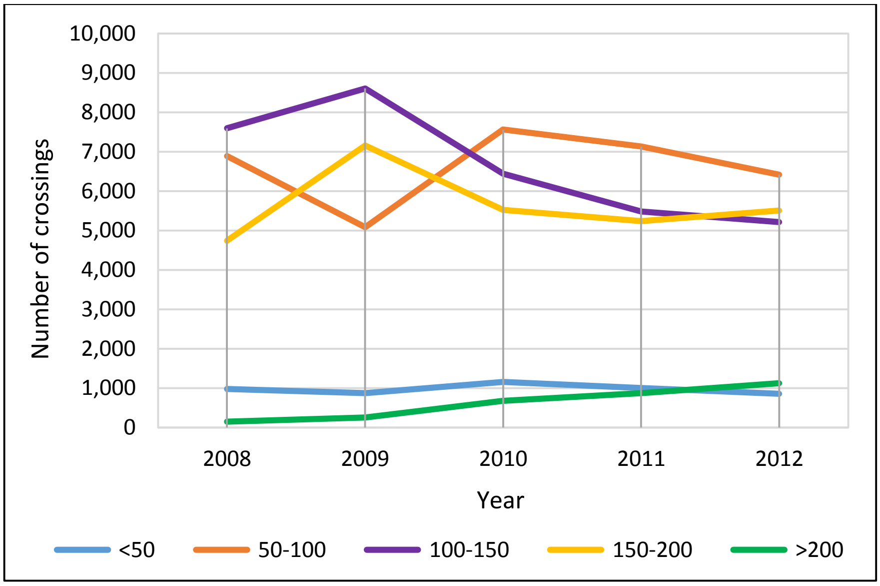


Figure 2.26 Statistics of crossings classified by LOA

Figure 2.26 shows that the size of vessels passing this area is increasing. The number of crossings by vessels that have an LOA under 150 m is decreasing, but the number of crossings of vessels with an LOA over 150 m is increasing because some deep-water container terminals along the Thi Vai river are on-going operation.

Figure 2.27 shows the lateral distribution of traffic at some gates along the three fairways, as shown in Figure 2.24.

It shows that at all gates traffic of in-bound and out-bound vessels is distributed almost entire the width of the fairways.

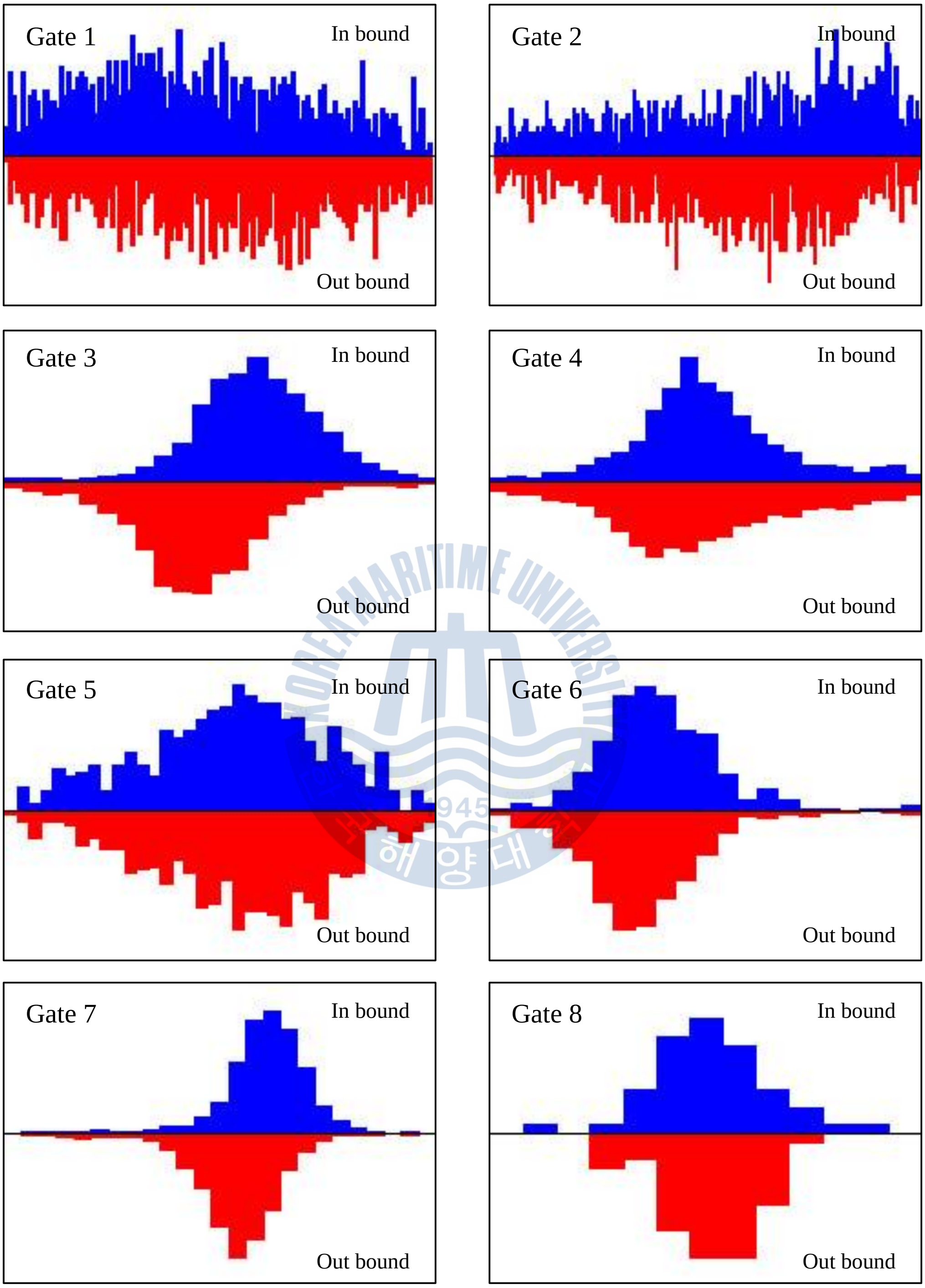


Figure 2.27 Lateral distribution of traffic at some gates

The following figures show distribution of vessel size, vessel type, and passing time at Gate No.4. It consists of traffic in all three main fairways in the area.

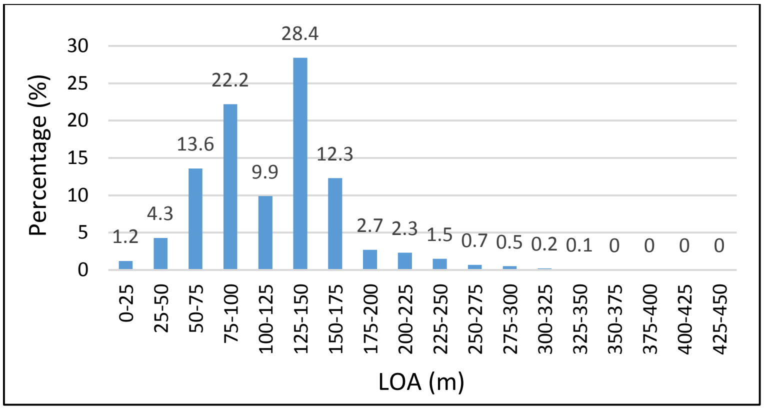


Figure 2.28 Distribution of vessels' length at Gate No.4

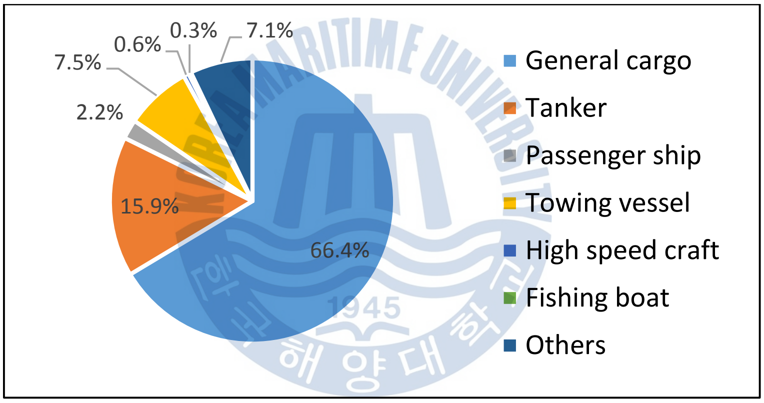


Figure 2.29 Distribution of vessels' types at Gate No.4

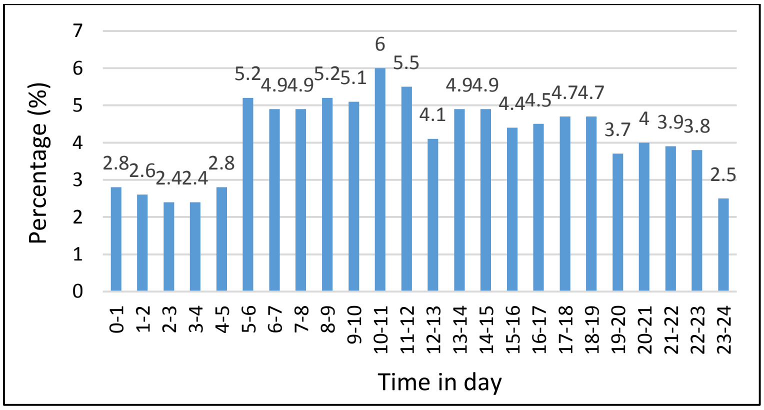


Figure 2.30 Distribution of passing time at Gate No.4

2.5 Traffic Safety Assessment in the Vung Tau Waterway using the IWRAP (IALA Waterway Risk Assessment Program) Model

In order to understand the traffic in the Vung Tau Waterway, this dissertation did an assessment of traffic safety in the waterway by using the IWRAP Mk2 program, which applies the IWARP model, based on the AIS data gathered during the three-month period from November 2012 to February 2013.

2.5.1 Introduction to the IWRAP Model

The IWRAP Mk2 program (IALA, 2012) was developed by the Canadian Coast Guard, the Technical University of Denmark, and the Maritime Simulator Center Warnemende. It was based on the IWRAP model.

In the IWRAP model the frequency of accidents in a waterway can be calculated by a basic formula as follows:

$$\lambda = NG \times P \qquad (2)$$

here:

- λ : frequency of collisions or grounding accidents
- NG : geometric number of potential collisions or groundings
- P : causation factor

For calculating the NG value, the IWRAP model divides collisions and groundings accidents into the following types:

Table 2.9 Collision/grounding types in the IWRAP model

Collisions	Head-on and Overtaking collisions
	Crossing collisions
	Area collisions
Groundings	Powered groundings
	Drifting groundings

By dividing to subtypes, the NG value of a subtype can be calculated based on the specific scenario of each one. Figure 2.31 shows an example scenario of a head-on collision type:

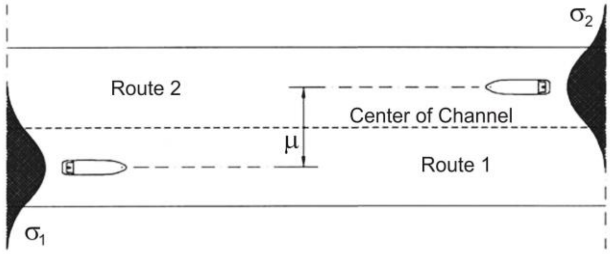


Figure 2.31 A scenario of head-on collision

For calculating causation factor (causation possibility), a causation possibility model was used. The IWRAP Mk2 program proposed applying the Bayesian Networks model. The IWRAP Mk2 program uses the default caution probability value as in Table 2.10 (IWRAP, 2012b).

Table 2.10 Default causation factor of the IWRAP Mk2 program

Condition	**Causation factor**
Head-on collisions	0.5×10^{-4}
Overtaking collisions	1.1×10^{-4}
Crossing collisions	1.3×10^{-4}
Collisions in bend	1.3×10^{-4}
Collisions in merging	1.3×10^{-4}
Grounding-forget to turn	1.6×10^{-4}

2.5.2 Marine Traffic Safety Assessment using the IWRAP Model

According to Item 2.4, there are four types of marine traffic in the Vung Tau Waterway: traffic of off-shore fishing boats; traffic of fishing boats that operate inside the Vung Tau Waterway; traffic of inland waterway vessels; and traffic of ocean-going vessels. However, the traffic of inland waterway vessels is mostly pilot boats, small passenger boats, bunker barges and hydrofoil passenger vessels. It has a small affect on marine traffic safety in the area, especially on ocean-going vessels, so this type of traffic is ignored in this assessment.

In addition, as presented in Item 2.4, the traffic in the Soai Rap Fairway is very light, so it is also ignored.

Based on Item 2.4, the traffic of the off-shore fishing boats and fishing boats that operate inside the Vung Tau Waterway do not follow any traffic route. So that in the IWRAP Mk2 program their traffic is represented as traffic areas, as shown in Figure 2.32.

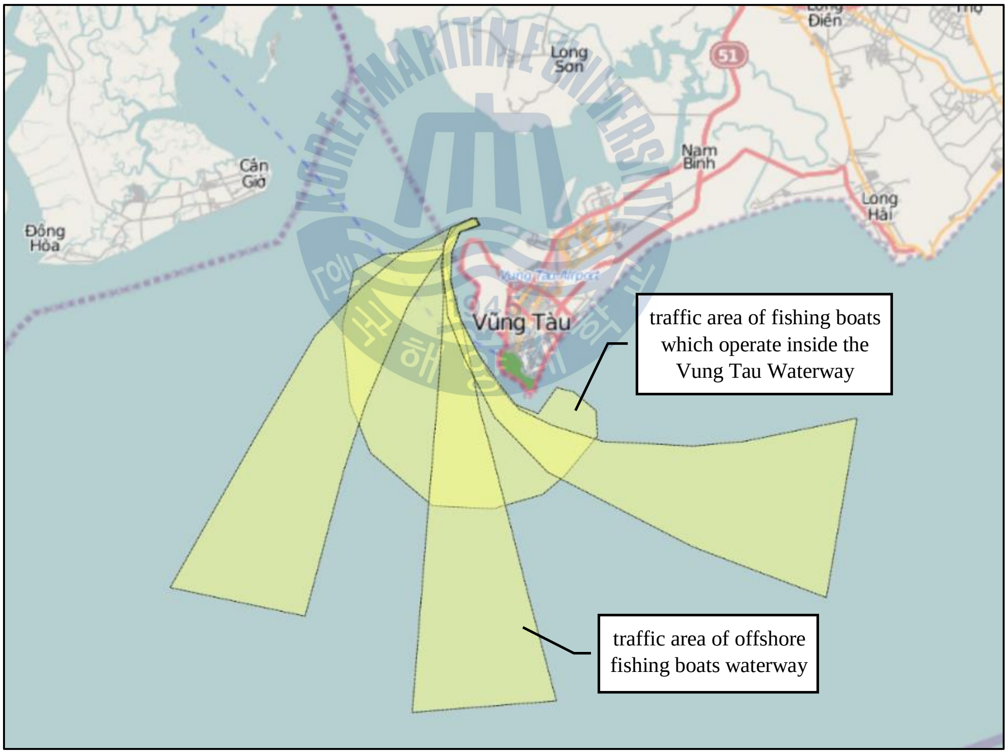


Figure 2.32 Representation of fishing boats traffic in the Vung Tau Waterway by the IWRAP Mk2 program

Also based on the traffic survey results as presented in Item 2.4, ocean-going vessels traffic in the Vung Tau Waterway is represented in the IWRAP Mk2, as in Figure 2.33.

The lateral distribution of traffic, ship types, ship size, and speed at each gate is calculated by using the TOAIS-2 program (a dedicated program) based on the AIS data for ninety days.

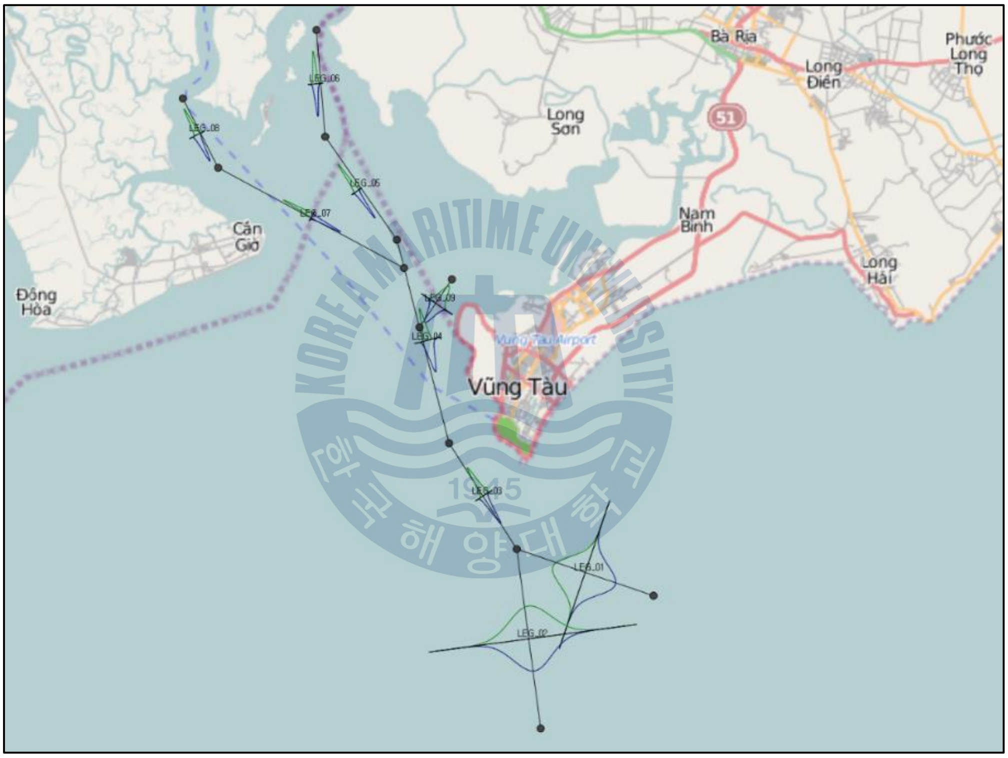


Figure 2.33 A representation of ocean-going vessels traffic in the Vung Tau Waterway by the IWRAP Mk2 program

The following figure and table show assessment results of marine traffic safety in the Vung Tau Waterway by using the IWRAP Mk2 program

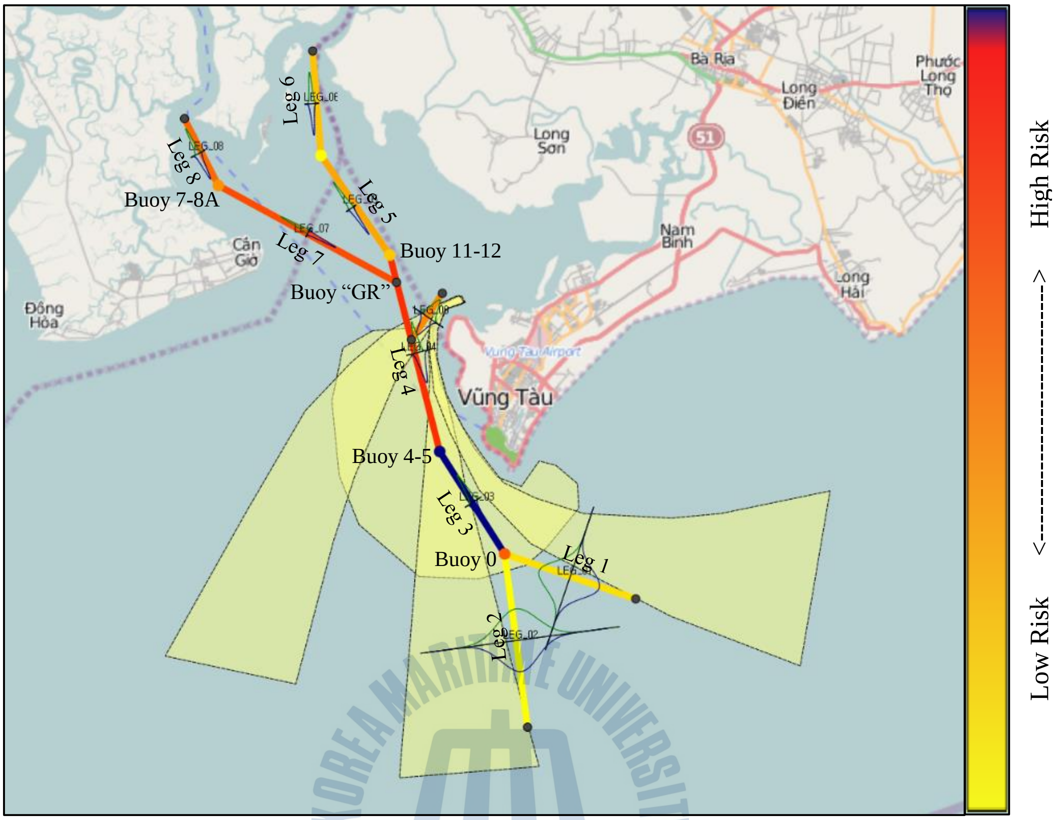


Figure 2.34 Risk assessment results using the IWRAP Mk2 program

Table 2.11 Frequency of collision accidents in the waterway according to the assessment of the IWRAP Mk2 program

	Waterway no de	Unit
Powered Grounding	---	Years between incidents
Drifting Grounding	---	Years between incidents
Total Groundings	---	Years between incidents
Overtaking	36,33	Years between incidents
HeadOn	7,25	Years between incidents
Crossing	201,6	Years between incidents
Merging	148,2	Years between incidents
Bend	17,77	Years between incidents
Area	97,46	Years between incidents
Total Collisions	4,103	Years between incidents

The assessment results in Figure 2.34 show that the risk of collision accidents in the Sai Gon-Vung Tau Fairway from Buoy No.0 to Buoys No.4-5 is the highest in the waterway. Following are parts of the Sai Gon-Vung Tau Fairway from Buoys No.4-5 to Buoys No.11-12 and from Buoy “GR” to Buoys No.7-8A.

The following section will compare traffic safety assessment results in the Vung Tau Waterway with the Busan and the Straits of Malacca waterways.

Figures 2.35 and 2.36 show assessment results in the Busan and the Straits of Malacca waterways by using the IWRAP Mk2 program.

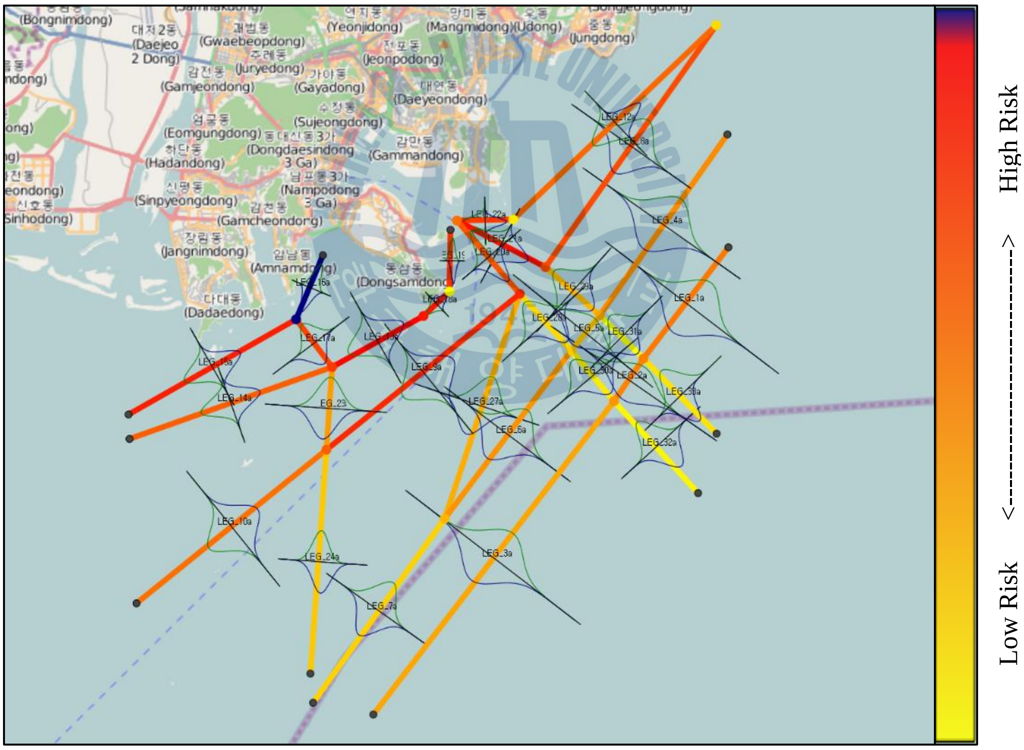


Figure 2.35 Risk assessment results in the Busan waterway

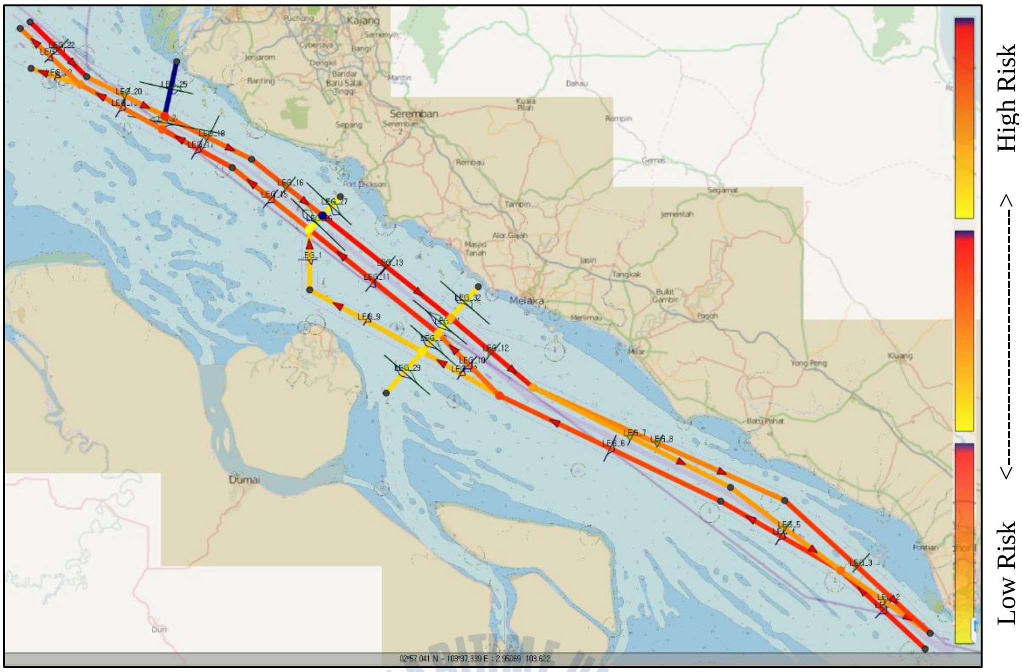


Figure 2.36 Risk assessment results in the Straits of Malacca

Table 2.12 shows a detailed comparison of the risks of collision in the Vung Tau Waterway with the Busan and the Straits of Malacca waterways, based on assessment by using the IWRAP model.

