WORLD MARITIME UNIVERSITY

Dalian, China

THE STUDY ON PROMOTING OF DALIAN VESSEL TRAFFIC SERVICES

By

YAN HAIFENG

The People's Republic of China

A dissertation submitted to the World Maritime University in partial Fulfillment of the requirements for the award of the degree of

MASTER OF SCIENCE

Maritime Safety and Environment Management

2016

Declaration

I certify that all the material in this research paper that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this dissertation reflect my own personal views, and are not necessarily endorsed by the University.

Signature: Yan Haifeng

Date: August 5, 2016

Supervised by: Fu Yuhui,
Professor
Dalian Maritime University

Assessor:

Co-assessor:

ACKNOWLEDGEMENTS

It is great honor to study in the program of Maritime Safety and Environmental Management 2016. My sincere gratitude goes to World Maritime University and Dalian Maritime University who offered me this great opportunity to learn the knowledge that I desired. Thanks for Dalian Maritime Safety Administration and Liaoning Maritime Safety Administration who sent me to this program.

Thanks for my family to be so supportive, especially my wife. During my busy studying, she has taken good care of my son without much help from me. She is also very helpful with talking me out of the heavy load of study.

I am profoundly thankful to the faculty teaching and providing supportive work for the program. Through the program, I have learned so much about maritime safety and environmental protection. I believe that what I have learned here will be put to good use in my career in the future.

I greatly appreciate Professor Fu Yuhui for his guidance of the writing of this dissertation. His rigorous attitude to academic study has inspired me greatly. His rich knowledge, patience and humble attitude move me deeply inside.

I am very grateful to Mr. Zhao Jian, Professor Wang yanhua and Professor Ma Shuo for being understanding and supportive during my personal crisis. With their help, I've passed through hardship and finished the program in time.

Also, to my dear energetic classmates, thanks for your company during the time of study. You are so delightful and you have brought me so much more pleasure than I have ever expected. Hope you keep your young heart forever.

ABSTRACT

Title of Dissertation: **The Study on Promoting of Dalian Vessel Traffic Services**

Degree: **MSc**

The purpose of this dissertation is to enhance the safety of navigation by improving Dalian Vessel Traffic Services.

It is apparent that the major factors of accident contribution are different with respect to different VTS area. Dalian VTS area has its unique characteristics of climate, hydrography, port layout and other navigation related external environment to ships. Through analysis of accident investigations and questionnaires filled up by experts in relevant fields, the top five accident contribution factors are brought forward for Dalian VTS area. The adverse influences that those factors have brought up are mentioned and the current count-measures addressing those factors are described.

Through analysis, the deficiencies of those count-measures are identified and improved measures are given in five possible ways. Those introduced measures which have placed emphasis on practicality are expected to promote safety of navigation and efficiency of port operation. It is believed that by adopting those practices, Dalian VTS will elevate external safety environment for ships in its coverage.

KEY WORDS: Dalian VTS, VTS, navigational safety, maritime accidents

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURE

LIST OF ABBREVIATION

AIS	Automatic Identification System
CCTV	Closed-circuit Television
CNY	Chinese Yuan
COLREGS	Convention on the International Regulations for Preventing Collisions at Sea, 1972
DLMSA	Dalian Maritime Safety Administration
DLVTS	Dalian Vessel Traffic Services
DMU	Dalian Maritime University
EUR	Euro
GT	Gross Tonnage
IALA	International Association of Lighthouse Authorities
IMO	International Maritime Organization
LNG	Liquefied Natural Gas
LNMSA	Liaoning Maritime Safety Administration
MSA	Maritime Safety Administration
NM	Nautical Mile
RADAR	Radio Detection and Ranging
VHF	Very High Frequency
VLCC	Very Large Crude (Oil) Carrier
VTS	Vessel Traffic Services
WMU	World Maritime University