Table 2.12 Comparison of collision risks in the Vung Tau Waterway and other waterways by using the IWRAP model

Collision Types	**Frequency of accidents in a years in …**		
	Vung Tau (in 2013)	**Busan** (in 2013)	**Malacca** (in 2012)
Overtaking	0.027525	0.036805	0.187196
Head-On	0.137931	0.060976	0.006329
Crossing	0.004960	0.054585	0.058754
Merging	0.006748	0.042863	0.020563
Bend	0.056275	0.066800	0.015211

Collision Types	**Frequency of accidents in a years in …**		
	Vung Tau (in 2013)	**Busan** (in 2013)	**Malacca** (in 2012)
Area	0.010261	0.000000	0.000000
Total (A)	0.243700	0.262029	0.288053
Vessels/hour (B)	2.50	6.60	8.30
A / B	**9.75**	**3.97**	**3.47**

Table 2.12 shows that the number of collision accidents which might happen in a year in the Vung Tau Waterway is the smallest compared with the Busan and the Straits of Malacca waterways. However, when considering the number of passing vessels, it shows that collision risks in the Vung Tau Waterway is about three times higher than those of the Busan and the Straits of Malacca waterways.

Table 2.12 also shows that the risk of head-on collisions in the Vung Tau Waterway is clearly higher than in the Busan and the Straits of Malacca waterways. Head-on collisions risks are the main problem here.

This is the main part that makes risk of collision in the Vung Tau Waterway become high.

2.6 Traffic Management

The Maritime Administration of Vung Tau (Vung Tau Port Control) is the government agency responsible for the management of all marine traffic in the Vung Tau Waterway. However, before the Vung Tau VTS Center was in operation (April 3, 2013), it was not effective in traffic management in the waterway. The traffic monitoring function was almost unable to be carried out.

Currently, the management of safe navigation in the area is carried out by a combination of the Vung Tau Port Control, the Vung Tau VTS Center, and the pilot companies.

In this dissertation the organization and operation of the Vung Tau VTS Center will be presented in the following section.

2.6.1 The Sai Gon–Vung Tau VTS System

The Sai Gon–Vung Tau VTS System was installed at the end of 2011, went into trial operation from May 19, 2012 (VMS South, 2012), and went into official operation from April 3, 2013.

Its functions are monitoring and supporting marine traffic in the whole of the Sai Gon–Vung Tau Fairway, a part of the Vung Tau–Thi Vai Fairway, a part of the Song Dinh Fairway, and a part of the Soai Rap Fairway.

Its system is the V3000 VTS system from the Holland Institute of Traffic Technology B.V. (HITT) Company. The system consists of three radar stations, one AIS station, four CCTV stations, and two VTS centers, as shown in Figure 2.37.

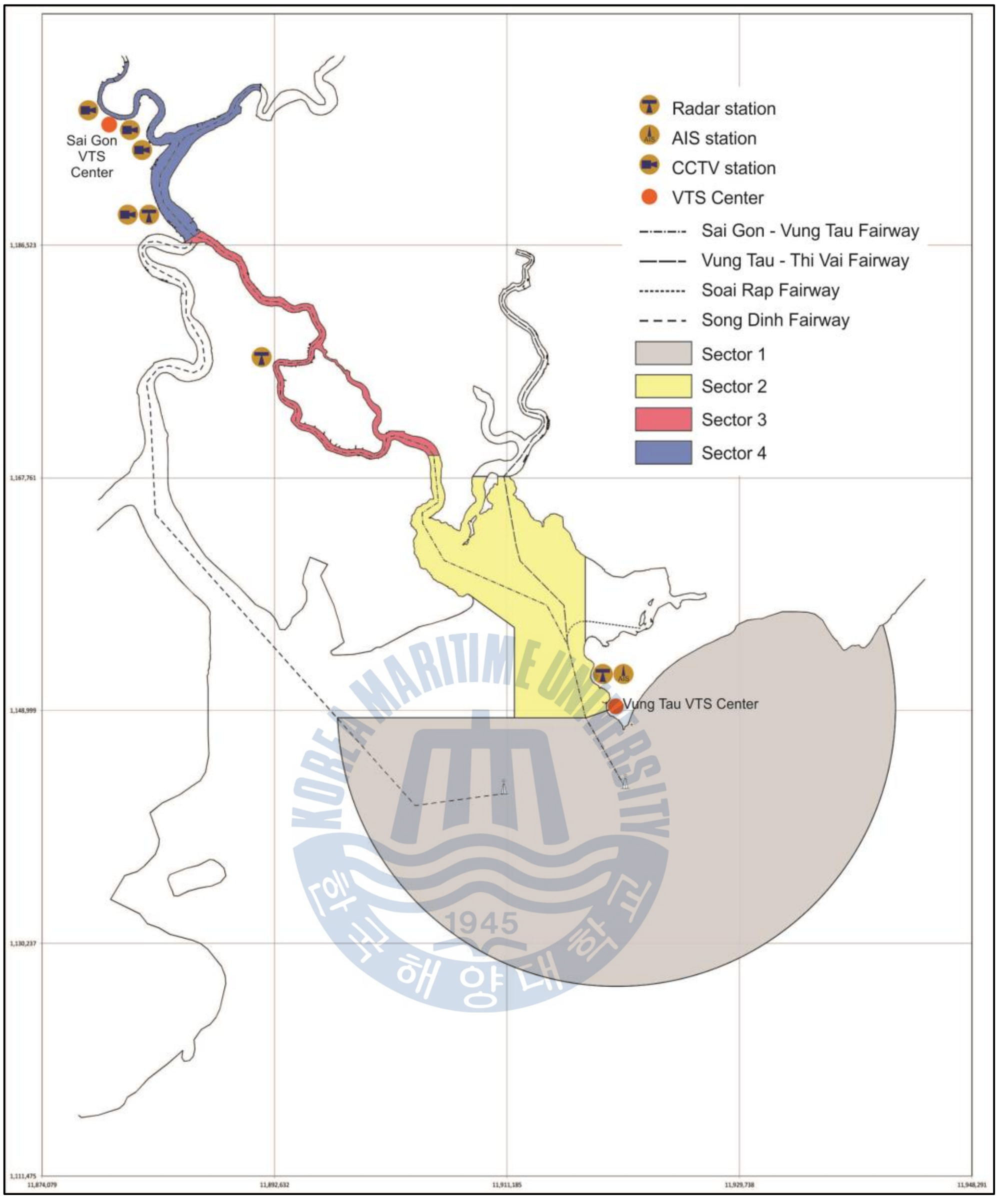


Figure 2.37 The system configuration of the Sai Gon–Vung Tau VTS system

The Sai Gon–Vung Tau VTS system is managed by the Maritime Administration of Ho Chi Minh City.

Figure 2.38 shows the organization of the Maritime Administration of Ho Chi Minh City

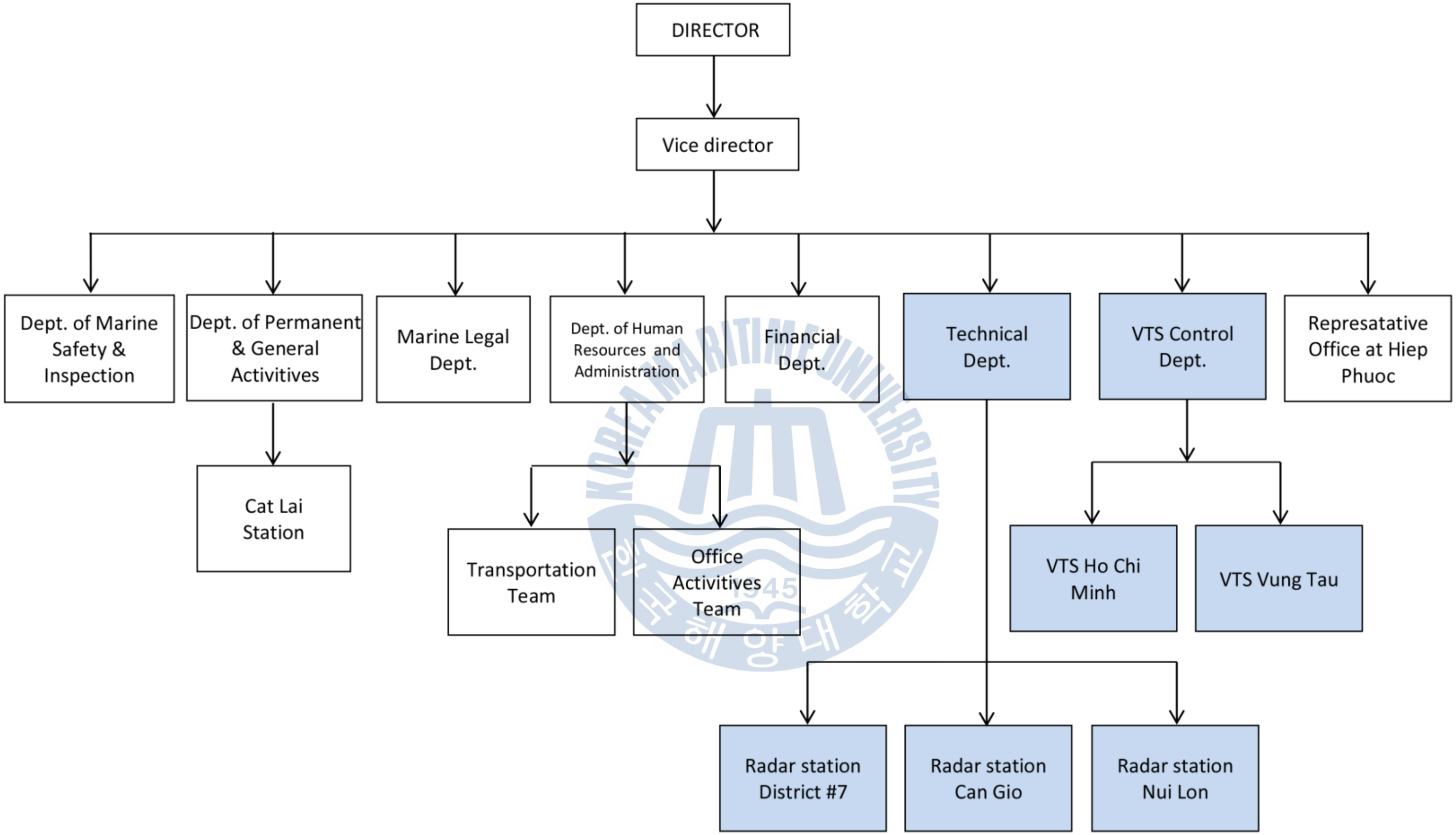


Figure 2.38 The organization of the Maritime Administration of Ho Chi Minh City

Table 2.13 shows some information related to personnel resources of the Sai Gon–Vung Tau VTS System

Table 2.13 The Sai Gon–Vung Tau VTS System personnel resources

Position	**Number**	**Sea experience (years)**	**Working experience in the VTS Center (years)**	**English skills**
Director	1	10	1.5	Good
Vice-Director	1	5	1.5	Good
Officer	10	2	0.8	Good
Supervisor	7	3	1.0	Good
Consultant	3	20	0.8	Good

2.6.2 The Vung Tau VTS Center

Figure 2.39 shows the organization of the Vung Tau VTS Center

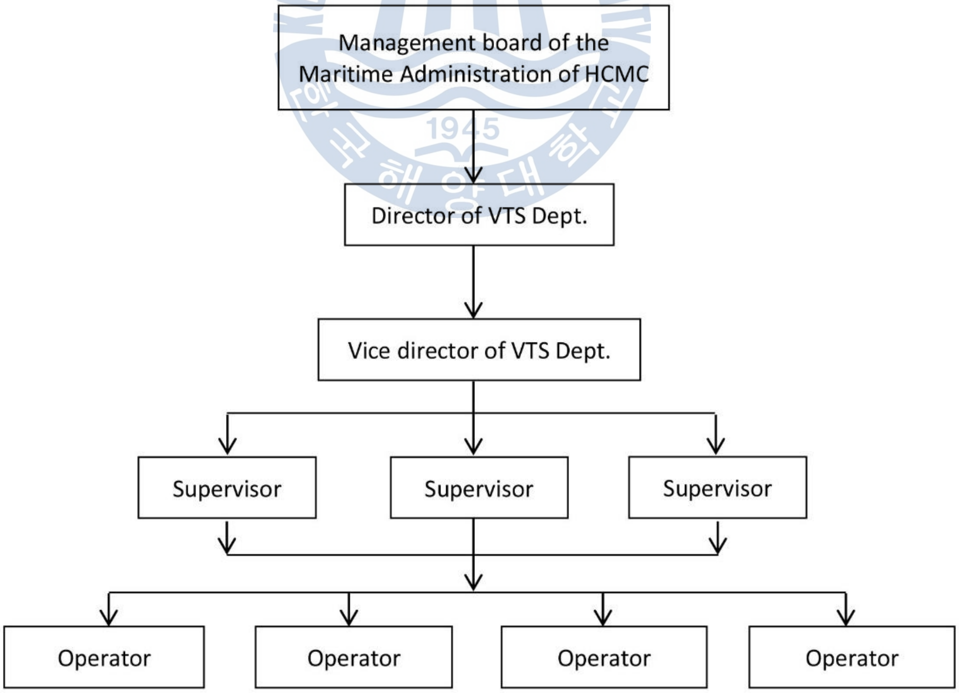


Figure 2.39 The organization of the Sai Gon–Vung Tau VTS Center

Figure 2.40 shows an outside view of the Vung Tau VTS Center

Figure 2.40 Outside view of the Vung Tau VTS Center

Seven officers, five supervisors, and one consultant work in this VTS Center. However, they frequently rotate between the Sai Gon VTS Center and the Vung Tau VTS Center. The organization of a watch is shown in Table 2.14.

Table 2.14 Organization of watches in the Vung Tau VTS Center

Watch	Officer	Supervisor	Consultant
07:00 ~ 15:00	2	1	1
15:00 ~ 22:00	2	1	by telephone
22:00 ~ 07:00	2	1	by telephone

Figure 2.41 shows the configuration of the VTS operations room

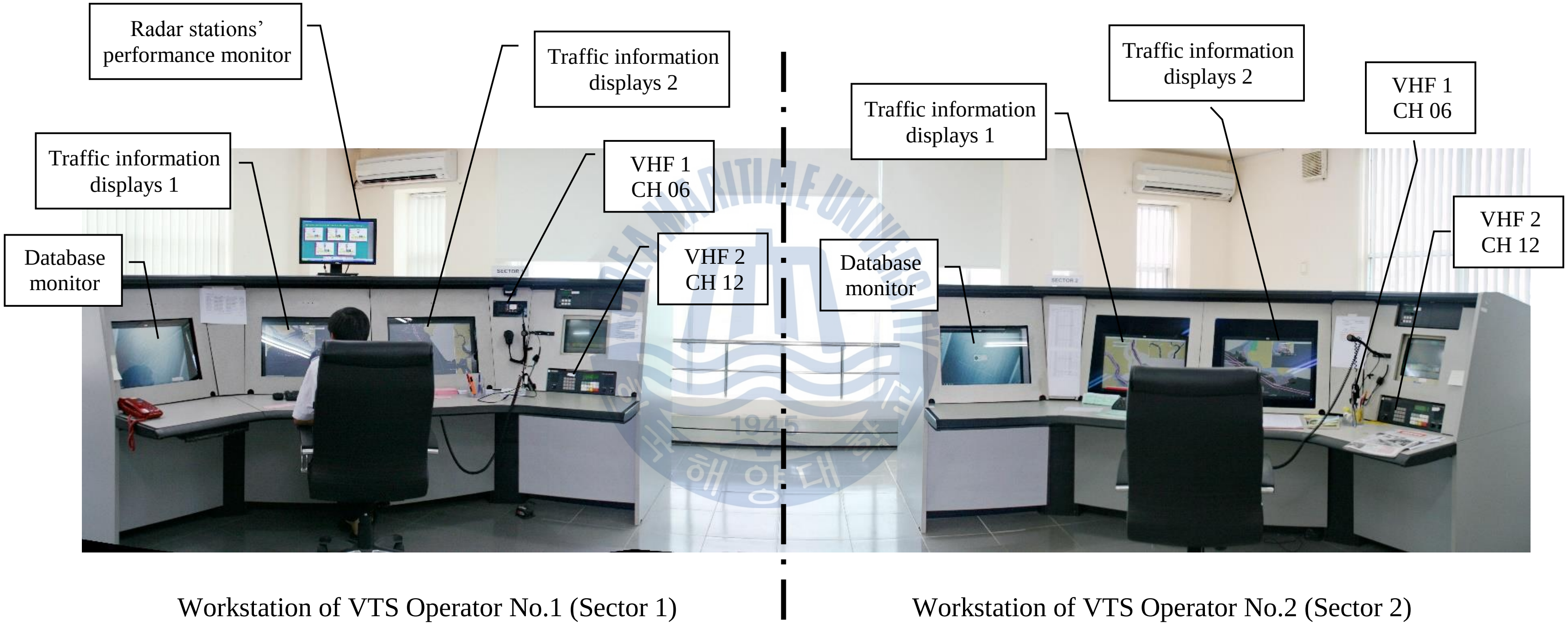


Figure 2.41 Configuration of the VTS operations room in the Vung Tau VTS Center

2.7 Results and Discussion

A study on marine environment factors and their affects on ships has shown that:

(1) A strong wind (wind force is more than five) has a negative affect on vessels, for example, drifting. However, the maximum possibility of wind force more than four is only about 7%. This means most of the time the wind force is so low that it has no negative affect on vessels

(2) Just like with the wind, strong currents in the Vung Tau area can also cause vessels to drift. Currents in the Vung Tau area are mostly tidal streams so they have some of following features:

    a. The direction of the current is mostly along with the fairway
    b. Speed of both of the current along the fairways and the lateral current (from west to east, in area from Buoy No.1 to Buoy No.5) depends on time of day
    c. The current's speed decreases when it is far from the mouth of the river. Around Buoy No.14 it can reach to 4.0 knots, but at Buoy No. 0 it decreases to less than 2.0 knots

    For the above reasons vessels usually pass this area at a suitable time to minimize negative affects of currents. In other words, it could be said that currents have only a small negative affect on vessels

(3) Rain and fog have almost no negative affect on vessels because there are only 10-12 foggy days in a year and rain usually lasts for only 1 or 2 hours

(4) The width of the fairway is safe for two-way traffic

(5) The depth of the fairway in some areas could cause some problems for deep-draft vessels. But by lightening or taking advantage of the tide this problem will be minimized

As seen from the five results above, **it could be said that the marine environment factors in the Vung Tau Waterway have only small affects on traffic safety in the waterway**.

The traffic survey results show that:

(1) At all gates traffic of in-bound and out-bound vessels are distributed almost entire the width of the fairways although the widths of the fairways are wide enough for two-way channel, as shown in Item 2.2.5.

(2) Off-shore fishing boat traffic crosses the ocean-going vessels' lanes. Some days in a month the fishing boats cross the fairway of ocean-going vessels a hundred times

(3) In the inner waterway there are some fishing activities which cause many space restrictions on ocean-going vessels

These above results show the marine traffic in the Vung Tau Waterway has "dis-order" characteristics.

The assessment results by using the IWRAP model show that the risks of head-on collsion in the waterway is the highest among all the collision types.

Because of the two above, it shows that **the "dis-order" problem is the main factor that affects traffic safety in the Vung Tau Waterway.**

To improve traffic safety in the Vung Tau Waterway, the traffic should be well organized and/or managed. There are some solutions to solve this problem, such as issuing new regulations, increasing amount of penalties, etc. However, improving efficiency of the Vung Tau VTS Center is the solution that we should consider first. Because two of the VTS's main functions are navigation supporting and traffic organization, if the efficiency of the Vung Tau VTS Center is improved, the "dis-order" movement of vessels will be reduced.

The survey results in the Vung Tau VTS Center show that:

(1) The Vung Tau VTS System has very good hardware, a modern system from a world-famous company

(2) Most VTS officers there have limited sea experience (about 2 years) and limited VTS officer experience (less than 1 year)

Because of the lack of sea and working experience, VTS officers there have difficulties in assessing collision risks of a vessel, so their work efficiency is limited. This causes the efficiency of the Vung Tau VTS Center to be limited, although its hardware is very good.

For the above reasons, **it is necessary to have a supporting system for improving VTS officers' competency, so that they can assess collision risks better. With such a system the efficiency of the Vung Tau VTS Center will be improved.**

In addition, the supporting system should have other functions which the VTS officers also need, such as: alert vessels that run a risk of collision, running aground, or sailing off-route or over-speed.

To be able to develop the supporting system as mentioned above, the first and most important matter is to select the most appropriate assessment model for the system. This will be discussed in the next chapter.

Chapter 3. Analysis of Maritime Traffic Safety Assessment Models

3.1 General

Table 3.1 shows several traffic safety assessment models and their features (Kim Dae Won, 2011). The first model, the IWRAP model, has been developed to provide a standardized method of assessing the risks within most waterways. The outputs from IWRAP can be used to assess the risk in each section of a waterway and, in turn, to determine the degree of risk to navigation throughout the entire waterway. The model also allows different scenarios to be developed, so that proposed changes to a section of a waterway may be tested and analyzed before their implementation.

Table 3.1 Features of some popular maritime traffic safety assessment models

Assessment Models	**Features**
IWRAP (IALA Waterway Risk Assessment Program)	– Recommended by IALA (quantitative model) – Calculating collision & grounding probabilities based on traffic volume/track data – Theoretical explanation of the calculation process is limited – Difficult to apply in areas which have complicated traffic tracks
PAWSA (Ports and Waterways Safety Assessment)	– Recommended by IALA (qualitative model) – Assessment by group of experts – Highly dependent on group members

Assessment Models	Features
ES (Environment Stress)	– The most used model in marine traffic safety in Korea, Japan, and Turkey – Calculates maneuvering difficulties imposed by surrounding environments – Quantity subjective factor of the mariner's stress – Risk criteria which are applied are the same for inner and outer harbors
PARK (Potential Assessment of Risk)	– Developed in Korea in 2010 – Assessment risk of collisions between own ship and a target ship considering the affects of many factors such as type, size, crossing situation, speed, distance, inner/outer harbor and competency of officers – Good for applying in waterways which have complex traffic – Land affect does not clearly impose on risk value
FSA (Formal Safety Assessment)	– Official safety assessment by IMO – Various models were developed based on this model, such as MARA, PMSC, etc. – Could be influenced by the assessor's opinion
US (Unsafe Ship handling)	– Assessment by stopping distance – Ship-handling simulation is the precondition – Cannot be applied in complex traffic conditions

Assessment Models	Features
Others	– Assessment by vessel encountering frequencies – Assessment by give-away action frequencies – Assessment by complexity of traffic routes – SJ Model (Mariner's subjective awareness) – BC Model (Collision awareness) – Assessment models used in road traffic engineering

Each model has advantages and certain limits, so research and experimenting must be done to learn an appropriate model for the waterways

The RTSS proposes to provide VTS officers with risks of collision of vessels in quantitative terms in real-time, so that the assessment models which use statistical methods are not able to be used for developing the system.

Also, the RTSS requires an assessment model which is similar to the comprehensive risk analysis method. Among the above models, the ES model and the PARK models are the two models which use this method. So these two models will be studied in detail to select an appropriate model for the Vung Tau Waterway.

The following section will discuss the ES model and the PARK model in detail.

3.2 The Environment Stress Model (ES Model)

The ES model was developed in Japanese for risk assessment in waterways. It expresses in quantitative terms the degree of stress imposed on a ship-handler by topography and traffic environments (Inoue Kinzo, 2000). This model is used in marine traffic assessment by the Maritime Safety Audit in Korea.

The calculation of the stress value in the ES model includes the following three parts:

(1) Evaluation of ship-handling difficulty arising from restrictions of the water area available for maneuvering. A quantitative index expressing the degree of stress on ship-handlers by topographical restrictions (ESL value, ES value for Land) is calculated on the basis of the TTC (Time to Collision) with any obstacles

(2) Evaluation of ship-handling difficulty arising from restrictions on the freedom to make collision avoidance maneuvers. A quantitative index expressing the degree of stress on ship-handlers by traffic congestion (ESS value, ES value for Ship) is calculated on the basis of the TTC with ships

(3) Evaluation of ship-handling difficulty caused by both topography and traffic environments, in which the stress value (ESA value, ES value for Aggregation) is derived by superimposing the ESL value and the ESS value in the same course

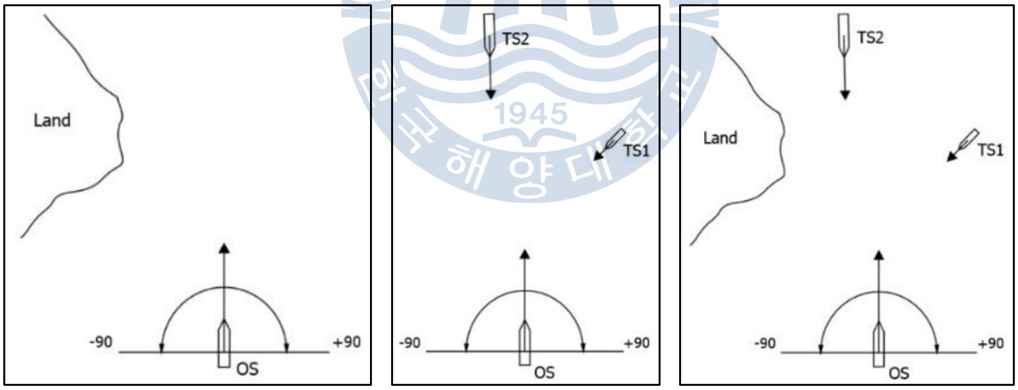


Figure 3.1 Stress to ship-handler caused by land (topography), ships (traffic environments) and an aggregation of the two.

The degree of stress can be classified according to the extent to which a dangerous situation causes a particular SJ (Subjective Judgment) value in the range of ±90°.

Table 3.2 shows the stress ranking in the ES model set up by classifying the range of stress from 0 to 1000

Table 3.2 Stress ranking in the ES model

SJ	MARINERS' JUDGMENT	ES value $\Sigma(SJ)_i$	STRESS RANKING	ACCEPTANCE CRITERIA
0	Extremely safe	0	NEGLIGIBLE	ACCEPTABLE
1	Fairly safe			
2	Somewhat safe			
3	Neither safe nor dangerous	500	MARGINAL	
4	Somewhat dangerous	750	CRITICAL	UNACCEPTABLE
5	Fairly dangerous	900	CATASTROPHIC	
6	Extremely dangerous	1000		

3.3 The Potential Assessment of Risk Model (PARK Model)

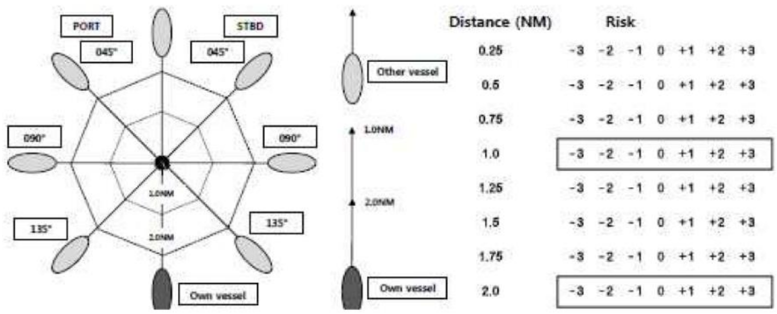
In order to develop a marine traffic safety assessment model in accordance with the characteristics of Korean coastal areas as well as Korean seamen, the Korean research team studied the elements related to the marine traffic safety of ships in Korea. Then questionnaires were constructed and a survey was conducted of Korean crews. The collected data was then analyzed to build the model.

After the study the research team divided elements that could affect the traffic safety of a ship into two groups:

Internal elements: (a) characteristics of the vessel such as type, size, tonnage; (b) competency of crews, especially of the officer of watch, etc.

External elements: (a) the position correlation between own ship (OS) and target ships (TS) such as distance, approaching side, crossing situation (overtake, ahead, crossing); (b) speed correlation such as faster than/equal/ slower; (c) topographic correlation such as inside/outside confined waters, etc.

The questionnaire was constructed as shown in Figures 3.2 and 3.3.



Source: Kim Jong Sung et al., 2011

Figure 3.2 A question related to crossing situations

Source: Heo Tae Young et al., 2012

Figure 3.3 A question related to the distance correlation

By performing an analysis of variances and multiple comparison of the survey results obtained, the elements which affect the safe navigation of ships are shown in Table 3.3.

Table 3.3 Elements which affect the marine traffic safety of a ship

Internal elements	**External elements**
1. Type of ship	8. Crossing situation
2. Tonnages	9. Approaching side
3. Length	10. Inside/outside harbor
4. Width	11. Speed correlation
5. Career	12. Speed difference
6. License	13. Distance
7. Position	

By regression analysis of the above elements, the impact of each element was determined, as shown in Table 3.4. The risk of marine traffic safety of own ship in correlation with a target ship is quantified by the "Risk" value that is calculated by the following formula.

$$\begin{aligned} \text{Risk value} = \; & 5.081905 + \text{type factor} + \text{ton factor} + \text{length factor} \\ & + \text{width factor} + \text{career factor} + \text{license factor} \\ & + \text{position factor} + 0.002517 \times \text{LOA} + \text{crossing factor} \\ & + \text{side factor} + \text{in/out harbor factor} + \text{speed factor} \\ & - 0.004930 \times \text{speed difference} - 0.430710 \times \text{distance} \end{aligned} \quad (3)$$

Table 3.4 Value of factors which indicate the impact of each element on the marine traffic safety of a ship

Ton factor

not more than 500 ton	0.634656
500-1,000 ton	-0.229980
1,000-3,000 ton	2.180813
3,000-5,000 ton	-0.093240
5,000-7,000 ton	-0.345600
7,000-10,000 ton	-0.765630
10,000-15,000 ton	-0.126220
15,000-20,000 ton	-0.131530
20,000-25,000 ton	0.217815
25,000-30,000 ton	-0.145350
30,000-50,000 ton	-0.656140
50,000-60,000 ton	0.063690
60,000-75,000 ton	-0.381260
75,000-100,000 ton	0.313252
more than 100,000 ton	0.000000

Career factor

not more than 1 year	-0.104830
1-3 years	-0.332360
3-5 years	-0.064230
more than 5 years	-0.136730

Crossing factor

CR45	0.468465
CR90	0.500211
CR135	0.660194
HO	0.626923

Length factor

not more than 70 m	-1.065590
70-90 m	-2.487910
90-108 m	-0.533920
108-123 m	-0.142000
123-140 m	-0.091250
140-160 m	0.754828
160-185 m	-0.499360
185-223 m	-0.927940
223-243 m	0.562870
243-259 m	0.046498
259-277 m	0.709714
more than 277 m	-0.249550

License factor

merchant 1 class	0.177682
merchant 2 class	0.109177
merchant 3 class	0.245199

Position factor

captain	0.184283
chief officer	0.176755
2nd officer	0.296052
3rd officer	-0.075180

Side factor

TS on Stbd side	-0.056600
TS on Port side	0.000000

Width factor

not more than 10 m	0.500588
10-15 m	-0.025510
15-20 m	0.210588
20-25 m	-0.289200
25-30 m	0.360838
30-35 m	0.099504
35-40 m	0.343936
40-45 m	0.046159
more than 45 m	-0.289570

Type factor

fishing vessel	-0.072820
container ship	-0.335320
pure car carrier	-0.031670
tanker	-0.082580
LNG/LPG carrier	0.315854
passenger ship	-1.597980
towing vessel	-0.116540
other cargo ship	0.000000

Speed factor

OS speed # TS speed	0.120578
OS speed < TS speed	-0.056520
OS speed > TS speed	0.000000

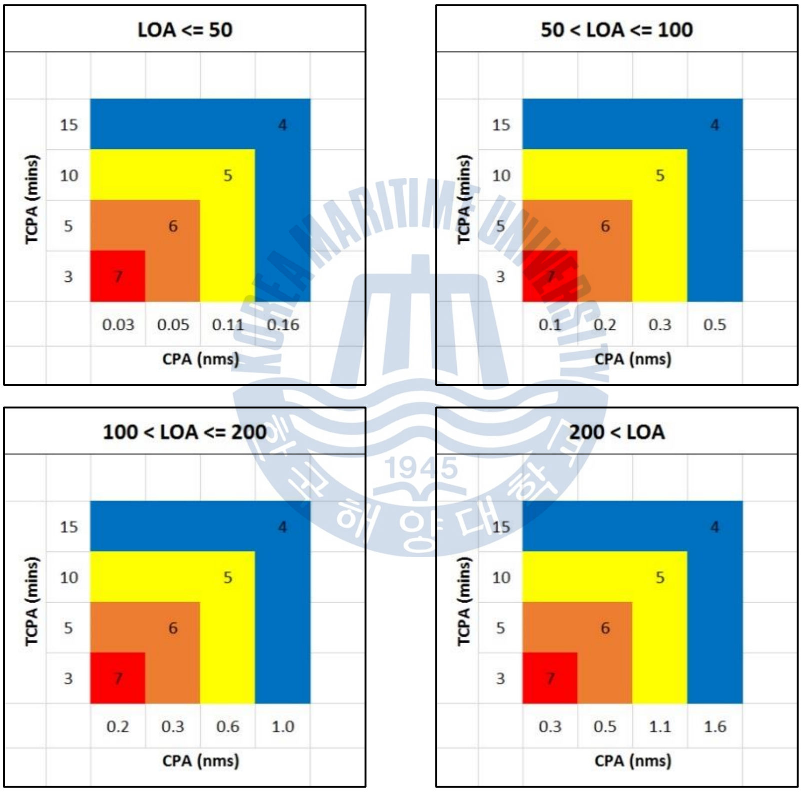
In/out harbor factor

OS inner harbor	0.062305
OS outer harbor	0.000000

In addition, the risk value calculated by the model should be calibrated based on the actual distance to collision (CPA: Closet Point of Approach) and time to collision (TCPA: Time to Closest Point of Approach) between own ship and each target ship. The risk value which is calibrated is called the Corrected Risk value.

Table 3.5 shows the calibration table which is used to calibrate the risk value

Table 3.5 Calibration table of the PARK model



According to the LOA (Length Overall), CPA, and TCPA of the target ship, an accordance color zone is selected. If the risk value of this target ship is higher than the value inside the color zone, the corrected risk value will be equal to the value inside the color zone. In the opposite case the corrected risk value will be equal to the risk value. In case the CPA and TCPA of the target ship are not in any color zones (outside the color zones), the maximum value of the risk value will be 3.0 (Somewhat Safe).

The aggregate risk of the marine traffic safety of an own ship is determined by its corrected risk value with the most dangerous target ship. In other words it is the maximum of corrected risk values of the own ship with each target ship.

Figure 3.4 shows stress rankings in the ES model and the PARK model

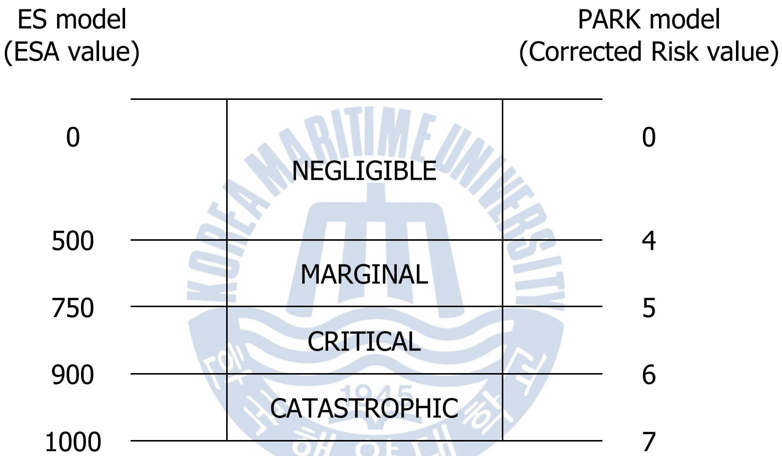


Figure 3.4 Stress ranking of the ES model and the PARK model

3.4 Selection of the Assessment Model for Use with the RTSS

Selecting a model consistent with the Vung Tau Waterway plays a key role in the efficiency of the RTSS. Based on analysis in Item 3.1, there are only two models which can be used for the RTSS: the ES model and the PARK model.

The following section discusses the ES model and the PARK model to select the most appropriate model for use in the RTSS program.

3.4.1 Considering Elements which Affect the Safe Navigation of Vessels

From 2008 to 2012 there were twenty-two accidents in the Vung Tau area. About 81% of them (eighteen accidents) happened because of errors related to vessel control. These accidents were caused by external elements, such as the environment conditions, topography and traffic conditions, and by internal elements, such as the competency of ship-handlers, the ship's characteristics, etc.

Figure 3.5 shows positions of accidents in the Vung Tau Waterway from 2008 to 2012.

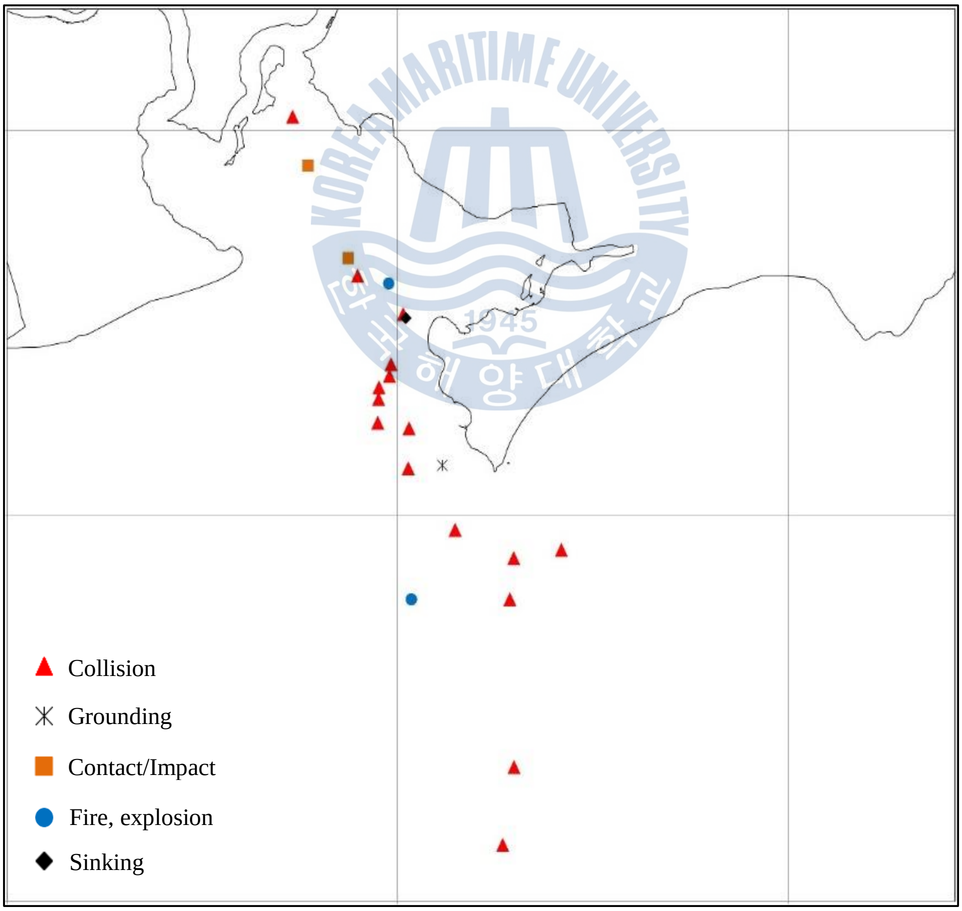


Figure 3.5 Positions of accidents from 2008 to 2012

This figure shows that all of the accidents occurred at least more than one nautical mile from the coast line. This means that the coast line did not cause the accidents. So the affects of traffic conditions and internal elements (the competency of ship-handlers, the ship's characteristics, etc.) were the main causes of accidents in this area.

Items 3.2 and 3.3 above show that the PARK model takes into account more elements related to traffic conditions, ship-handlers' competency, and vessels characteristics than the ES model.

For the two above reasons, qualitatively using the PARK model to evaluate maritime traffic safety in the Vung Tau Waterway will give results that are more consistent than those of the ES model.

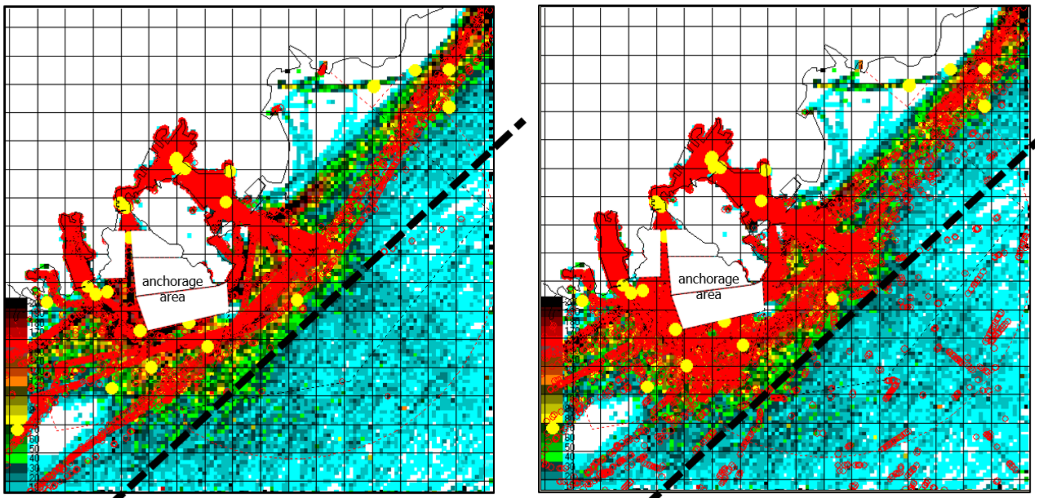
3.4.2 Considering Results of the Study on Comparison Assessment Applying the ES Model and the PARK Model in the Busan Adjacent Waterway

Nguyen (Nguyen Xuan Thanh et al., 2013) did a study on comparison assessment applying the ES model and the PARK model in the Busan adjacent waterway. The two models were compared by the two following methods:

(1) Compare assessment results of the ES model and the PARK model with statistics of collision accidents in the Busan adjacent waterway

(2) Compare assessment results of the ES model and the PARK model in some typical traffic scenarios in the Busan adjacent waterway

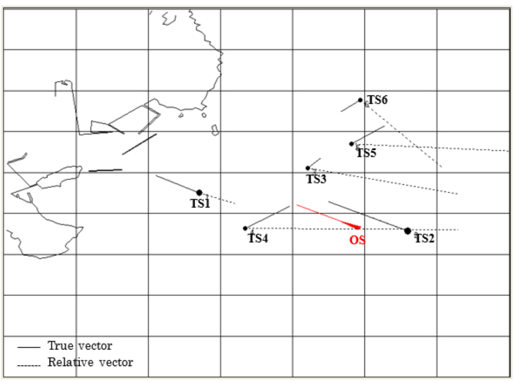
Figure 3.6 shows comparison results between the two models using the method (1) above. On the two pictures the background is a traffic density map of the Busan adjacent waterway, yellow points are positions of accidents from 2008 to 2012 and red circles show positions where the stress level of ship-handlers is in the Unacceptable rank (ESA over 750 or Corrected Risk Value over 5.0).



Assessment result by using the ES model　　　Assessment result by using the PARK model

Figure 3.6 Assessment results in the Busan adjacent waterway by using the ES model and the PARK model

Figure 3.7 shows one typical traffic scenario used in the comparison applying method (2) as mentioned above.



Information of own ship and target ships

ID	Type	LOA (m)	B (m)	Course	Speed (knot)	CPA (nm)	TCPA (min)
OS	Cont_ainer	113	18	303	15.5		
TS1	Other	100	16	305	11.3	0.3	33
TS2	Pass_enger	160	25	303	20.1	0.3	8
TS3	Tug	21	6	37	4.6	1.2	4
TS4	Cont_ainer	96	11	49	12.5	0	4.2
TS5	Tanker	34	9	46	9.9	2	0.5
TS6	Tug	25	8	224	6	1.8	9.8

ESA value of OS: 76.3 -> Negligible rank

Corrected Risk value of OS: 4.8 -> Marginal rank

Figure 3.7 A typical traffic scenario used in the comparison method (2)

The results of this study are:

- In waterways within the harbor and in the approaching channel the evaluation results of both models were similar
- In the coastal waters (over 2 nautical miles from the coast line) the PARK model gives more consistent results than the ES model

This study shows that in the Busan waterway the PARK model gives assessment results of traffic risks in the coastal area better than the ES model. Thus, if traffic in the Vung Tau Waterway has the same characteristics as the coastal area of the Busan waterway, the PARK model should be used.

Figure 3.8 shows traffic routes in the area along the coast line in the Busan waterway. Figure 3.9 shows traffic routes from Buoy No.0 to ports in the Vung Tau Waterway.

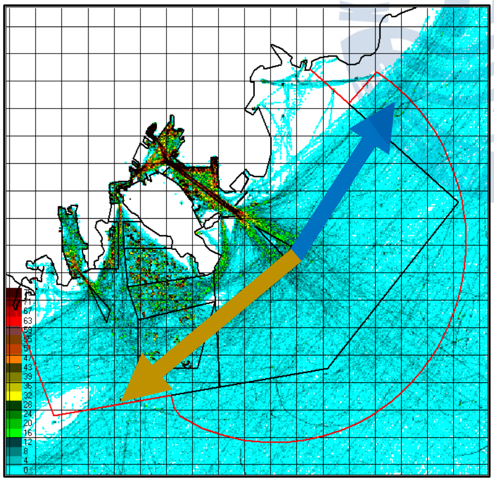


Figure 3.8 Traffic route along the coastline in the Busan waterway

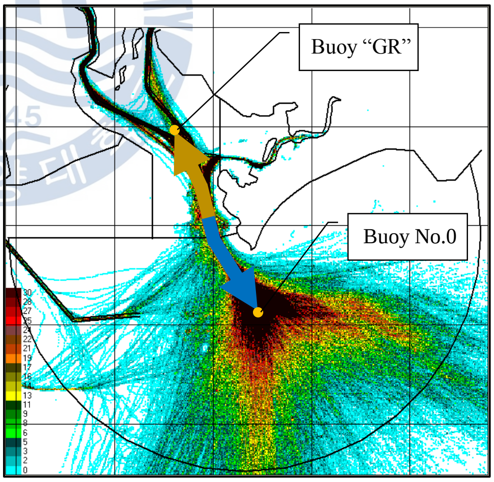


Figure 3.9 Traffic route from Buoy 0 to Buoy “GR” in the Vung Tau Waterway

Comparing these two figures, it can be seen that traffic from Buoy No.0 to Buoy “GR” in the Vung Tau Waterway is similar to traffic along the coastline in the Busan waterway. So qualitatively the results of Nguyen’s research in the

Busan waterway can be applied to the Vung Tau Waterway. In other words, qualitatively the PARK model will give assessment results more exact than the ES model will give for the Vung Tau Waterway.

3.4.3 Comparing the Assessment Results of the PARK Model and the ES Model with the IWRAP Model

In this dissertation the traffic safety of ocean-going vessels in the Vung Tau Waterway (the main traffic type in this area) was assessed by the PARK model and the ES model based on the AIS data collected from October 7 to 10, 2013. Figures 3.10 and 3.11 show the density map of areas that have a traffic risk in the "Critical" rank based on the assessment of the ES model (ESA value over 750) and the PARK model (Corrected Risk value over 5.0, Somewhat Dangerous).