CHAPTER 1
INTRODUCTION

1.1 Background：Vessel Traffic Services and navigational safety

For centuries, shipping transportation is the major way of transportation for the world trade. In order to facilitate ships to carry merchandise in a safe and expeditious way, at the very beginning, coast states established navigational aids along their coast line. The navigational aids were only light houses and light beacons, and then the radio beacons and RADAR beacons came into service. With the appearance of bigger and faster ships, some sophisticated ways of shipping safety management came forth, such as the establishing of ship routing system, setting of speed limit. By using those passive navigational safety management techniques, the safety of navigation and the protection of environment had been improved accordingly. However, in area around harbors and narrow passages, crowding traffic not only slow down each other, add operational cost but also increase chances of accidents. H. W. Li (2010) found 80 percent of accidents happened around harbors and narrow channels. To address this problem, active ways of safety management were introduced by coast states. The active safety system is established on shore with the functions: the providing of information to the traffic, the organizing of traffic and the providing of navigational aid if needed. Those active methods are carried out for maximizing the traffic efficiency with minimum the risks as far as possible by interacting with ships. Those shore-ship interacting services are named Vessel Traffic Services.

1.2 The purpose of this research

Dalian VTS center which locates in northeast China is a sub-branch of Dalian Maritime Safety Administration who is responsible for maritime safety in Dalian port. Since its establishment, Dalian VTS center has been contributing in improving safety of ships in Dalian VTS area. Dalian VTS center has achieved significant success by improving navigational environment, disciplining navigational order, realizing dynamic monitoring, reducing the number of accidents, assisting search and rescue operations, assisting accident investigations, etc. However, there are still accidents involving property lost, casualties and environment damage in Dalian VTS area every year. According to statistics from Dalian Maritime Safety Administration, there are 109 shipping related accidents happened in Dalian VTS area between 2011 and 2015. Clearly, there is still room for improvement of safety in Dalian VTS area. To reduce the number of accidents and improve safety, the accident contribution factors behind those accidents must be identified and addressed. Of course, there are many factors that affect safe navigation such as: navigational circumstances of port, weather, quality of VTS, ship survey, quality of seafarers, the management of shipping company, etc. Due to the content limitation, only several top accident contribution factors are analyzed. The main content of this dissertation is to analyze several contribution factors of accidents and find ways to address those factors by improving existing VTS safety measures.

1.3 Methodology

During the writing of this dissertation, opinions were exchanged and advice was taken from experts from ships, shipping company, Dalian port authority, Dalian pilot station, Dalian Environment Bureau, Dalian Fishing Bureau, Dalian VTS center, Dalian Maritime Safety Administration. Questionnaires about the most important risk contribution factors were filled out by experts in relevant areas mentioned above. Relevant literature was reviewed, for example: IMO A.857(20), IALA VTS Manual 2008, articles from journals, dissertations and information from website. Through

above activities together with the analysis of accident reports provided by DLMSA for Dalian VTS area between 2011 to 2015, the main accident contribution factors that are distinct for Dalian VTS coverage are identified. Through the analysis of several chosen factors, the corresponding existing safety measures that are less sufficient are to be improved.

1.4 The research content

The dissertation is about the improving of navigational safety in Dalian VTS area by improving existing VTS safety practices, the main content is:

2.1-2.5 The overall introduction of Dalian VTS area including: Dalian VTS, Dalian Port layout, climate, hydrology and the statistics of accidents.

3.1-3.5 The analysis of accident contribution factors.

4.1-4.5 The improvement of VTS safety measures to address accident contribution factors analyzed in chapter 3.1-3.5.

5.1--5.2 Conclusions and the prominent factors of accident contribution left to be solved.

CHAPTER 2

Basic facts of Dalian VTS area

2.1 Dalian Vessel Traffic Services

Dalian Vessel Traffic Services Center was established by Dalian Maritime Safety Administration in 1998.

2.1.1 Various systems of Dalian VTS

According to *Dalian VTS Guide for Users(2015)*, edition four, Dalian VTS has the following systems to facilitate its services. See table 1.