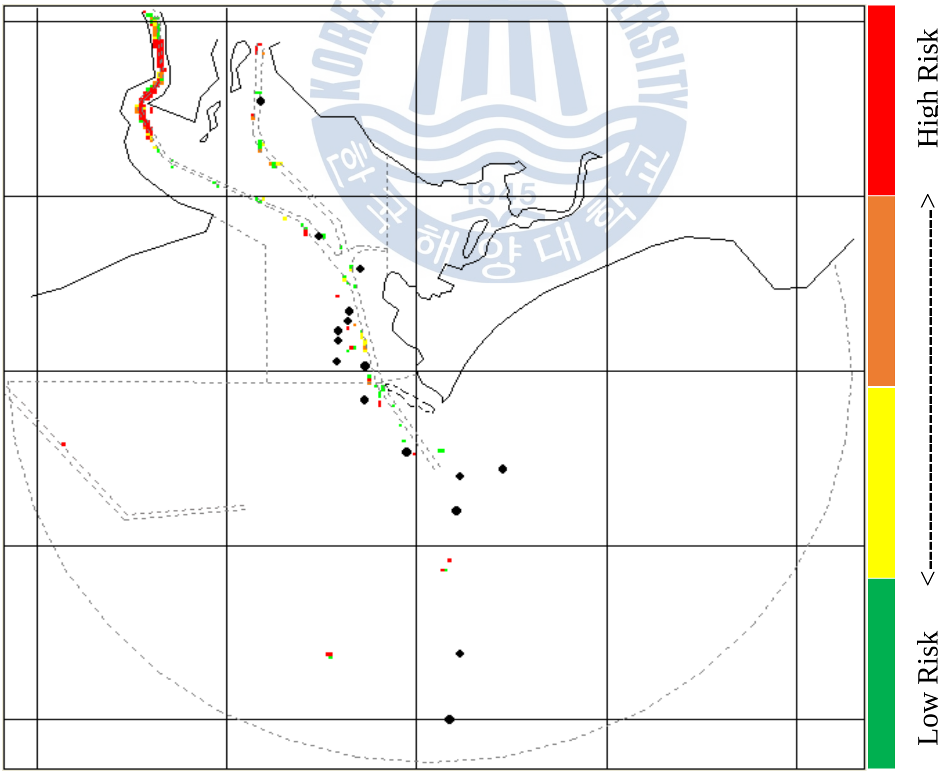


Figure 3.10 Risk assessment results by using the ES model

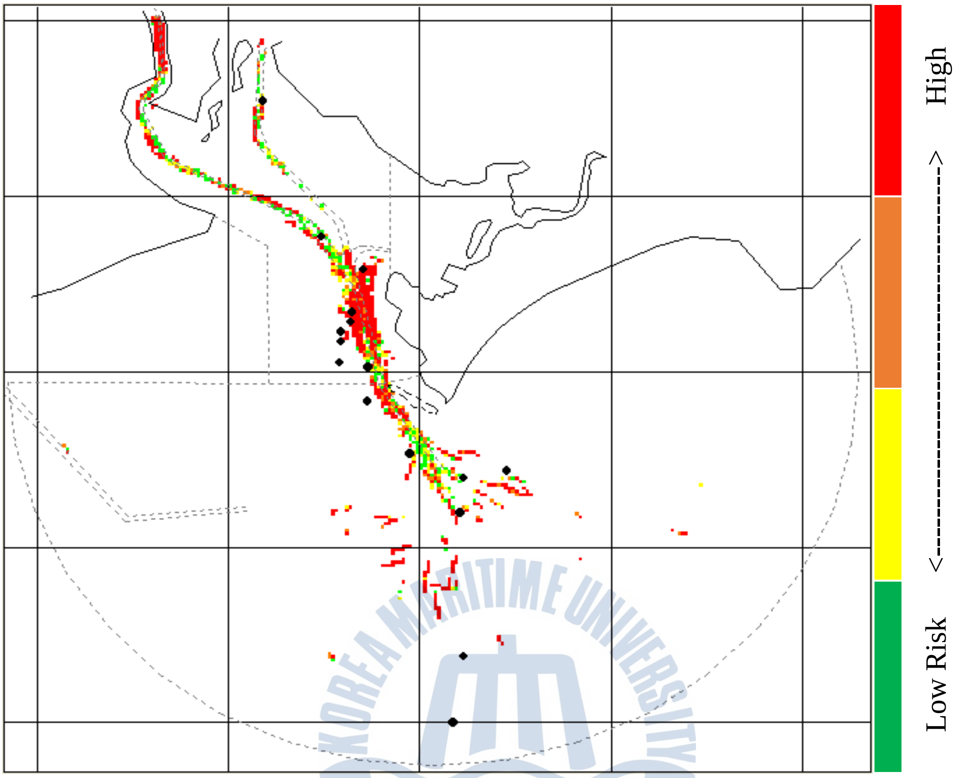


Figure 3.11 Risk assessment results by using the PARK model

The IWRAP model is a model which has very high reliability and is recommended by the International Maritime Organization and the International Association of Lighthouse Authorities (IMO, 2010a). This dissertation therefore uses the assessment results of the IWRAP model as the standard to evaluate the reliability of the PARK model and the ES model in the Vung Tau Waterway.

Comparing Figures 3.10 and 3.11 with the assessment results of the IWRAP model in Figure 2.34 above, it shows that the assessment results of the PARK model are more similar to the assessment results of the IWRAP model than to those of the ES model. So it can be said that the PARK model is more suitable than the ES model for traffic assessment traffic safety in the Vung Tau Waterway.

3.4.4 Comparing the Assessment Results of the PARK Model and the ES Model with the Statistics of Collision Accidents in the Vung Tau Waterway

In Figures 3.10 and 3.11 the black dots represent positions of the collision accidents which occurred in the Vung Tau Waterway from 2008 to 2012.

It is clear that in the assessment results of the ES model the positions of collision accidents are not close to the high risk areas, but they are very close to high risk areas in the assessment results of the PARK model. This shows that the assessment results of the PARK model are more consistent for use with the Vung Tau Waterway than the ES model.

3.5 Results and Discussion

There are several traffic safety assessment models in use. However, the model which could be used for the supporting system must be able to assess collision risks of vessels in real time. Therefore, only the ES model and the PARK model can be used.

The following table shows the advantages and disadvantages of the ES model and the PARK model based on the way the two models were developed.

Table 3.6 Advantages and disadvantages of the PARK model and the ES model

Items	PARK model	ES model
Advantages	- Considers many factors related to traffic safety between two ships, such as type, size, crossing situation, speed, distance, competency of officers, etc. Able to assess stress on	- Affects of time to collision (TTC) in regards to both land and other ships are considered

Items	PARK model	ES model
	ship-handlers from all types (8 types) and all sizes of target ships (15 DWT classes, 12 length classes and 9 width classes)	
Dis-advantage	- Affects of land on ship controlling is not fully considered. The only two classes considered are inner and outer harbors - Affects of CPA and TCPA are not clearly considered - The aggregate impact of many vessels around the own ship is not considered	- Mostly considers TTC and does not consider other factors such as bearing, range, type, size of target ship, competency of duty officers, etc. (only two GT classes: over and under 10,000 GT) - Only considers affects of environments (land and ship) in the 180 degrees in front of the bridge, so that in the outer harbor waterway the ESA value is usually very low (Negligible)

Table 3.6 shows that the PARK model considers more factors than the ES model, especially factors relating to types and sizes of vessels and to the crossing situation of two ships. So qualitatively the PARK model will assess the risks of collisions of vessels in the Vung Tau Waterway better than the ES model because

traffic in this area consists of many types and many sizes of vessels and of all types of crossing situations.

The comparison results between the PARK model and the ES model with some different methods show that:

(1) The collision assessment results in the Vung Tau Waterway by the PARK model is closer to the results of the IWRAP model than the results of the ES model are

(2) Similarly, the collision assessment results of the PARK model are also closer to positions of collision accidents than the results of the ES model are

Considering the above analysis, it can be said that using the PARK model to assess marine traffic safety in the Vung Tau Waterway will give better results than the ES model. So the PARK model is the most appropriate model for assessing collision risks in the Vung Tau Waterway. It is selected for use in this dissertation.

Chapter 4 The Real Time Supporting System (RTSS) for VTS Officers

The analysis results of Chapter 2 show that the program that can help VTS officers to assess collision risks of a vessel will improve the efficiency of the Vung Tau VTS System. Chapter 3 shows that the PARK model is the most appropriate model for assessing the collision risks of a vessel in the Vung Tau Waterway.

This chapter will present details about:

- The process of developing the Real Time Supporting System (RTSS) for VTS officers applying the PARK model. The RTSS will support VTS officers in the Vung Tau VTS Center in alerting vessels that run a risk of collision, going aground, or sailing off-route or over-speed
- Feedback of VTS officers who used the system

Figure 4.1 shows the development and implementation process of the RTSS

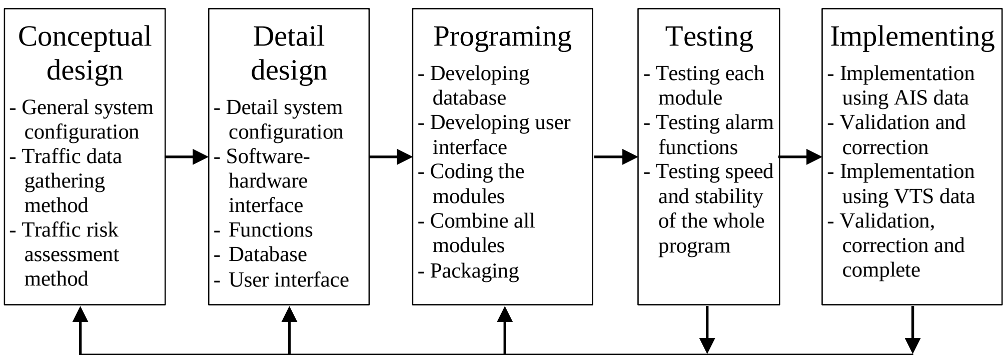


Figure 4.1 Developing process for the RTSS

4.1 Conceptual design

Investigation of the present VTS systems in the Vung Tau VTS Center shows that the system already has some support functions such as alerting when two vessels are too close or an anchored vessel drifts or penetrates a pre-defined area, as shown in Figure 4.2. However, it does not have an alert function for a vessel that runs a risk of collision, running aground, or sailing off-route or over-speed.

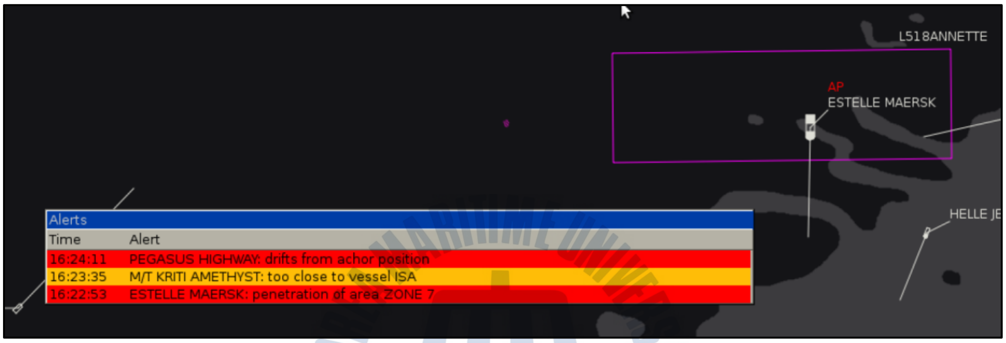


Figure 4.2 A sample of the alert functions in the existing VTS system

Because of restrictions of the manufacturer, a user is not allowed to modify the software of the VTS System. Therefore, the RTSS should be designed to operate independently, but also to be integrated with the VTS system in the future when it is possible.

Figure 4.3 shows the conceptual design of the RTSS

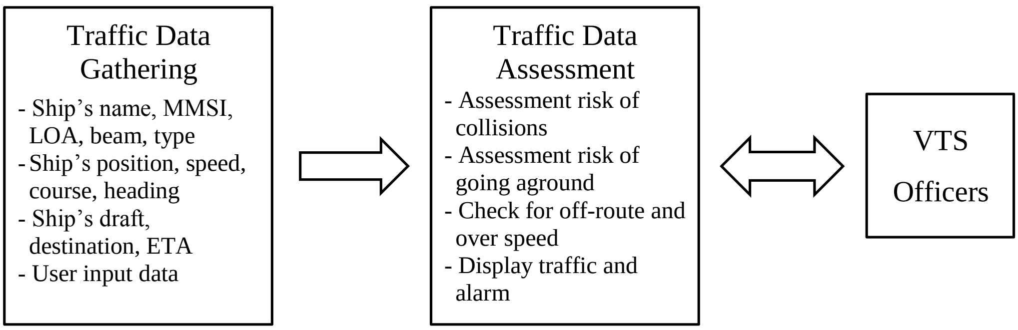


Figure 4.3 Conceptual design of the RTSS

In this diagram a function of the Traffic Data Gathering block is gathering traffic data of vessels in the waterway, such as the vessel's name, position, speed, type, etc. These data are able to be collected via an independent AIS and/or radar system, or via the VTS System. In addition, this block can collect data relating to coast lines, fairways, tides, and user data.

Functions of the Traffic Data Assessment are assessment of collision risks of a vessel based on the PARK model and alerting VTS officers about vessels that run a risk of collision. In addition, this block also has some other functions, such as

(1) alerting vessels that are in danger of running aground or sailing off-route or over-speed and (2) displaying coastlines, fairways, and vessel traffic.

Through the screen a VTS officer is able to know the risk of collision of vessels quantitatively by the corrected risk value. When a vessel risks collision, running aground, or sailing off-route or over-speed, the VTS officer will be alerted by a sound alarm and warning message.

In case some data about a vessel such as type and size of vessel or destination are not exact or missing, the VTS officer can correct or input the exact or missing information to the RTSS directly.

4.2 Detail Design

Detail design of the RTSS is shown as Figure 4.4.

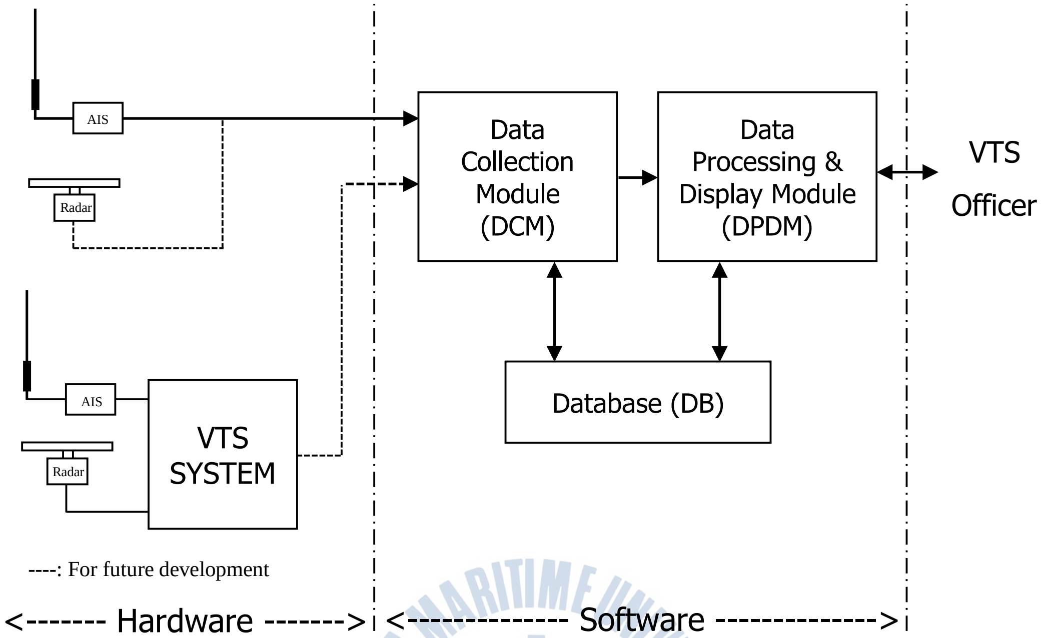


Figure 4.4 Detailed design of the RTSS

Functions of the Data Collection Module (DCM) and Data Processing & Display Module (DPDM) in this figure are explained as follows:

The Data Collection Module (DCM) is designed to collect traffic data such as follows:

(1) Coastlines
(2) Tides
(3) Fairways
(4) Narrow water areas
(5) Safe speed restriction areas
(6) Vessel's static data: MMSI number, name, call sign, and dimensions
(7) Vessel's voyage data: destination and draft
(8) Vessel's dynamic data: position, speed, course, and heading

The data from (1) to (5) were collected from the user. The data from (6) to (8) were collected from the user and through the following two sources:

- AIS and/or radar combined with user input data
- The VTS system

The data will be transferred to the DPDM module and also be stored in the database (DB)

The DPDM will perform the following functions:

- Assessment risks of maritime traffic safety by using the PARK model
- Prediction of a vessel's position to evaluate the risk of grounding
- Off-route checking based on the vessel's actual position
- Over-speed checking based on the actual speed of the vessel

At the end the DPDM will send to the user the following information:

- Quantitative value of the maritime traffic risk of vessels (Corrected Risk value) and alert notification in case there are any vessels in critical or catastrophic situations
- Alert notification to a vessel that runs the risk of going aground
- Alert notification to a vessel that is off-route
- Alert notification to a vessel that is over-speed

VTS officers are able to confirm the alarm notifications, input data, view log of alarm, and set alarm limits and options, etc.

Detailed designs of the DCM and DPDM are presented as follows:

4.2.1 The Data Collecting Module (DCM)

To create favorable conditions for system implementation, the DCM was designed as two independent channels, as shown in Figure 4.5.

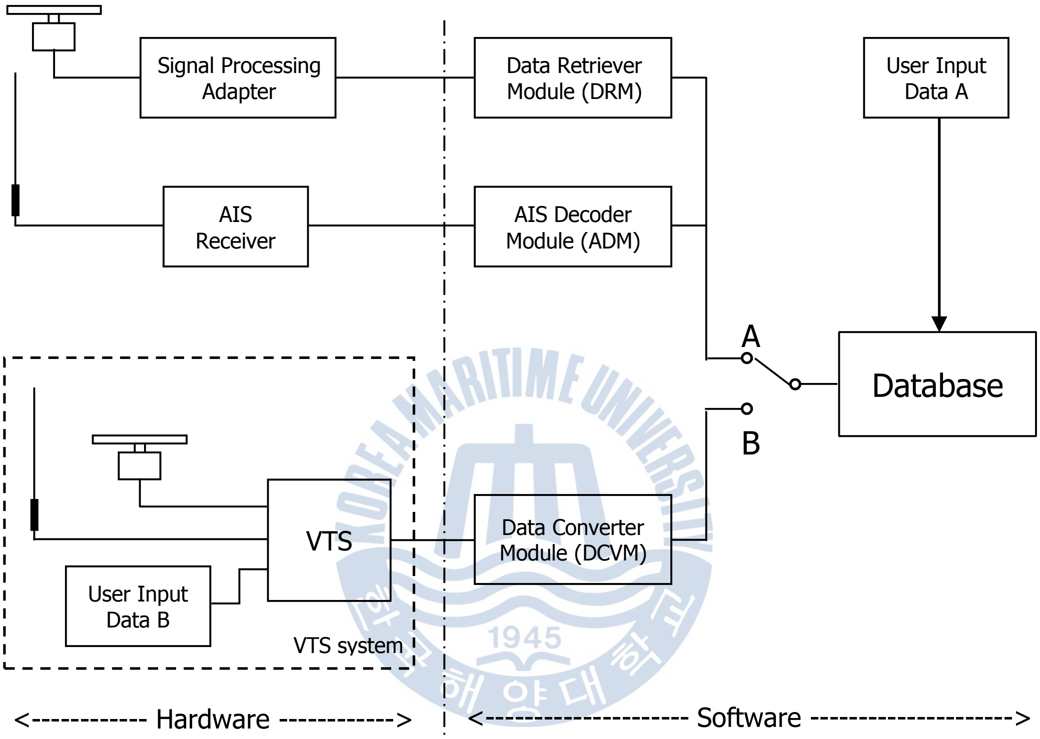


Figure 4.5 Design of the Data Collection module

Channel A collects data from the AIS receiver (Navigation Center, 2012) or radar. The AIS Decoder Module (ADM) and Data Retriever Module (DRM) are responsible for converting AIS signals or radar signals to text data and then storing them in a database. The User Input Data A (UID A) will receive data that are inputted directly by the user and then store them in a database to correct any wrong data received from the AIS, such as:

- Type of vessel
- Dimension
- Draft

- Destination, etc.

The data collected in Channel A are totally independent from the data of the VTS system. This will create favorable conditions for implementing the system in the trial period at the VTS center.

In Channel B the traffic data are collected through the VTS system. Most VTS systems are able to collect information about vessels through radar, AIS, and VTS officers. These data will be stored in the database of the VTS system and export to text files, if necessary. The DCM will query data from the database of the VTS system or get data from text files and then convert them by using the Data Converter Module (DCVM) and finally store them in the database.

The advantages of Channel B are the data are more comprehensive (all vessels, including non-AIS vessels) and more exact (data are already integrated from the three sources: radar, AIS, and VTS officers). However, this channel requires the RTSS to be connected to the VTS system. So Channel B is suitable for the second stage of implementation after the RTSS has passed the trial step.

In addition, the User Input Data A module is also used to collect user input data, such as coast lines, narrow water areas, tide tables, fairways, limits of safe speed, and user's settings.

4.2.2 The Data Processing and Display Module (DPDM)

Figure 4.6 shows details design of the Data Processing and Display module.

The function of the Data Filter Block is to filter data based upon a list of MMSI numbers of vessels which should be excluded from traffic safety monitoring, such as pilot boats, small passenger boats, etc. (this list is inputted by the VTS officer). Data after filtering will be passed to the next blocks.

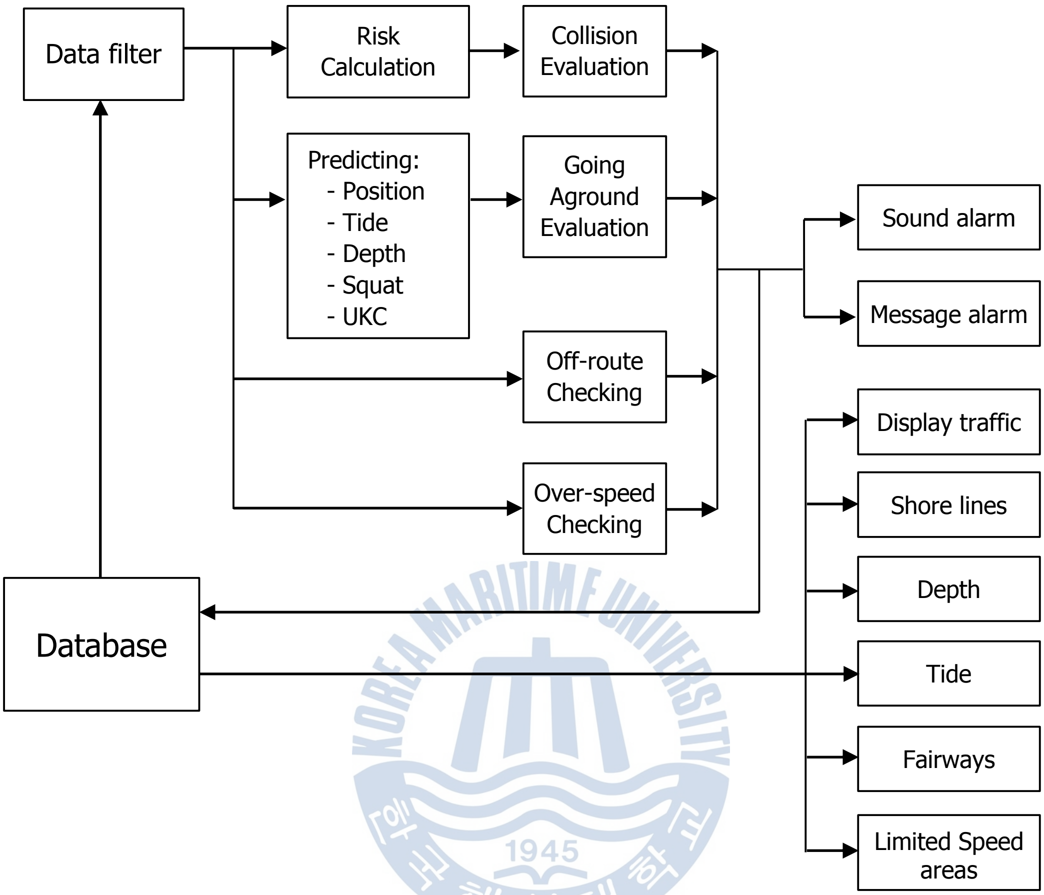


Figure 4.6 Design of Data Processing and Display module

Based on filtered data, the Risk Calculation block will calculate the Risk value of each vessel by using the PARK model. Then results will be sent to the Collision Evaluation block to evaluate the risk of collision of each vessel based on a limit value which is set by the VTS officer.

The Predicting block will predict the position of vessels based on present position, course over ground, and user predefined time period (15, 20, 30, etc. minutes). Then the tide height, water depth, and vessels' squat will be also predicted to find the vessel's UKC (under keel clearance). The output result of this block (the vessel's UKC) will be sent to the Going Aground Evaluation block to evaluate the risk of grounding based on the UKC limit value that is inputted by the VTS officer according to regulations of the Maritime Administration.

Functions of the Off-route Checking block and the Over-speed Checking block are checking errors of the ship-handlers as regards being off-route and over-speed from the fairway based on the actual position and speed over ground of the vessel and relevant regulations of Maritime Administration.

Data related to vessels that run a risk of collision, going aground, off-route error, or over-speed error will alert the VTS officers by sound and message alarms and also be stored in the database as alarm logs.

In addition, this module also undertakes the function of displaying traffic in the area in a graphic mode based on collected data. It gives VTS officers a visual view of the traffic conditions in the area. For the convenience of the user the traffic in the area is displayed in a main window (traffic of the whole area) and some sub-windows (traffic of sub areas, which is defined by the user).

4.3 Programming and Testing the System

According to its conceptual and detail design, the RTSS consists of two parts: hardware and software. The software will be installed in a computer which is connected to hardware such as the AIS, radar, or the VTS system. Therefore, the Data Retriever Module, the AIS Decoder Module, and the Data Converter Module have to programed to be compatible with the hardware.

Because some equipment such as digital radar and a signal processing adapter is lacking, the Data Retriever Module cannot be programmed at present. The Data Converter Module also cannot be brought into operation because of some restrictions when getting data from the VTS system.

Considering its design the RTSS software is not a complicated program. It has only two modules and the data to be stored are also small. Therefore, the Visual

Basic programing language and Microsoft Access database are selected to develop the RTSS program and database.

The process of programing is shown in Figure 4.7.

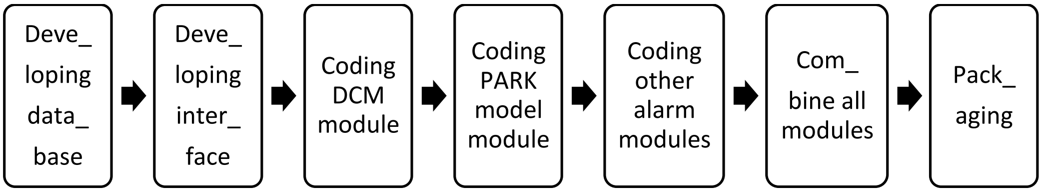


Figure 4.7 Programing process of the RTSS program

During the programing process many tests were carried out to verify each form and module within the program. Some principal tests are shown as follows:

(1) Check for the correct operation of Channel A of the DCM module (collecting data from the AIS receiver which is connected with the computer directly)

(2) Check for the correct operation of Channel B of the DCM module (using a database which simulates a database of the VTS system)

(3) Check for the correct operation of the Data Processing Module:

   a. Exact calculation of the risk value by using the PARK model

   b. Exact calculation of the predicted positions, tides, water depth, squat, and UKC

   c. Exact operation of the modules: Collision Evaluation, Going Aground Evaluation, Off-route Checking, and Over Speed Checking

(4) Check for the correct operation of functions: display traffic situation, alarm, collect data from the user, etc.

(5) Run the system using Channel A to collect data and check the speed, reliability, and stability of the system

(6) Run the system using Channel B to collect data and check the speed, reliability and stability of the system

Test results of the RTSS are shown in Table 4.1 and some following figures:

Table 4.1 Test results of the RTSS

No.	**Items**	**Results**	**Remarks**
Check for the correct operation of the Channel A of the DCM module			
1	Confirm that the AIS signal is decoded and displayed exactly	Yes	Comparing with other programs. (Figures 4.8 & 4.9)
2	Confirm that receiving and decoding processes work continuously and stably for a long time	Yes	During 7 days continously
Check for the correct operation of the Channel B of the DCM module			
4	Confirm that the data are restored exactly as the data which were stored in the database	Yes	Visually checked randomly (Figure 4.10)
5	Confirm that the data restoring process works continuosly and stably for a long time	Yes	During 7 days continously
Check for the correct operation of the Data Processing and Display Module			
6	Confirm the exact calculation of the Corrected Risk value according to the PARK model	Yes	Comparing with manual calculation (Figure 4.11 & Table 4.2)
7	Confirm the Corrected Risk value is recalcuated automatically when the traffic situation is changed	Yes	Visually checked
8	Exact calculation of the predicted position	Yes	Comparing with manual calculations (Figure 4.12)
9	Exact calculation of the predicted tide	Yes	
10	Exact calculation of the predicted SQUAT	Yes	

No.	Items	Results	Remarks
11	Exact calculation of the predicted UKC	Yes	
12	Correct operation of the Collision Alarm	Yes	Visually checked (Figures 4.14, 4.15)
13	Correct operation of the Grounding Alarm	Yes	
14	Correct operation of the Over Speed Alarm	Yes	
15	Correct operation of Off-route Alarm	Yes	
Check for the correct operation of functions: display traffic situation, alarm, collect data from user, etc.			
16	Exact display of the traffic situation	Yes	Visually checked (Figure 4.13)
17	Exact display of alarm messages and alarm sound	Yes	Visually checked (Figure 4.14, 4.15)
18	Exact obtaining and storing of user input data	Yes	Visually checked (Figure 4.16)
Run the system using Channel A to collect data and check for the speed and stability of the system			
19	Processing speed from collecting AIS data until finishing display information when the total number of vessels is 50 vessels	≅ 1 second	
20	Processing speed from collecting AIS data until finishing display information when the total number of vessels is 100 vessels	≅ 3 seconds	
21	Processing speed from collecting AIS data until finishing display information when the total number of vessels is 200 vessels	≅ 5 seconds	
22	Confirm that the program runs continously and stably for a long time	Yes	During 7 days continously

Figures 4.8 and 4.9 show test results of Channel A of the Data Collection Module (collecting traffic data via independent equipment such as AIS and/or radar). Figure 4.8 shows the AIS data which are received by a profesional program (ShipPlotter) via the AIS receiver.

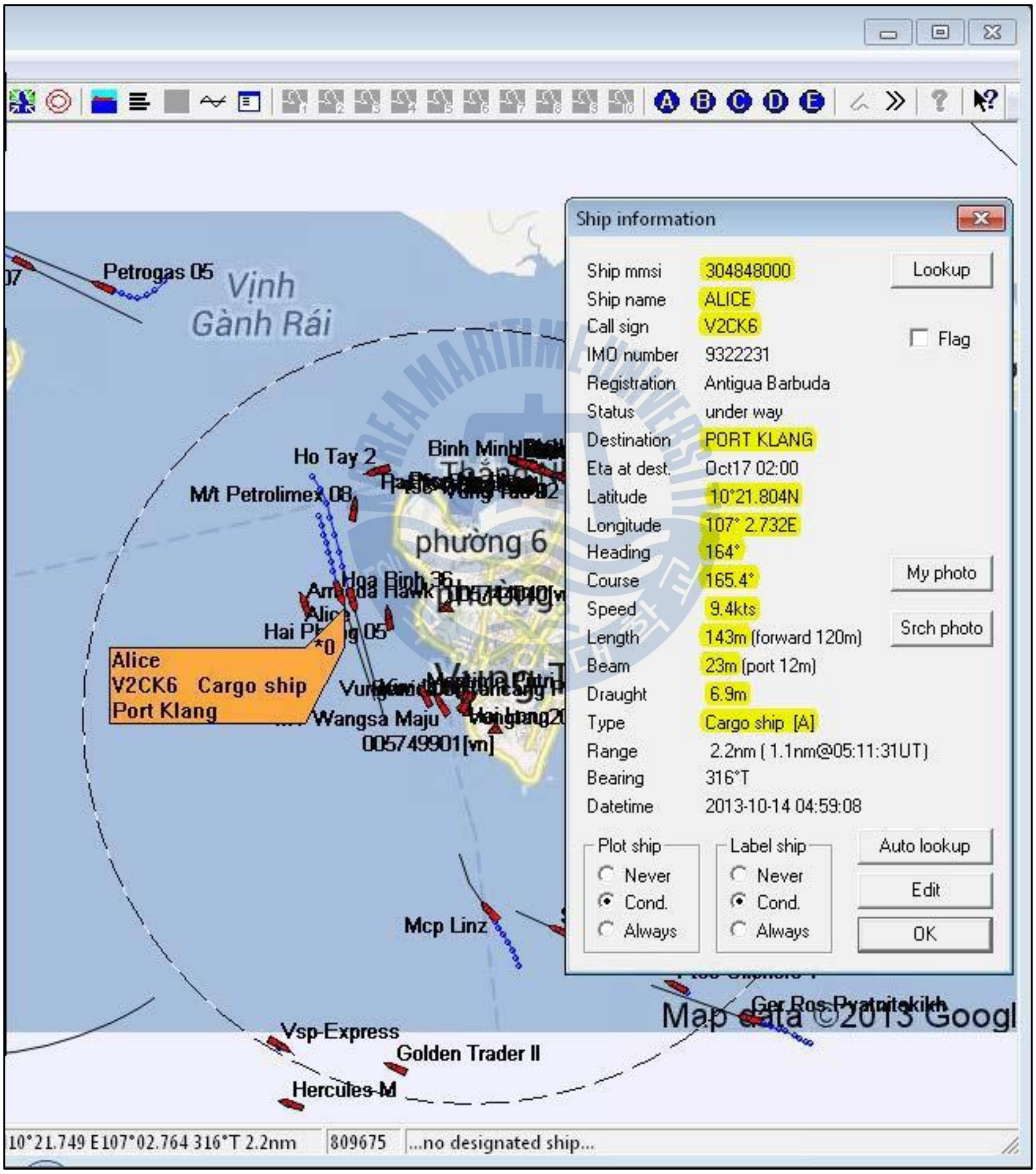


Figure 4.8 The AIS data of the vessel ALICE which are received by the ShipPlotter program

Figure 4.9 shows the AIS data which are received by the RTSS program via the AIS receiver. The data such as MMSI, IMO number, position, course, speed, LOA, beam, etc. are completely the same as those of the ShipPlotter program.

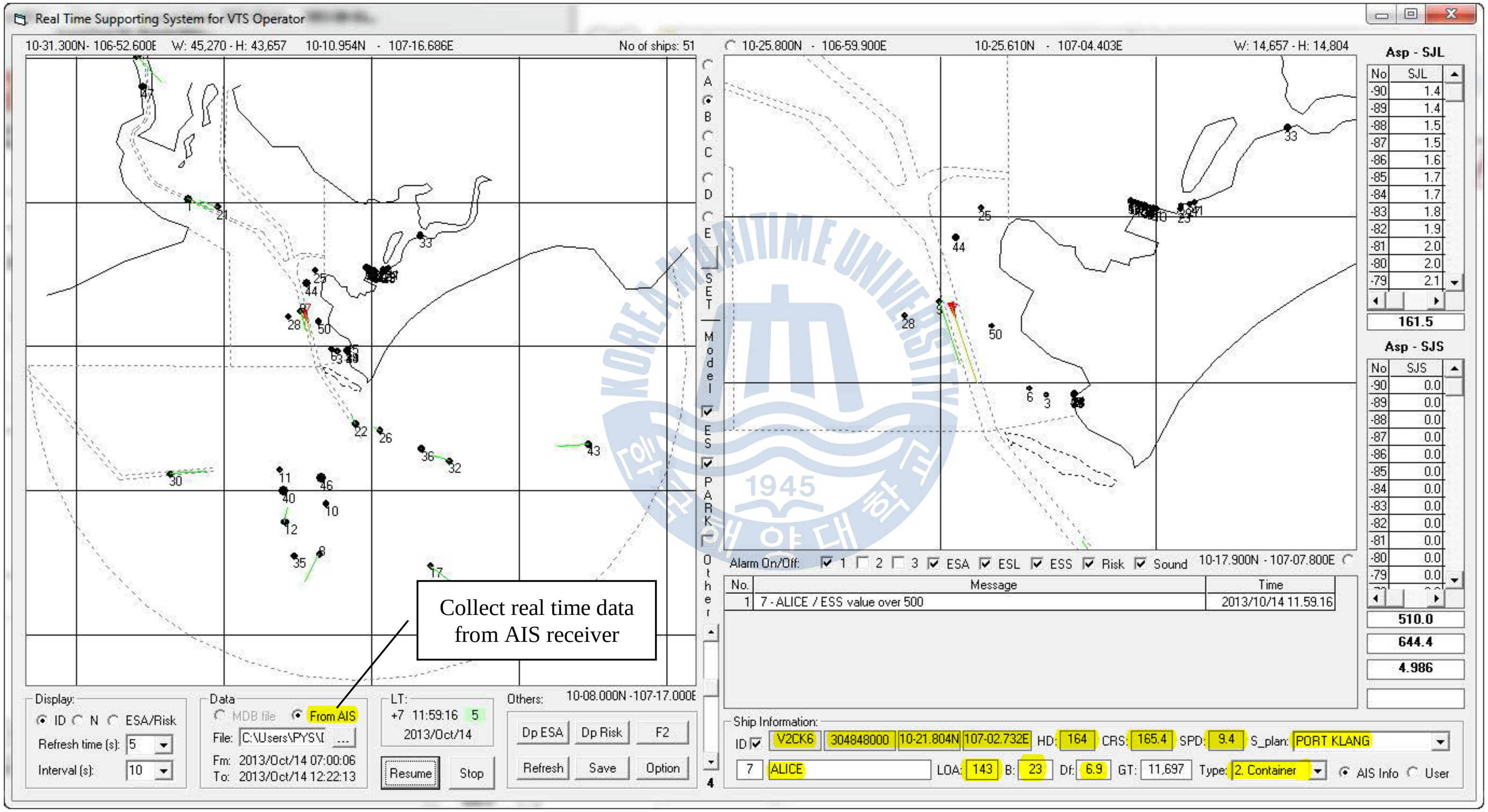


Figure 4.9 The AIS data of the vessel ALICE which are received by the RTSS program

Figure 4.10 shows test results of the Data Converter Module in the DCM module. The AIS data, which are converted from the database, as shown in Figure 4.10, are same as when they were received via the AIS receiver, Figure 4.9.

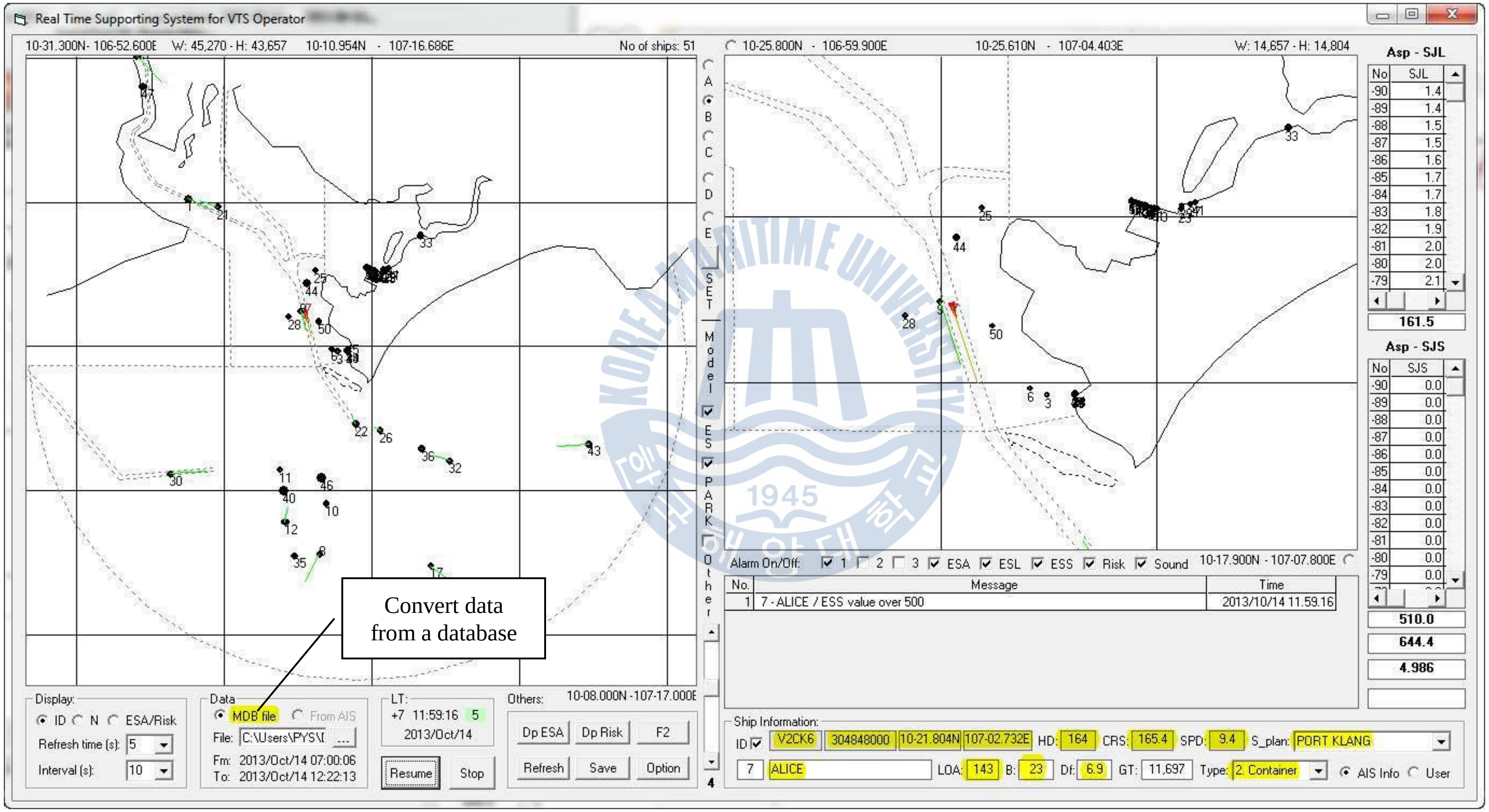
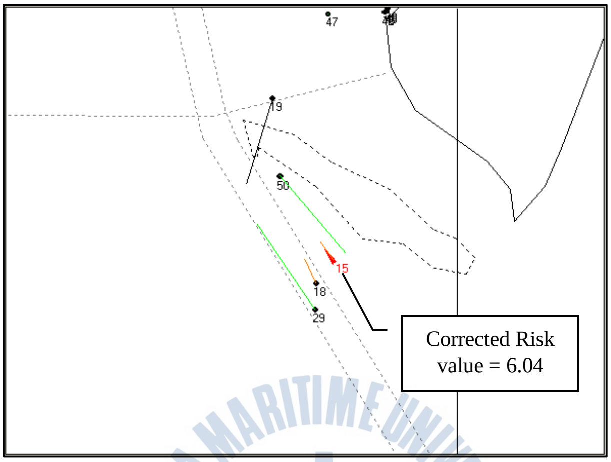


Figure 4.10 The AIS data of the vessel ALICE which are converted from the database

Figure 4.11 and Table 4.2 show test results of the PARK module. The Corrected Risk value that is calculated by the PARK module in the RTSS program is exactly same as manual calculations.



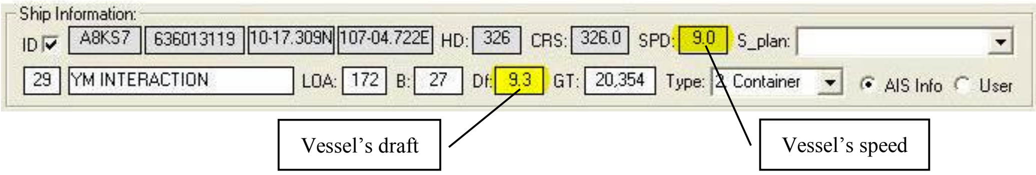
Information	Vessels' ID			
	Own ship	**Target ships**		
	15	**18**	**29**	**50**
Name	SAOMAI 03	GER.ROS. PYATNITSKIKH	BIENDONG TRADER	THANH HAI 07
Latitude	10-18.993N	10-18.863N	10-18.713N	10-19.465N
Logitude	107-03.940E	107-03.842E	107-03.834E	107-03.625E
Type	Tug boat	Tanker	Container	Container
LOA	64	140	128	150
B	13	16	19	20
Course	325	333.7	324.5	137.9
Speed	2.2	2.6	10.1	9.9
CPA		0.07	0.25	0.07
TCPA		16.4	1.3	2.8
Risk value	6.04			

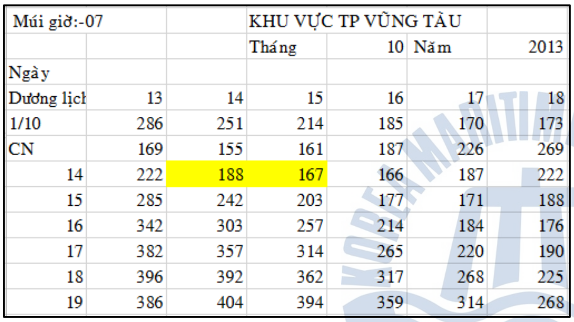
Figure 4.11 Corrected Risk value that is calculated by the RTSS program

Table 4.2 Manual calculations of the Corrected Risk value

No.	Items	Vessels' ID		
		18	29	50
1	Type factor	-0.116540	-0.116540	-0.116540
2	Ton factor	2.180813	2.180813	2.180813
3	Length factor	-1.065590	-1.065590	-1.065590
4	Width factor	-0.025510	-0.025510	-0.025510
5	Career factor	0	0	0
6	Licence factor	0	0	0
7	Rank factor	0	0	0
8	Length correlation factor	0.352380	0.322176	0.377550
9	Crossing factor	0.660194	0	0
10	Starboard factor	0	0	-0.0566
11	In habour factor	0	0	0
12	Slow speed factor	0.120578	-0.056520	-0.056520
13	Speed correlation factor	-0.070077	-0.038947	-0.243609
14	Distance correlation factor	5.079933	4.952919	5.043944
	Total	7.116181	6.152801	6.037938
	After conversion	3.00	5.00	6.04
	Risk value of Vessel No.16	6.04		

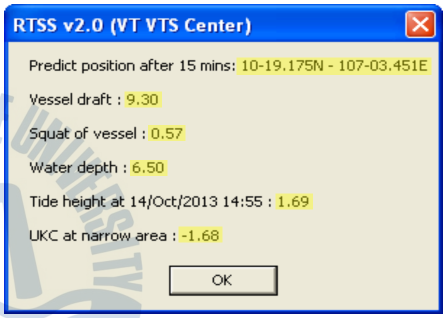
Figure 4.12 shows test results of the module for calculating predicted position, tide, squat, and UKC. Results calculated by the RTSS are exactly the same as those manually calculated.





Múi giờ:-07			KHU VỰC TP VŨNG TÀU			
			Tháng	10	Năm	2013
Ngày						
Dương lịch	13	14	15	16	17	18
1/10	286	251	214	185	170	173
CN	169	155	161	187	226	269
14	222	188	167	166	187	222
15	285	242	203	177	171	188
16	342	303	257	214	184	176
17	382	357	314	265	220	190
18	396	392	362	317	268	225
19	386	404	394	359	314	268

Vietnamese tide table at Vung Tau(ICOE, 2013)



Predicted position, squat, tide, and UKC are calculated by the RTSS program

	RTSS	Manual calculation
Predicted position after 15 minnutes	10-19.175N 107-03.451E	10-19.175N 107-03.451E
Draft	9.3	9.3
Squat	0.57	0.57
Tide	1.69	1.69
UKC	-1.68	-1.68

Figure 4.12 Test results of the module for calculating predicted position, tide, depth, squat, and UKC

This figure shows the test results of the correction of traffic display: length and direction of vector, colors, etc.

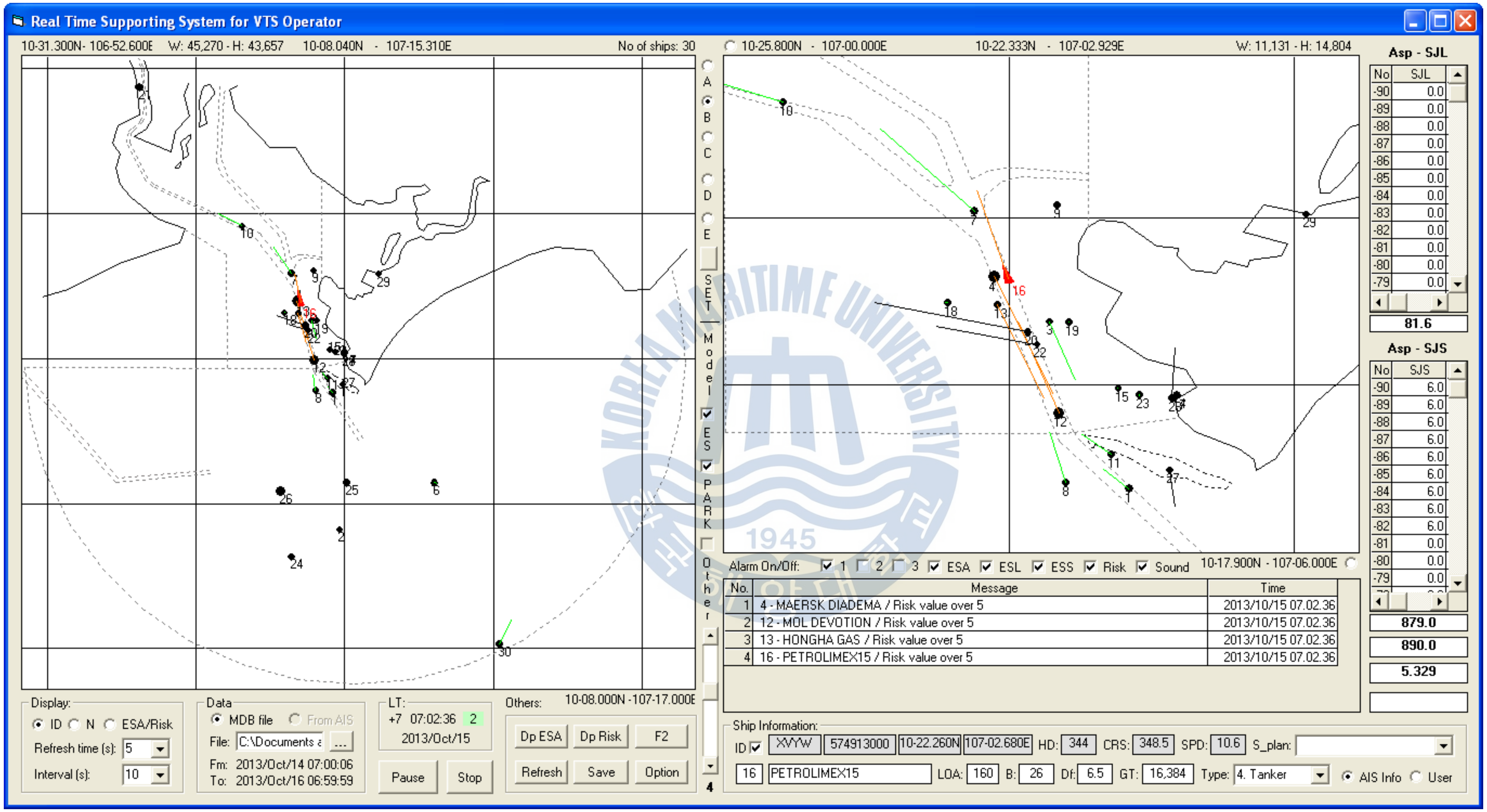


Figure 4.13 Checking for the correct display of the traffic in the waterway

Figure 4.14 shows test results of the collision risk alarm function.

When the corrected risk value of a vessel is less than 5.0 (somewhat safe), the moving vector of the vessel is a green vector.

When the corrected risk value of a ship is between 5.0 and 6.0 (somewhat dangerous), the RTSS program will alarm by sound. Together with this on the screen the moving vector will become yellow and an alarm message sounds.

When the corrected risk value is over 6.0 (dangerous), the RTSS program will alarm by sound, red vector, and alarm message, as shown in Figure 4.14.

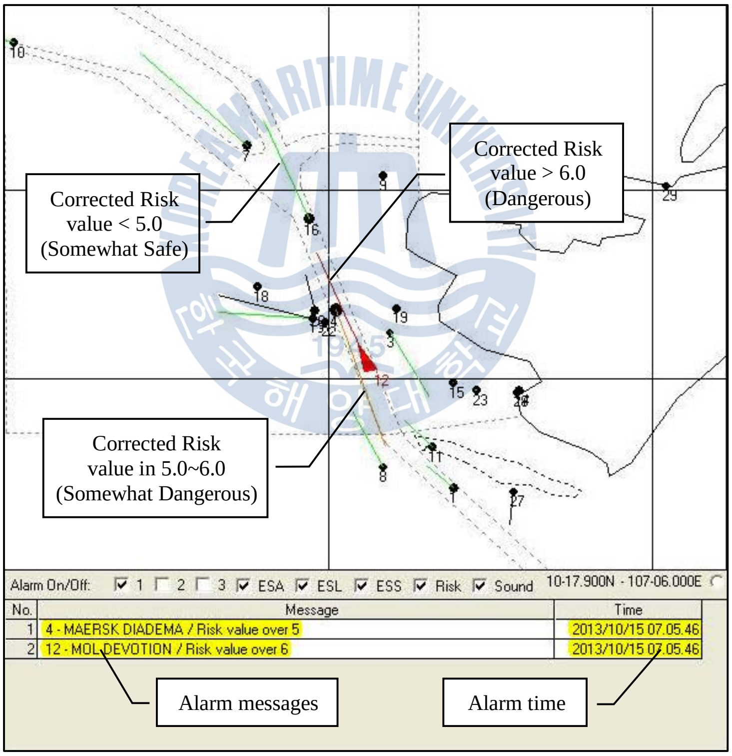


Figure 4.14 Test results of the collision risks alarm function

Figure 4.15 shows test results of the grounding risk alarm function. When a vessel is approaching narrow water, the RTSS program will alarm by sound, red color vector, and alarm message.

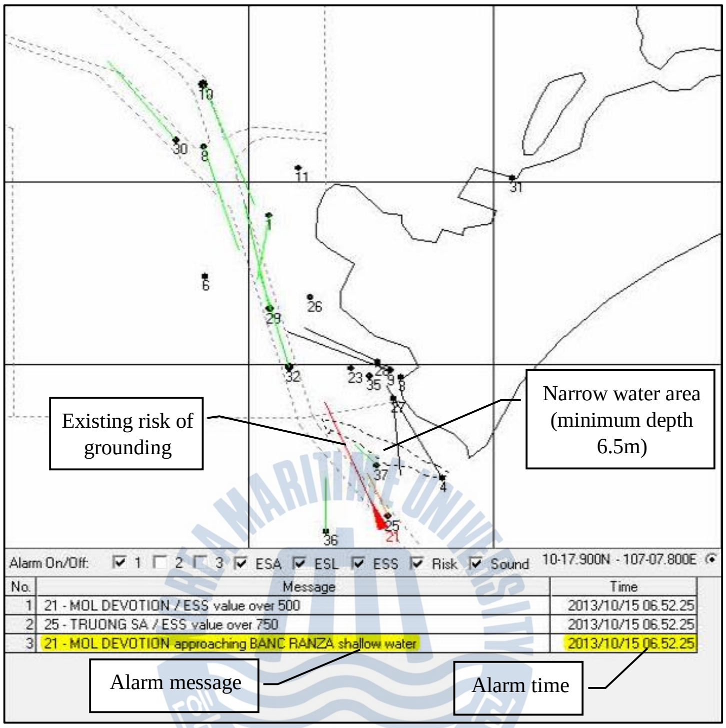


Figure 4.15 Test results of the grounding risks alarm function

Figure 4.16 shows test results of the user setting menu.

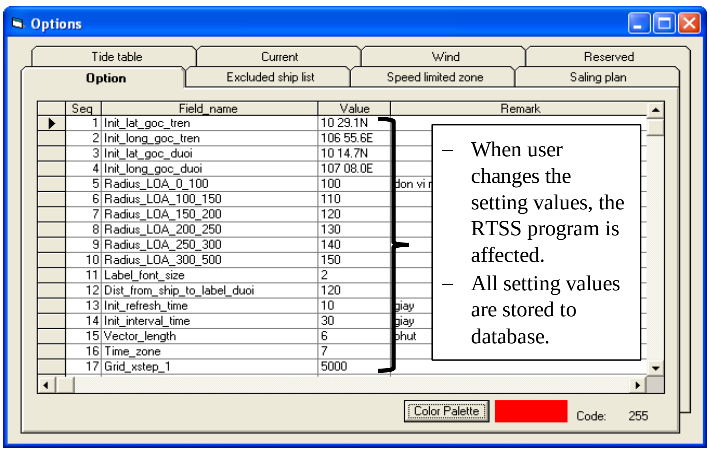


Figure 4.16 Test results of the user setting menu

4.4 Introducing the Collision Assessment and Course Adviser Module

The Collision Aseessment and Course Adviser (CACA) module is an module which is being developed based on the PARK model. This module will calculate the risk of the own ship at each degree when it makes a turn of 360 degrees to port or starboard.

Based on this calculation and the International Regulations for Preventing Collisions at Sea (COLREGS, 1972), the program will advise courses which comply with the COLREGS and have a risk value in the negligible rank.

The configuration of this module is shown in Figure 4.17.

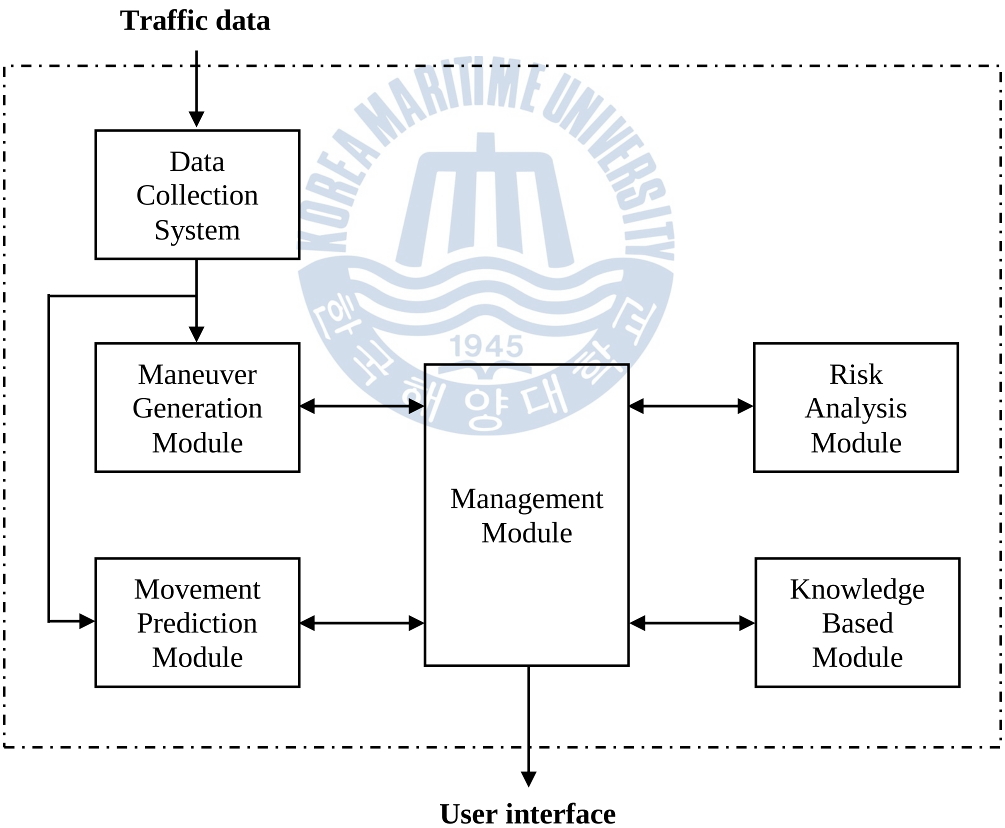


Figure 4.17 Configuration of the Collision Aseessment and Course Adviser module

This module can be integrated into the RTSS or developed to become a stand-alone program. In case it is integrated into the RTSS, the VTS officers will easily know the course which is safe for vessels in danger of collision. If the module is developed to become a Risk of Collision Alarm and Course Adviser System (CORAS) program, it can be used onboard vessels for helping officers alert risks of collision to all surrounding vessels, especially non-SOLAS vessels such as fishing boats, ocean barges, small tug boats, etc. In addition, it also gives him advice about safety courses for avoiding collisions.

Figure 4.18 shows the design of the CORAS's display. It is composed of own ship and target ship information and a risk circle.

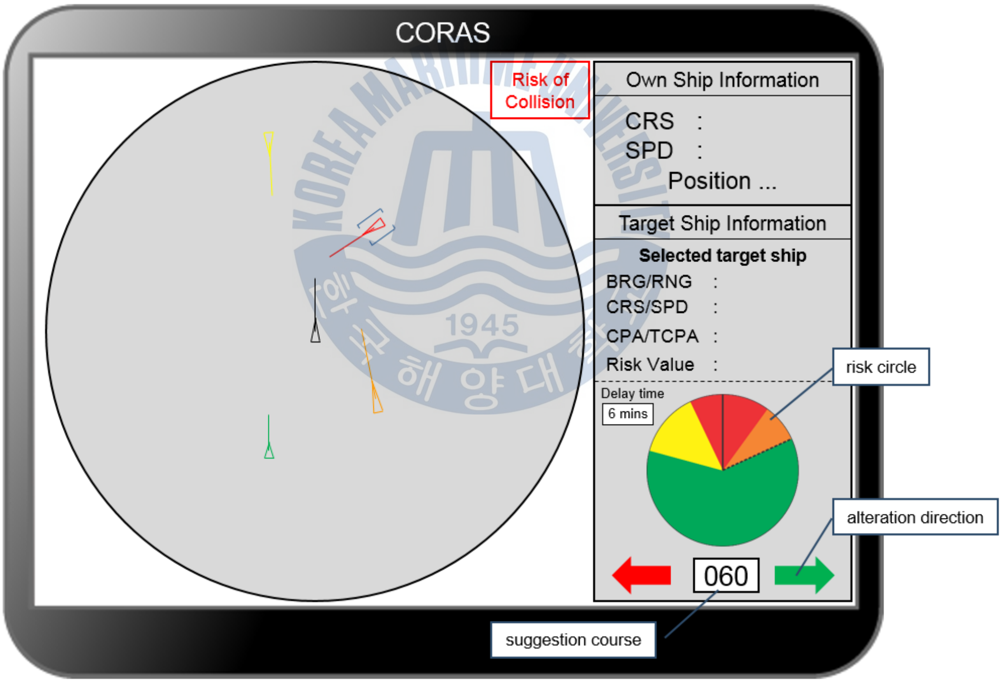


Figure 4.18 The design of the CORAS's display

Figures 4.19 to 4.22 show some screens of the CORAS program in tests

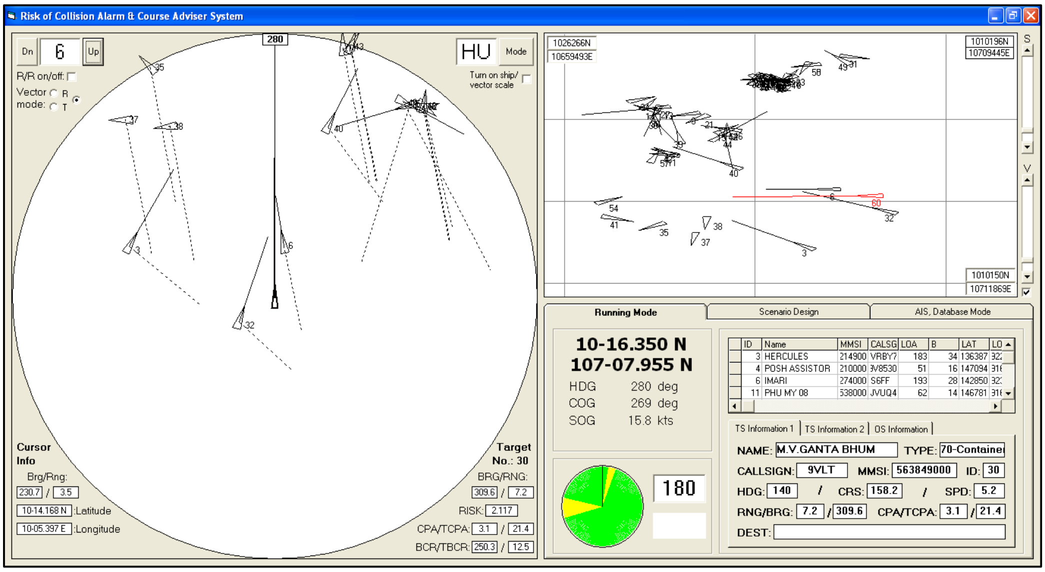


Figure 4.19 The main screen of the CORAS program (in test mode)

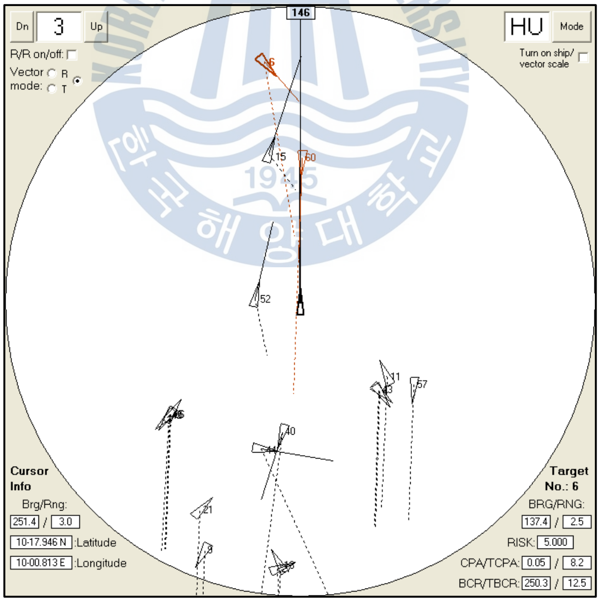


Figure 4.20 The radar screen of the CORAS program (in test mode)

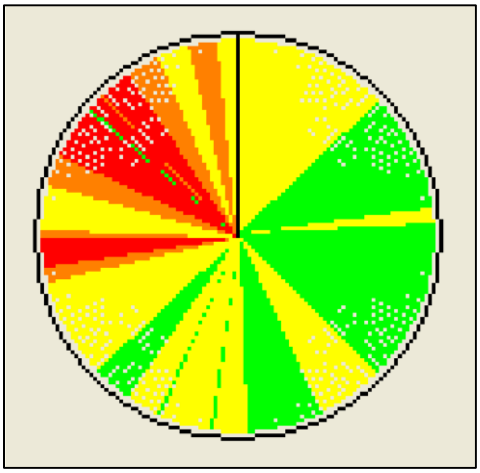


Figure 4.21 Risk circle when own ship makes a 360 degree turn

(in test mode)

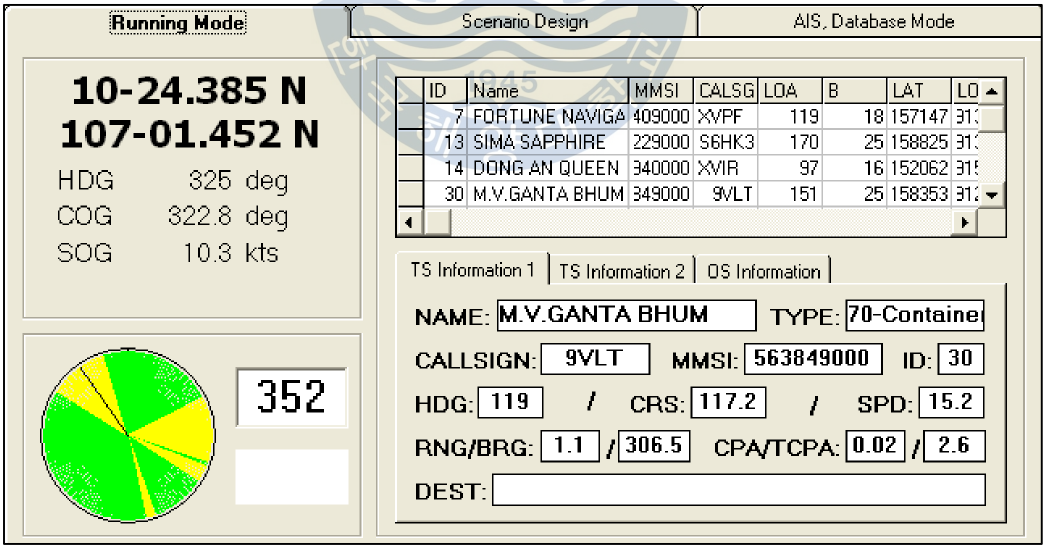


Figure 4.22 Information of own ship and target ships (in test mode)

Figure 4.23 shows the design screen of the RTSS when it is integrated with the CACA module. By integrating the RTSS with the CACA module, the VTS officers are able to know collision risks around any vessels. Together with this, the CACA module also gives VTS officers the advised course for reference, as shown in Figure 4.23. These two functions of the CACA module will help VTS officers more easily to recommend ship-handlers the safest course.

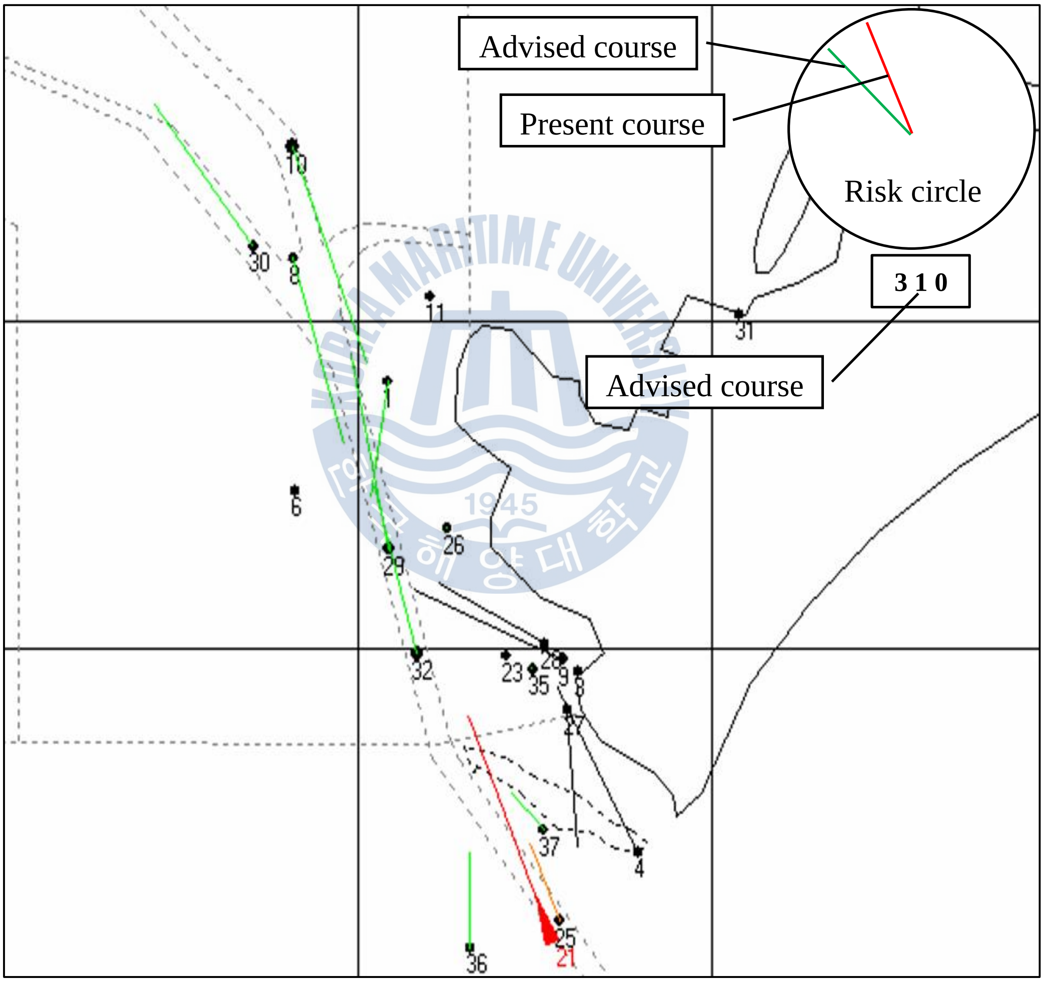


Figure 4.23 Design screen of the RTSS when it is integrated with the Collision Aseessment and Course Adviser module

4.5 Implementation and Operations Validation of the RTSS in the Vung Tau VTS Center

After finishing the checking procedure, the RTSS program was implemented in the Vung Tau VTS Center according to the following plan:

(1) Implementation of the system with the traffic data collected by Channel A of the DCM module (using an independent the AIS receiver).

(2) Evaluation and correction of the program

(3) Implementation of the system with the traffic data collected by Channel B of the DCM module (using data collected by the hardware of the VTS system)

(4) Evaluation, correction, and completion of the program

However, because of some restrictions, this dissertation only discusses the implementation of the RTSS using AIS data from an independent AIS receiver and evaluates the system based on the feedback of the VTS officers in the Vung Tau VTS Center.

4.5.1 Implementing the System Using AIS Data from the AIS Receiver

The implementation of this step in the Vung Tau VTS Center was carried out as follows:

(1) Introduce the risk assessment models in general and the PARK model in detail to the VTS officers

For the VTS officers in the Vung Tau VTS Center the concept of a Marine Traffic Safety Assessment Model is totally new, so to help them understand clearly the RTSS, some introductions about traffic safety assessment models were required. They learned about some types of marine traffic safety assessment models and the advantages and disadvantages of each type. Then all of them were introduced to the PARK model in detail as follows:

- Elements affecting marine traffic safety that are considered in the PARK model, such as: ship type, length, beam, crossing situation, distance, speed, etc.
- The survey method and the statistical analysis method to develop the formula for calculating the risk values
- The method of calibrating the risk value with the CPA and TCPA to get the corrected risk value
- The risk ranking scale based on the corrected risk value as shown in Figure 3.4

(2) Introduction to the configuration and operation flow-chart of the RTSS

For the purpose of understanding clearly the operation of the RTSS, the VTS officers were introduced to the configuration of the RTSS as shown in Figure 4.4 and its operation flow-chart as shown in Figure 4.24.

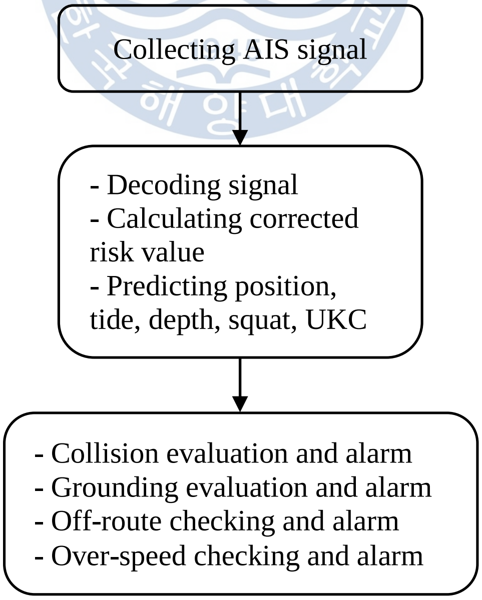


Figure 4.24 Operation flow-chart of the RTSS

(3) Introduction to using the RTSS

The VTS officers were introduced to using the RTSS program as follows:

- Open, start, pause, stop, close
- Meaning of alarms, turn on/off sound alarms
- Meaning of information on the screen
- Selecting sub-windows and setting their scale
- User settings
- etc.

(4) Installation and running the RTSS

To make the VTS officers more at ease when reading the alarm information, the RTSS monitor was installed close to the sitting position of the VTS officers, as shown in Figures 4.25 and 4.26.

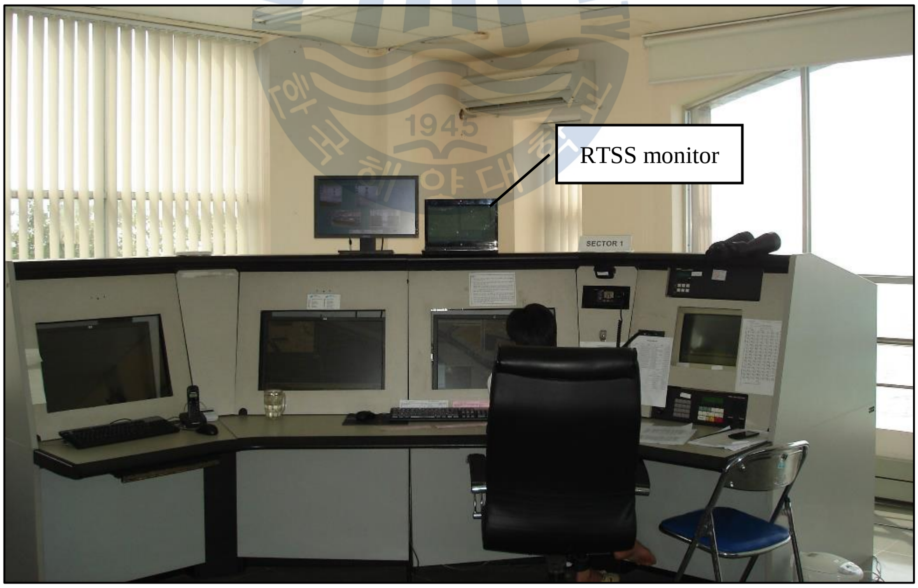


Figure 4.25 Position of the RTSS monitor on the console of each sector

Figure 4.26 Close view of the RTSS in working position

The RTSS was connected with an AIS receiver which operates independently of the VTS system.

In case there is a vessel which is in the “Critical” and/or “Catastrophic” degree of risk, the RTSS will sound an alarm and display an alarm message on the screen. At that moment the VTS officer will look at the screen and learn which vessel is in danger and where it is. Then he will verify the actual risk of the vessel based on his experience and give out appropriate timely respond action, if it is needed for supporting safe navigation of the vessel.

All the AIS data and alarm logs are stored to the database for replay if necessary.

4.5.2 Operations Validation of the System Based on Feedback of the VTS Officers

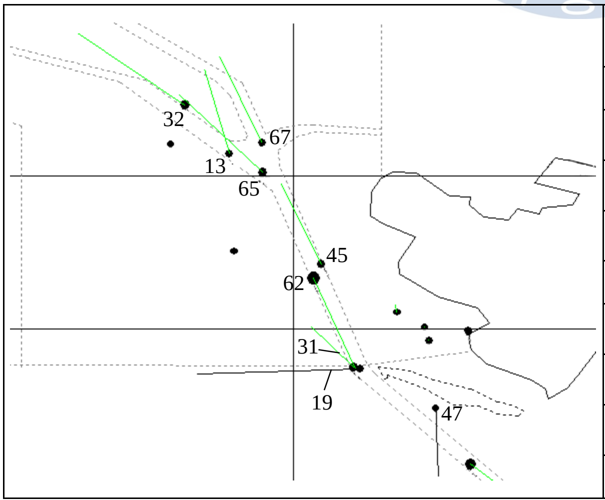
The RTSS is in trial operation in the Vung Tau VTS Center. For evaluating the advantages, disadvantages, and effects of the system, a questionnaire survey was carried out of the VTS officers in the Vung Tau VTS Center, who use the RTSS directly.

Six VTS officers were asked to answer the questionnaire form. They have about 1.2 years of experience as VTS officers and about two years of sea experience.

The questionnaire survey form is presented in Annex 2. The following is a summary of replies to this survey.

*** Question 1**

In this question the VTS officers were shown six traffic situations as in Figure 4.27. In each traffic situation the VTS officers were asked to circle the ships that are confronting risks of collision. The VTS officers have to use VHF communication to support them.



ID	Name	Type	LOA	Beam	Draft	CRS	SPD
32	KUO HSIUNG	Cont.	166	27	6.9	321	11.6
13	HONG HA GAS	Tanker	79	12	4.0	351	10.7
65	UNI PROMOTE	Cont.	182	28	8.6	330	11.4
67	BBC GDANSK	General cargo	122	18	6.1	345	11.2
45	PRIME SUN	Tanker	130	24	8.1	345	10.5
62	MOL COSMOS	Cont.	320	46	10.6	166	11.8
31	JAKARTA BRIDGE	Cont.	172	28	9.4	330	5.9
19	PETRO EXPRESS 05	Others	Hydrofoil passenger vessel				
47	HAI LONG	Others	Pilot boat				

Figure 4.27 A sample traffic situation in Question 1

According to the PARK model, when the corrected risk value is over 4.0, the vessel is in the “Marginal” rank. That means the risk of collision exists; however, the ship-handler still should be able to control his vessel safely by himself. But when the corrected risk is over 5.0, the vessel will be in the “Critical” rank. That means it is very difficult for him to control his vessel safely. In this case the possibility of a risk is becoming an accident is clearer. The VTS officers should support the ship-handlers to pass the waterway safely.

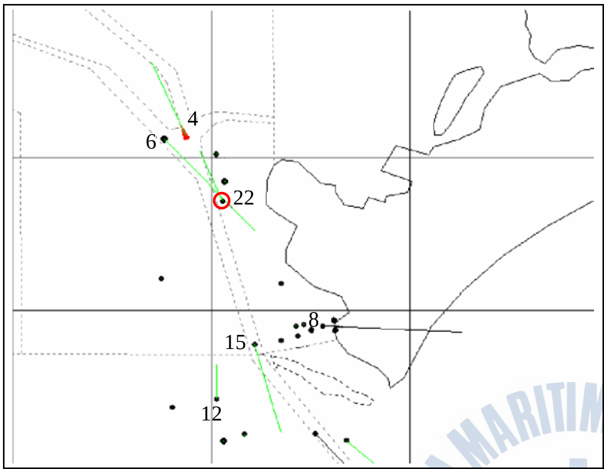
Table 4.3 shows a summary of survey results of Question 1. Column Three shows the identification number of vessels which are circled (selected) by more than 50% of VTS officers. Column Four shows vessels which have a corrected risk value over 5.0. Column Five shows the percentage of matching between Columns Three and Four.

Table 4.3 Summary of the survey results of Question 1

Situa_ tions No.	**Total number of vessels in situation**	**Identification number of vessels that should be supported according to…**		**Percentage of matching between VTSOs opinions and the PARK model**
		VTSOs (selected by over 50% of VTSOs)	**the PARK model (Risk > 5.0)**	
(1)	(2)	(3)	(4)	(5)
1	6	6, 22	6, 22	100 %
2	4	6, 20	20	50%
3	5	9, 20	9, 20	100%
4	7	13, 68, 32	13, 68	66%
5	9	13, 31, 62, 65, 67	31, 65	40%
			Average	**71%**
			Un-matching (different) rate	**29%**

*** Question 2**

The VTS officers were asked to evaluate the collision risk of a vessel based on the rank scale of the PARK model (1-Negligible/ 2-Marginal/ 3-Critical/ 4-Catastrophic). A sample traffic situation from this question is shown in Figure 4.28



ID	Name	Type	LOA	Beam	Draft	CRS	SPD
4	GAS MOXIE	Tanker	122	20	4.9	340	10
6	CAPE FELTON	Cont.	170	25	8.9	143	14.8
22	EVEREST 1	Cont.	64	13	5.4	341	6.8
12	0____0	Fishing boat					
15	JAYA CONFIDENCE	Cont.	71	17	5.1	167	11.5
8	VSP EXPRESS	Others	53	10	3.5	137	14.3

☐ Negligible ☐ Marginal ☐ Critical ☐ Catastrophic

Figure 4.28 A sample traffic situation in Question 2

Table 4.4 shows a summary of survey results of this question. The results show that the average difference between the assessment of the VTS officers and the PARK model is 0.4. Because the maximum deviation is 3.0, so the different rate is about 10%.

Table 4.4 Summary of the survey results of Question 2

Situations No.	**Average assessment results of VTSO** (converted to scale from 0 to 7)	**Standard deviation**	**Assessment results of the PARK model**	**Differences between the PARK model and the VTSOs**
1	5.4	0.3	6.0	-0.6
2	5.5	0.5	4.8	0.7
3	5.3	0.4	5.0	0.3
4	5.9	0.6	5.0	0.9
5	4.8	0.2	4.0	0.8
Average / Standard deviation				**0.4 / 0.6**

*** Question 3**

VTS officers were asked to give their ideas after using the RTSS. Namely, they were asked to evaluate the exactness of alarm notifications by comparing them with the actual traffic conditions of the vessel at the notification time based on the scale: 1-Always different/ 2-Usually different/ 3-Sometimes different, sometimes same/ 4-Usually same/ 5-Always same.

The average result of this question is 3.7, that closes to the answer "Usually same". This means the alarm notifications of the RTSS are usually same with the actual traffic condition of the vessel for which there was an alarm.

*** Question 4**

VTS officers were asked: "Does the program confuse you because you have to focus on more information when working?". In this question about 66.7% of the VTS officers thought that they did not meet any difficulty when they had to expand their focus to the RTSS monitor.

*** Question 5**

VTS officers were asked to evaluate the usefulness of the RTSS. They were asked to answer the question: "If the RTSS program can give correct alarms, do you think that it will be a useful program for VTS officers?". 100 percent of VTS officers agreed that the RTSS is a useful and a necessary program for supporting VTS officers, if the alarm functions work correctly.

Generally, the results of the questionnaire survey of VTS officers in the Vung Tau VTS Center show that:

(1) The difference between the evaluation of the VTS officers and of the PARK model is about 30% in Question 1 and about 10% in Question 2. This means that the results calculated by the PARK model can be a good level to assess risks of collision for the VTS officers

(2) According to the summary results of Question 3, the alarm notifications of the RTSS are usually suitable to the actual traffic conditions of the vessel in alarm. This is the assessment of the VTS officers after using the RTSS and receiving thousands of notifications from it. Together with results of Questions 1 and 2, it is shown that the PARK model is a suitable model to be used to assess risks of collision in the Vung Tau Waterway

(3) The results of Questions 4 and 5 show that all VTS officers think that the RTSS is a useful tool and that its reliability should be improved to make it become an indispensable supporting tool for the VTS officers. In addition, most of them said that the RTSS does not cause any confusion when they have to extend their focus to it while working.

Chapter 5 Conclusions and Future studies

The Vung Tau Waterway is a waterway which plays a very important role in the marine transportation system in southern Vietnam. The marine traffic safety in this waterway has a great impact on the economic development of Ho Chi Minh City, Dong Nai Province, and Ba Ria-Vung Tau Province.

This disertation attempts to find a solution for improving marine traffic safety in this area. Accordingly, the affects of marine environment factors, such as winds, currents, tides, waves, fog, rain, widths and depth of waterway on captains and pilots (ship-handlers) were evaluated by survey results with experts and comparision results with guidelines from the PIANC. This first step demonstrated that the marine environment factors are not the main factors which affect traffic safety in the waterway.

Following this step, the marine traffic in this area was surveyed by using a remote survey system based on the AIS data in combination with data from other sources, such as the Vietnam Maritime Administration, VTS officers, Port Control officers, Border Guard Department officers, and fishermen. The survey results showed that the disorderly movement of ocean-going vessels, inland waterway vessels, off-shore fishing boats, and fishing activities inside the Vung Tau Waterway are the main factors which affect marine traffic safety in the waterway.

From the above analysis an idea arose that improving the effectiveness of the Vung Tau VTS Center would help to reduce the "dis-order" movement of vessels with better support and organization.

Thus, the organization, human resources, and hardware specifications of the Vung Tau VTS Center were studied to discover a specific solution. This study showed that most VTS officers there lack sea experience as well as VTS operations experience. If there should be a supporting system which is able to help them learn about the collision risks of a vessel, it would improve their working competency. So effectiveness of the Vung Tau VTS Center will be improved and obviously, it will help to improve the marine traffic safety in the area.

The plan for improving marine traffic safety used in this dissertation is developing a Real Time Supporting System (RTSS) for VTS officers that is able to alert vessels in collision risk situations.

Based on a study on comparing the ES model and the PARK model in the Busan waterway and then studying the suitableness of the PARK model for the Vung Tau Waterway, the PARK model was selected to develop the RTSS.

Finally, the RTSS has been developed and implemented in the Vung Tau VTS Center and it has received active feedback from the VTS officers.

The following are the findings of the study:

(1) Marine environment in the Vung Tau Waterway was analysed and its affects on ship-handlers were evaluated based on the assessment of pilots and on the standards of PIANC guidelines. The results show that marine environment factors in the Vung Tau Waterway such as winds, currents, tides, waves, fog, rain, and width and depth of waterway have only a small affect on traffic safety in the waterway

(2) Traffic in the Vung Tau Waterway was surveyed based on AIS data, statistical data, and interviews. The survey results showed that there is ocean-going vessels traffic (6 routes), inland waterway vessels traffic, off-shore fishing boats traffic (2 routes), and traffic of fishing boats that operate inside the waterway. The number of vessels passing this area was about 60 crossings/day in 2012. This number is projected to increase by about 5% a year in next few years. The number of vessels which have a length over

150 m is increasing while the number below 150 m is decreasing. Along the fairway both the larteral traffic distribution of in-bound and out-bound vessels distribute along the entire width of the fairway

(3) A quantitative assessment of marine traffic safety in the area was carried out by using the IWRAP model. The results showed that risk of collision accidents in the Sai Gon-Vung Tau Fairway from Buoy No.0 to Buoys No.4-5 is the highest in the waterway. Following danger points are parts of the Sai Gon-Vung Tau Fairway from Buoys No.4-5 to Buoys No.11-12 and from Buoy "GR" to Buoys No.7-8A.

(4) Through traffic survey and assessment by using the IWRAP model, it was shown that the "dis-order" movement of vessels in the Vung Tau Waterway is the main factor which affects traffic safety in this waterway. There are many solutions that can help to solve this problem. One feasible and effective solution is improving effectiveness of the Vung Tau VTS Center

(5) The survey of the Vung Tau VTS Center shows its effectiveness is still restricted by the lack of sea experience and working experience of VTS officers. So there is a need to establish a supporting system to support VTS officers for improving their competency and the Vung Tau VTS Center's efficiency. The supporting system should be able to help the VTS officers to assess collision risks of vessels quantitatively in real time. It must be built based on an assessment model that takes into account the risk of human factors

(6) Through analysis it was found that the assessment models other than the ES model and the PARK model use statistical or experts' opinions methods and do not take into account the risk of the human factors. So these models cannot be used for developing the supporting system. By comparing the ES model and the PARK model in the Vung Tau Waterway, the PARK model

was proved more appropriate than the ES model, based on some qualitative analysis such as:

a. Considering elements which affect the safe navigation of vessels
b. Analysing and applying results of the study on comparision assessment using the ES model and the PARK model in the Busan waterway
c. Comparing the assessment results of the ES model and the PARK model with the IWRAP model
d. Comparing the assessment results of the ES model and of the PARK model with statistical data of collision accidents in recent years

(7) The Real Time Support System (RTSS) for VTS officers has been developed. The system is able to evaluate the collision risks of vessels based on the PARK model in real time and to alert vessels that run a risk of collision. In addition, it is also able to alert vessels that are going aground, sailing off-route, or sailing over-speed. For further analysis of traffic situations, it can play back past traffic in the area for any period of time. Also, all alarm notifications are saved to an archive file for reference

(8) The RTSS was put into trial operation at the Vung Tau VTS Center. After beginning to use it, the VTS officers have commented as follows:

a. The alarms are usually suitable to the actual traffic situation of the vessels
b. They do not experience more difficulty when they have to focus on one more monitor during their duty time
c. All report that, if the alarm functions are improved for higher precision, the RTSS will be a very useful supporting system

In the future, the following studies should be carried out:

(1) Converting the PARK model to make it more suitable to the traffic in the Vung Tau Waterway by considering the affects of other factors of the marine environment and marine traffic conditions in the Vung Tau Waterway such as the affect of narrow waters on depth-draft vessels, the affect of fishing boats, etc.

(2) Connecting the RTSS with the VTS system so it can obtain traffic data of all ships passing in the waterway. At that time the RTSS will expand its range and the number of targets can be monitored;

(3) Improving the stability, speed, and user-friendliness of the program

(4) Adding supplementary functions, such as:

    a. Alerting vessels which may over take or be ahead at the bends of fairways

    b. Assisting VTS officers on traffic organization for preventing congested situations

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[2] Nguyen Xuan Thanh, Park Youngsoo, Park Jinsoo, Jae Yong Jeong (2013), Developing a Program to Pre-process AIS Data and Applying to Vung Tau Waterway in Vietnam – Based on the IWRAP Mk2 program, Journal of the Korean Society of Marine Environment & Safety, Vol. 19, No. 4, pp. 345-351

[3] Nguyen Xuan Thanh (2013), "Application of AIS on Marine Traffic Survey", Journal of Transportation Science and Technology, Vol.4-02/2013, pp.34-39

Proceedings:

[1] Nguyen Xuan Thanh, Park Youngsoo, Park Jinsoo (2012), "Study on the Marine Traffic in the adjacent of the Sai Gon – Vung Tau Fairway to manage Marine Safety", Proceedings of The Asia Navigation Conference 2012, pp.435-442

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Annex 1

PHIẾU THAM KHẢO Ý KIẾN
QUESTIONNAIRE SURVEY FORM

Thưa Quý Ông,
Dear Gentlemen,

Nhằm phục vụ cho công tác nghiên cứu một cách toàn diện nhằm tìm ra giải pháp nâng cao an toàn hàng hải ở vùng nước Vũng Tàu, nhóm nghiên cứu đứng đầu là T.S., Thuyền trưởng Lê Văn Ty, Trưởng Khoa Hàng hải - ĐH GTVT TP.HCM xây dựng phiếu này với mục đích tham khảo ý kiến của các Hoa tiêu, Thuyền trưởng và các Sĩ quan VTS…(những người thường xuyên làm công tác liên quan trực tiếp đến dẫn tàu qua vùng nước nói trên) về các vấn đề sau:

“Ảnh hưởng của điều kiện môi trường gió, dòng chảy, mưa và sương mù đến người dẫn tàu khi đi qua vùng nước Vũng Tàu”

Trong phiếu thăm dò này, người được thăm dò không yêu cầu phải cung cấp các thông tin cá nhân. Thay vào đó là những thông tin liên quan về nghề nghiệp như: vị trí, kinh nghiệm công tác, thâm niên đi biển... để làm tăng chất lượng và độ tin cậy của cuộc khảo sát.

Chúng tôi trân trọng và cảm ơn sự đóng góp quý báu của Quý Ông.

For the purpose of research to discover a comprehensive solution to improve the marine traffic safety in the Vung Tau Waterway, the research team headed by Dr. Captain Le Van Ty (Dean of Navigation Faculty - UT HCMC), devised this form for the purpose of consultation with the Pilots, Captains and VTS Officers who do work directly related to ship-handling in the waterway about following matters:

"Evaluation affects of marine environment factors such as winds, currents, rain, and fog on ship-handlers when passing the Vung Tau Waterway"

The respondent is not required to provide personal information. Instead, the relevant information on careers such as position, working experience, and sea experience are sought to increase the quality and reliability of the survey.

We appreciate and thank you in advance for your valuable contributions!

THÔNG TIN CỦA NGƯỜI ĐƯỢC THĂM DÒ

THE ANSWERER INFORMATION

Công việc của Ông hiện tại: (đánh dấu √ vào ô phù hợp)

Your present job (mark √on the appropriate box)

A. ☐ Pilot B. ☐ Master C. ☐ VTS Officer

Kinh nghiệm nghề nghiệp/*Working experience*:

A. Pilot :................. years

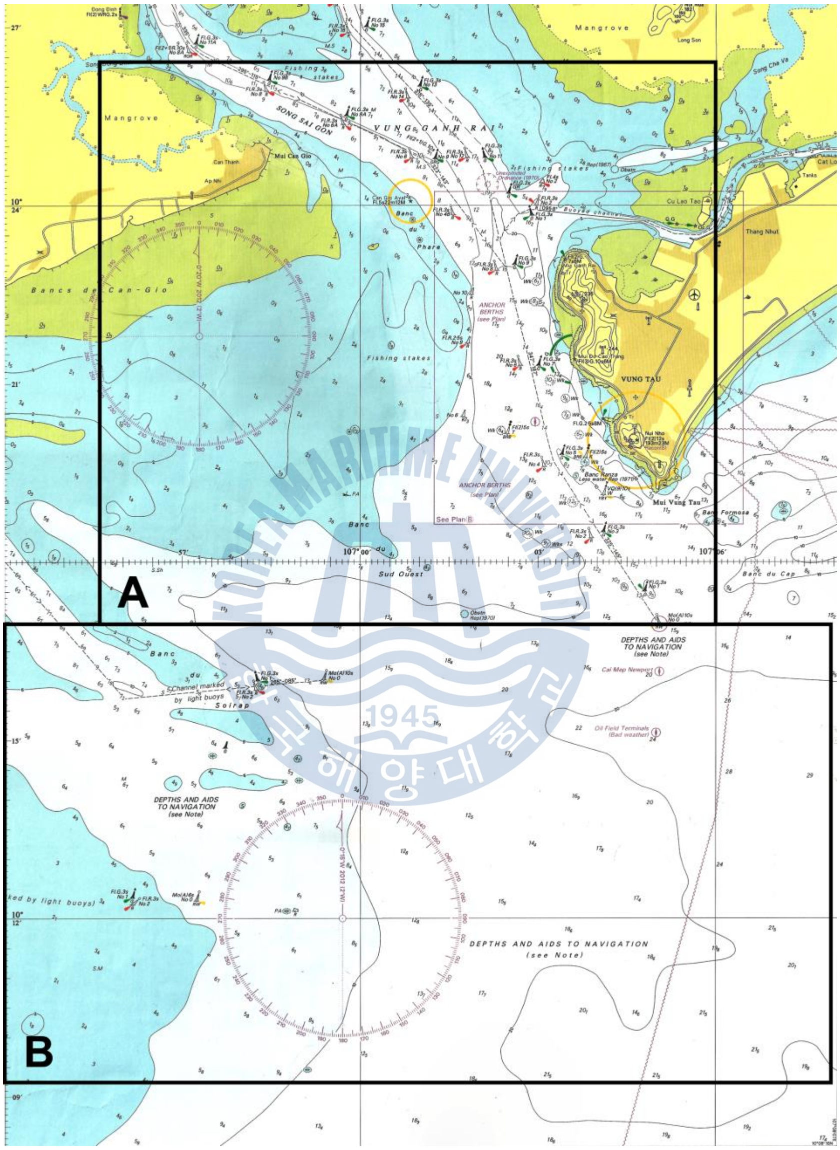
B. Master :................. years

C. VTS Officer :................. years

Kinh nghiệm đi biển/*Sea experience*:…………… years

Vùng nước Vũng Tàu (sau đây gọi tắt là khu vực nghiên cứu) được phân thành 2 vùng như hải đồ sau:

The Vung Tau Waterway (abbreviated to "research area") is divided into 2 parts as in the following figure



Hai khu vực của vùng nước Vũng Tàu

The two parts of Vung Tau Waterway

QUESTION	Level of effect Negative <----------------> Positive						
	-3	-2	-1	0	1	2	3
1. Xin vui lòng cho biết đánh giá của Ông về mức độ ảnh hưởng của DÒNG CHẢY đến việc dẫn tàu CHẠY XUÔI DÒNG trong khu vực với các cỡ tàu sau: ***Would you please give your evaluation about the effect of CURRENT to vessel when sails FOLLOWING current in some cases below:*** (-3: mất lái / -2: gây trôi dạt mạnh / -1: gây ăn lái kém, trôi dạt / 0: không ảnh hưởng / 1: tăng hiệu quả nghe lái / 2: tăng hiệu quả nghe lái rõ rệt / 3: tăng hiệu quả nghe lái rất rõ rệt) *(-3: not under command / -2: strong drifting / -1: reduce steering ability / 0: neutral / +1: increase steering ability / +2: increase steering ability clearly / +3: increase steering ability very clearly)*							
a. Ballast, LOA 50 - 100 m	☐	☐	☐	☐	☐	☐	☐
b. Ballast, LOA 100 - 150 m	☐	☐	☐	☐	☐	☐	☐
c. Ballast, LOA 150 - 200 m	☐	☐	☐	☐	☐	☐	☐
d. Ballast, LOA over 200 m	☐	☐	☐	☐	☐	☐	☐
e. Full load, LOA 50 - 100 m	☐	☐	☐	☐	☐	☐	☐
f. Full load, LOA 100 - 150 m	☐	☐	☐	☐	☐	☐	☐
g. Full load, LOA 150 - 200 m	☐	☐	☐	☐	☐	☐	☐
h. Full load, LOA over 200 m	☐	☐	☐	☐	☐	☐	☐
2. Xin vui lòng cho biết đánh giá của Ông về mức độ ảnh hưởng của DÒNG CHẢY đến việc dẫn tàu CHẠY NGƯỢC DÒNG trong khu vực với các cỡ tàu sau: ***Would you please give your evaluation about the effect of CURRENT to vessel when sails AGAINST current in some cases below:*** (-3: mất lái / -2: gây trôi dạt mạnh / -1: gây ăn lái kém, trôi dạt / 0: không ảnh hưởng / 1: tăng hiệu quả nghe lái / 2: tăng hiệu quả nghe lái rõ rệt / 3: tăng hiệu quả nghe lái rất rõ rệt) *(-3: not under command / -2: strong drifting / -1: reduce steering ability / 0: neutral / +1: increase steering ability / +2: increase steering ability clearly / +3: increase steering ability very clearly)*							
a. Ballast, LOA 50 - 100 m	☐	☐	☐	☐	☐	☐	☐
b. Ballast, LOA 100 - 150 m	☐	☐	☐	☐	☐	☐	☐
c. Ballast, LOA 150 - 200 m	☐	☐	☐	☐	☐	☐	☐
d. Ballast, LOA over 200 m	☐	☐	☐	☐	☐	☐	☐
e. Full load, LOA 50 - 100 m	☐	☐	☐	☐	☐	☐	☐
f. Full load, LOA 100 - 150 m	☐	☐	☐	☐	☐	☐	☐
g. Full load, LOA 150 - 200 m	☐	☐	☐	☐	☐	☐	☐
h. Full load, LOA over 200 m	☐	☐	☐	☐	☐	☐	☐

QUESTION	Level of effect Negative <----------------> Positive						
	-3	-2	-1	0	1	2	3

3. Xin vui lòng cho biết đánh giá của Ông về mức độ ảnh hưởng của GIÓ ĐÔNG BẮC (trên cấp 4) đến việc dẫn tàu trong khu vực với các cỡ tàu sau:
Would you please give your evaluation about the effect of NE WIND (over force 4) to vessel in some cases below:
(-3: mất lái / -2: gây trôi dạt mạnh / -1: gây ăn lái kém, trôi dạt / 0: không ảnh hưởng / 1: tăng hiệu quả nghe lái / 2: tăng hiệu quả nghe lái rõ rệt / 3: tăng hiệu quả nghe lái rất rõ rệt)
(-3: not under command / -2: strong drifting / -1: reduce steering ability / 0: neutral / +1: increase steering ability / +2: increase steering ability clearly / +3: increase steering ability very clearly)

QUESTION	-3	-2	-1	0	1	2	3
a. Ballast, LOA 50 - 100 m	☐	☐	☐	☐	☐	☐	☐
b. Ballast, LOA 100 - 150 m	☐	☐	☐	☐	☐	☐	☐
c. Ballast, LOA 150 - 200 m	☐	☐	☐	☐	☐	☐	☐
d. Ballast, LOA over 200 m	☐	☐	☐	☐	☐	☐	☐
e. Full load, LOA 50 - 100 m	☐	☐	☐	☐	☐	☐	☐
f. Full load, LOA 100 - 150 m	☐	☐	☐	☐	☐	☐	☐
g. Full load, LOA 150 - 200 m	☐	☐	☐	☐	☐	☐	☐
h. Full load, LOA over 200 m	☐	☐	☐	☐	☐	☐	☐

4. Xin vui lòng cho biết đánh giá của Ông về mức độ ảnh hưởng của GIÓ TÂY NAM (trên cấp 4) đến việc dẫn tàu trong khu vực với các cỡ tàu sau:
Would you please give your evaluation about the effect of SW WIND (over force 4) to vessel in some cases below:
(-3: mất lái / -2: gây trôi dạt mạnh / -1: gây ăn lái kém, trôi dạt / 0: không ảnh hưởng / 1: tăng hiệu quả nghe lái / 2: tăng hiệu quả nghe lái rõ rệt / 3: tăng hiệu quả nghe lái rất rõ rệt)
(-3: not under command / -2: strong drifting / -1: reduce steering ability / 0: neutral / +1: increase steering ability / +2: increase steering ability clearly / +3: increase steering ability very clearly)

QUESTION	-3	-2	-1	0	1	2	3
a. Ballast, LOA 50 - 100 m	☐	☐	☐	☐	☐	☐	☐
b. Ballast, LOA 100 - 150 m	☐	☐	☐	☐	☐	☐	☐
c. Ballast, LOA 150 - 200 m	☐	☐	☐	☐	☐	☐	☐
d. Ballast, LOA over 200 m	☐	☐	☐	☐	☐	☐	☐
e. Full load, LOA 50 - 100 m	☐	☐	☐	☐	☐	☐	☐
f. Full load, LOA 100 - 150 m	☐	☐	☐	☐	☐	☐	☐
g. Full load, LOA 150 - 200 m	☐	☐	☐	☐	☐	☐	☐
h. Full load, LOA over 200 m	☐	☐	☐	☐	☐	☐	☐

QUESTION	Level of effect Negative <----------------> Positive						
	-3	-2	-1	0	1	2	3
5. Xin vui lòng cho biết đánh giá của Ông về mức độ ảnh hưởng của MƯA VÀ SƯƠNG MÙ đến việc dẫn tàu trong khu vực với các cỡ tàu sau: ***Would you please give your evaluation about the effect of RAIN and FOG to vessel in some cases below:*** (-3: phải dừng tàu / -2: chỉ quan sát được bằng radar / -1: hạn chế cho việc quan sát bằng mắt thường / 0: không ảnh hưởng) *(-3: have to stop navigation / -2: can look out by radar only / -1: cause some restriction to look out by eye / 0: neutral)*							
a. 50 < LOA <100	□	□	□	□			
b. 100 < LOA <150	□	□	□	□			
c. 150 < LOA <200	□	□	□	□			
d. 200 < LOA	□	□	□	□			

Annex 2

PHIẾU THAM KHẢO Ý KIẾN
QUESTIONNAIRE SURVEY FORM

Kính gửi: Các điều hành viên và Giám sát viên VTS tại trạm VTS Vũng Tàu
Dear VTS Officers and VTS Supervisors in the Vung Tau VTS Center

Kính thưa Quý vị, nâng cao an toàn giao thông thủy ở vùng nước Vũng Tàu là mục tiêu mà chúng ta cùng hướng đến. Với mong muốn được đóng góp một phần nhỏ bé cho mục tiêu ấy, tôi đã nghiên cứu và xây dựng phần mềm hỗ trợ người điều hành viên VTS theo thời gian thực (tạm đặt tên là RTSS). Phần mềm sẽ đánh giá nguy cơ đâm va giữa các tàu và đưa ra các cảnh báo nhằm giúp người điều hành viên VTS lưu ý đến an toàn giao thông của các tàu này để có thể hỗ trợ kịp thời nhằm ngăn ngừa các rủi ro có thể xảy ra. Phần mềm được xây dựng dựa trên mô hình PARK (Potential Assessment of Risk), được phát triển tại Hàn Quốc, để đánh giá rủi ro đâm va giữa các tàu.

Phiếu tham khảo ý kiến này được xây dựng và gửi đến Quý vị với mong muốn nhận được ý kiến đánh giá quý báu của Quý vị về các nội dung:

- Các đánh giá về an toàn giao thông theo mô hình (thuật toán) sử dụng trong phần mềm có phù hợp với thực tế giao thông tại vùng nước Vũng Tàu hay không?;
- Các ưu và khuyết điểm của phần mềm;
- Các đóng góp của Quý vị để cải thiện phần mềm.

Rất mong nhận được sự hỗ trợ và giúp đỡ của Quý vị để phần mềm có thể trở thành một công cụ (tool) hữu ích trợ giúp cho người điều hành viên VTS.

Chân thành cảm ơn!

Dear Ladies and Gentlemen, Improving marine traffic safety in the Vung Tau Waterway is the goal which we are directing toward. With a desire to make my small contribution to this purpose, I did research to build a program for supporting the VTS officers there in real time. It is called RTSS (Real Time Supporting System for VTS officers). The program will evaluate risks of collision of all ships and then give alarms to vessels that have risks of collision. This will help the VTS officers pay attention to these vessels and give them timely support for preventing accidents. The program was developed based on the PARK (Potential Assessment of Risk) model, developed in Korea, for evaluating collision risks.

This questionnaire form is made and given to you with a desire to receive your valuable ideas about the following matters:

- *The collision assessment model used in the application is suitable to the actual traffic in the Vung Tau Waterway or not?*
- *The advantages and disadvantages of the program*
- *Your valuable ideas for improving the program*

I hope that I could receive your support and help for making the program become a useful tool for supporting for the VTS officers.

We appreciate and thank you in advance for your valuable contributions!

I. Thông tin cơ bản của người được tham khảo ý kiến

Some general information of person who was asked to answer this questionnaire form.

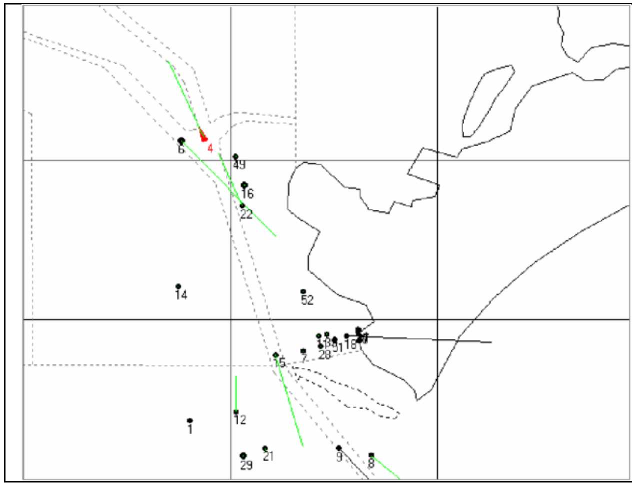
– Số năm làm việc tại trạm VTS Vũng Tàu ở vị trí điều hành viên/ giám sát viên VTS : ________ năm
How many years have you worked in the Vung Tau VTS Center as VTS Officer and/or VTS supervisor?

– Số năm kinh nghiệm đi biển : ________ năm
How many year did you have in sea experience?

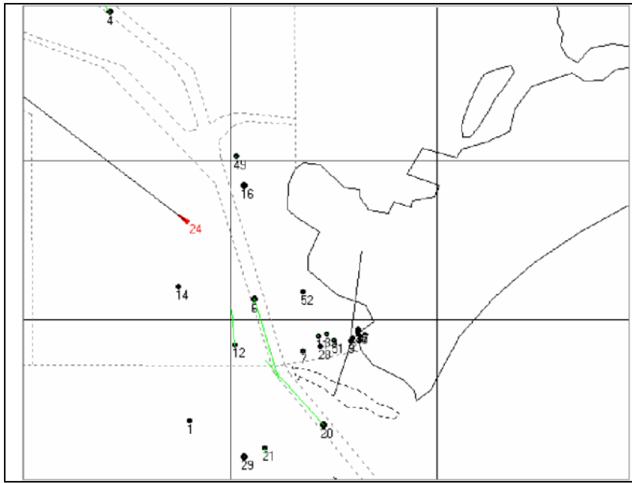
II. Các câu hỏi tham khảo ý kiến *(Questions for asking your own ideas)*

1. Bạn vui lòng khoanh tròn một hoặc nhiều tàu trong các tình huống sau, mà theo bạn đang có rủi ro đâm va cao và người sĩ quan VTS cần phải cung cấp thông tin hỗ trợ cho các tàu đó (thông qua liên lạc VHF) để đảm bảo an toàn giao thông.

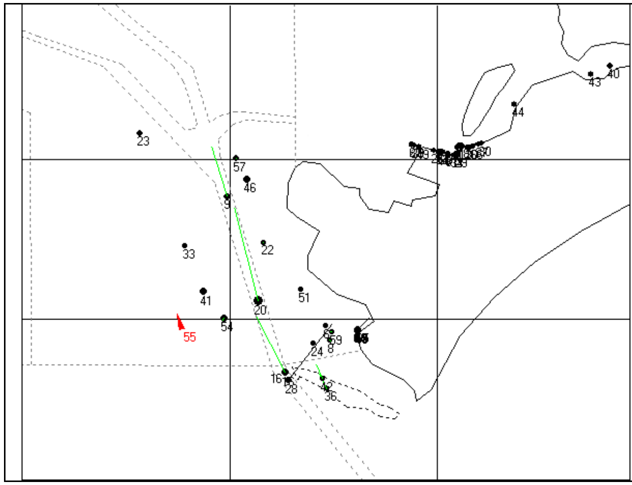
In your opinion, please circle one or many vessels, in the following situations, which have high risk of collision that a VTS Officer should give them supported information (through VHF communication) to secure the marine traffic safety.



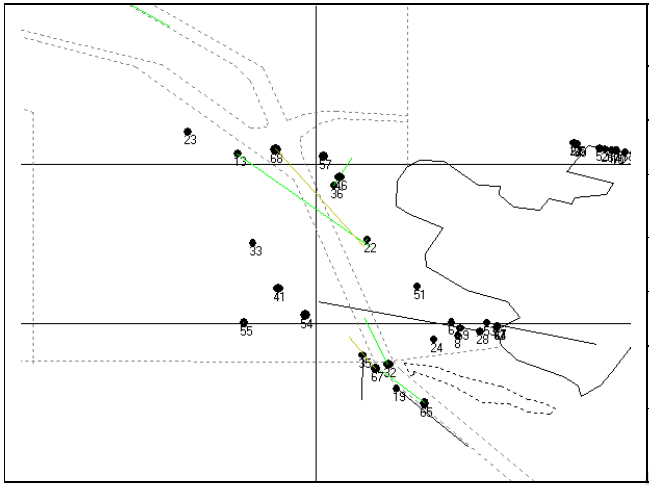
ID	Name	Type	LOA	Beam	Draft	CRS	SPD
4	GAS MOXIE	Tanker	122	20	4.9	340	10
6	CAPE FELTON	Cont.	170	25	8.9	143	14.8
22	EVEREST 1	Cont.	64	13	5.4	341	6.8
12	0____0	Fishing boat					
15	JAYA CONFIDENCE	Cont.	71	17	5.1	167	11.5
8	VSP EXPRESS	Others	53	10	3.5	137	14.3



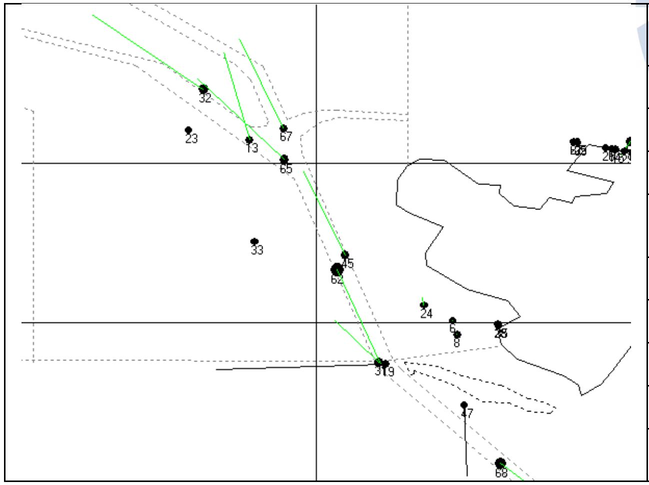
ID	Name	Type	LOA	Beam	Draft	CRS	SPD
24	PETRO EXPRESS 05	Others	Hydrofoil passenger vessel				
12	0____0	Fishing boat					
6	CAPE FELTON	Cont.	170	25	8.9	167	10.1
20	BOONTRIKA NAREE	General cargo	176	26	9.5	325	9.6



ID	Name	Type	LOA	Beam	Draft	CRS	SPD
9	GOLDEN NEXUS	Cont.	112	19	5.6	346	6.2
20	EVER ELITE	Cont.	299	42	9.0	349	11.5
16	SILVER SHADOW	Cont.	186	25	6.1	339	7.3
42	TAU CA 24	Fishing boat					
36	TAU CA 25	Fishing boat					



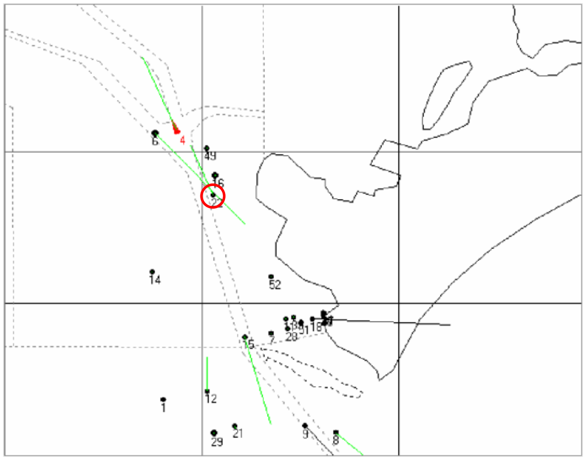
ID	Name	Type	LOA	Beam	Draft	CRS	SPD
13	HONG HA GAS	Tanker	79	12	4.0	143	14.3
68	APL CAIRO	Cont.	207	29	9.2	154	13.2
67	BBC GDANSK	General cargo	122	18	6.1	336	4.3
32	KUO HSIUNG	Cont.	166	27	6.9	344	5.8
65	UNI PROMOTE	Cont.	182	28	8.6	324	4.8
36	TAU CA 24	Fishing boat					
46	TAU CA 25	Fishing boat					



ID	Name	Type	LOA	Beam	Draft	CRS	SPD
32	KUO HSIUNG	Cont.	166	27	6.9	321	11.6
13	HONG HA GAS	Tanker	79	12	4.0	351	10.7
65	UNI PROMOTE	Cont.	182	28	8.6	330	11.4
67	BBC GDANSK	General cargo	122	18	6.1	345	11.2
45	PRIME SUN	Tanker	130	24	8.1	345	10.5
62	MOL COSMOS	Cont.	320	46	10.6	166	11.8
31	JAKARTA BRIDGE	Cont.	172	28	9.4	330	5.9
19	PETRO EXPRESS 05	Others	Hydrofoil passenger vessel				
47	HAI LONG	Others	Pilot boat				

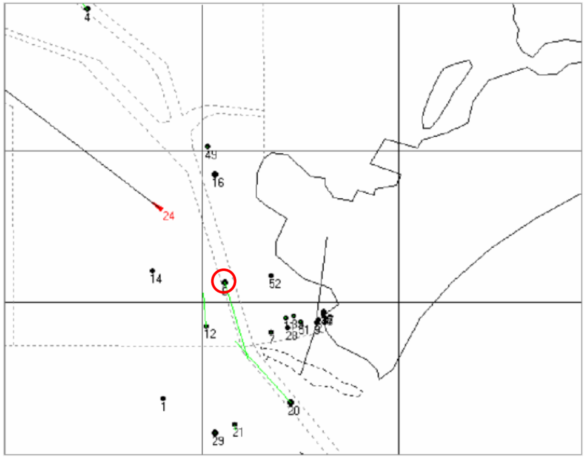
2. Bạn vui lòng cho biết, theo đánh giá của bạn thì mức độ rủi ro đâm va của tàu được khoanh tròn trong hình thuộc mức nào trong 4 mức sau: Không có nguy cơ đâm va / Có nguy cơ đâm va / Có nhiều nguy cơ đâm va / Nguy cơ đâm va là không tránh khỏi

Please tell me your idea about the risk of collision of the vessel in circle based on the following rank: Negligible / Marginal / Critical / Catastrophic.



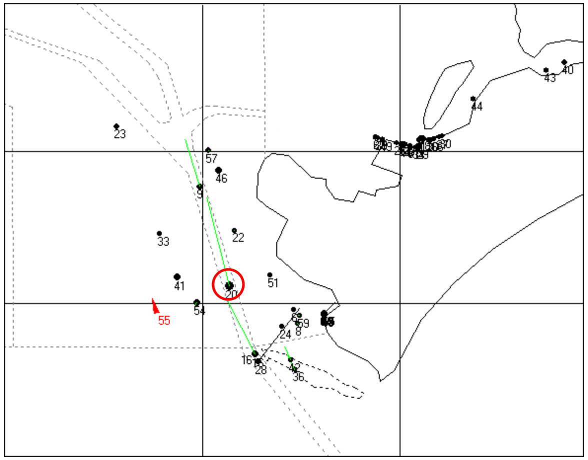
ID	Name	Type	LOA	Beam	Draft	CRS	SPD
4	GAS MOXIE	Tanker	122	20	4.9	340	10
6	CAPE FELTON	Cont.	170	25	8.9	143	14.8
22	EVEREST 1	Cont.	64	13	5.4	341	6.8
12	0____0	Fishing boat					
15	JAYA CONFIDENCE	Cont.	71	17	5.1	167	11.5
8	VSP EXPRESS	Others	53	10	3.5	137	14.3

☐ Negligible ☐ Marginal ☐ Critical ☐ Catastrophic



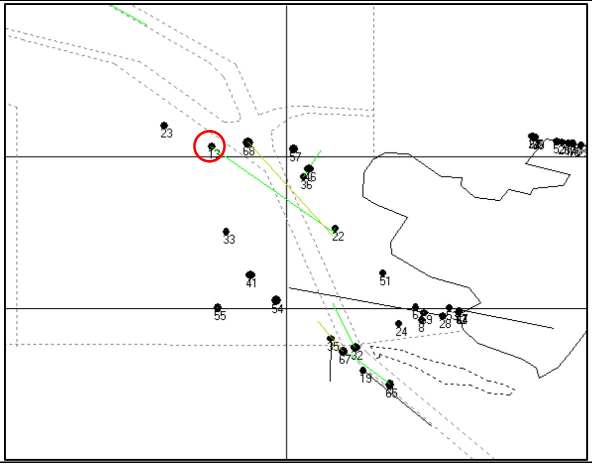
ID	Name	Type	LOA	Beam	Draft	CRS	SPD
24	PETRO EXPRESS 05	Others	Hydrofoil passenger vessel				
12	0____0	Fishing boat					
6	CAPE FELTON	Cont.	170	25	8.9	167	10.1
20	BOONTRIKA NAREE	General cargo	176	26	9.5	325	9.6

☐ Negligible ☐ Marginal ☐ Critical ☐ Catastrophic



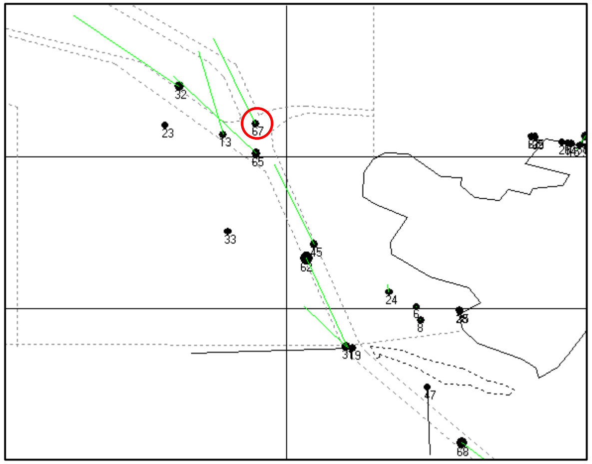
ID	Name	Type	LOA	Beam	Draft	CRS	SPD
9	GOLDEN NEXUS	Cont.	112	19	5.6	346	6.2
20	EVER ELITE	Cont.	299	42	9.0	349	11.5
16	SILVER SHADOW	Cont.	186	25	6.1	339	7.3
42	TAU CA 24	Fishing boat					
36	TAU CA 25	Fishing boat					

☐ Negligible ☐ Marginal ☐ Critical ☐ Catastrophic



ID	Name	Type	LOA	Beam	Draft	CRS	SPD
13	HONG HA GAS	Tanker	79	12	4.0	143	14.3
68	APL CAIRO	Cont.	207	29	9.2	154	13.2
67	BBC GDANSK	General cargo	122	18	6.1	336	4.3
32	KUO HSIUNG	Cont.	166	27	6.9	344	5.8
65	UNI PROMOTE	Cont.	182	28	8.6	324	4.8
36	TAU CA 24	Fishing boat					
46	TAU CA 25	Fishing boat					

☐ Negligible ☐ Marginal ☐ Critical ☐ Catastrophic



ID	Name	Type	LOA	Beam	Draft	CRS	SPD
32	KUO HSIUNG	Cont.	166	27	6.9	321	11.6
13	HONG HA GAS	Tanker	79	12	4.0	351	10.7
65	UNI PROMOTE	Cont.	182	28	8.6	330	11.4
67	BBC GDANSK	General cargo	122	18	6.1	345	11.2
45	PRIME SUN	Tanker	130	24	8.1	345	10.5
62	MOL COSMOS	Cont.	320	46	10.6	166	11.8
31	JAKARTA BRIDGE	Cont.	172	28	9.4	330	5.9
19	PETRO EXPRESS 05	Others	Hydrofoil passenger vessel				
47	HAI LONG	Others	Pilot boat				

☐ Negligible ☐ Marginal ☐ Critical ☐ Catastrophic

3. Theo bạn các cảnh báo về rủi ro đâm va do phần mềm đưa ra có phù hợp với thực tế giao thông tại thời điểm cảnh báo hay không? Vui lòng đánh giá dựa trên các mức sau: Luôn luôn khác / Luôn khác / Lúc đúng, lúc khác / Thường đúng / Luôn đúng

In your opinion, the alarms which are given by the program are suitable with the actual traffic situations at that time or not?Please rate based on the following scale: Always different / Usually different / Sometimes different, sometimes same / Usually same / Always same

☐ Always different ☐ Usually different ☐ Sometimes different, sometimes same
☐ Usually same ☐ Always same

4. Theo bạn phần mềm RTSS có gây cho bạn thêm rối khi phải chú ý đến thêm một thông tin nữa trong quá trình làm việc?

Would you please tell me that does the program make you confuse because you have to focus to one more information when working?

☐ Có *(Yes)* ☐ Không *(No)*

5. Theo bạn nếu phần mềm RTSS hoạt động tốt (tức các cảnh báo đưa ra là chính xác) thì nó có hữu ích cho người sĩ quan VTS không?

In case of the RTSS program can give correct alarms, do you think that it will be a useful program for VTS Officer?

☐ Có *(Yes)* ☐ Không *(No)*

6. Vui lòng cho biết các góp ý của bạn để cải thiện cho phần mềm tốt hơn

Would you please give me your ideas for improving the program?

a) ____

____

b) ____

____

c) ____

____

d) ____

____

e) ____

____