Table 1 - Various systems of Dalian VTS

system	description
Radar Surveillance Sub-system	Effective range of 30 nautical miles with tracking and replaying function. 10 radar stations locate at Dagang, Huangbaizui, Mineral Terminal, Dayao Wan, Laotie Shan, Sanyantou, Huangnichuan, Hulushanzui, Tashan and Dadingshan.
AIS Sub-system	Effective range of 30 nautical miles and identifying ships automatically, sending and receiving AIS messages.
VHF Communication Sub-system	Effective range of 30 nautical miles with multi-channel recording function
VHF Direction Finder Sub-system	Effective range of 30 nautical miles with

	the function of ships' positions identification.
Ship Data Processing Sub-system	Capacity of ship data processing 15,000 ships
Meteorology monitoring Sub-system	Real time monitoring of meteorology data at the observation point
CCTV Surveillance Sub-system	Assisting surveillance of terminals and the movements of ships
Data recording and playback Sub-system	Data recording and playback of audio, visual and radar image. All data will be recorded automatically as long as a month. The data that is intentionally recorded can be kept in hard drives permanently
X3 system	providing particulars of all merchant ships and their operation records in Dalian Port

Source: Dalian MSA. (2015). *Dalian VTS Guide for Users, edition four*. Dalian: Author.

2.1.2 Dalian VTS area

See figure 1. According to *Dalian VTS Guide for Users (2015), edition four:*

Dalian VTS area includes Dalianwan VTS Area, Dayaowan VTS Area.

Dalianwan VTS area means an arc centered on point Dasanshan Dao Lighthouse (38°51.9′N， 121°49.5′E) radius 13 nautical miles， which is

bounded by Dasanshan Dao Lighthouse. West of Dasanshan Dao Lighthouse is Dalianwan VTS area. Dayaowan VTS area means an arc centered on point Dasanshan Dao Lighthouse (38°51.9′N， 121°49.5′E) radius 13 nautical miles，which is bounded by Dasanshan Dao Lighthouse. East of Dasanshan Dao Lighthouse is Dayao Wan VTS area. (p.5)

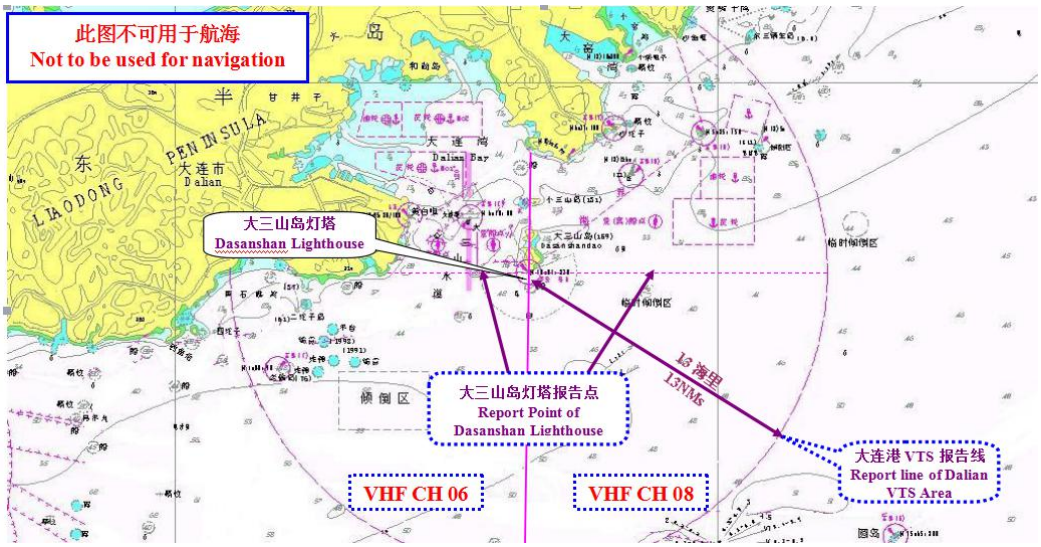

Figure 1 - Dalian VTS area

Source: Dalian MSA. (2015). *Dalian VTS Guide for Users*, edition four. Dalian: Author.

2.1.3 Dalian VTS users

According to *Dalian VTS Guide for Users(2015)*, edition four,

Dalian VTS users include ships or facilities (hereinafter referred to as ships), which are sailing, berthing, and operating inside VTS Area, and

relevant units and personnel. Following ships should report to VTS Center when they are inside Dalian Port VTS Area:

Foreign ships；

Following Chinese ships：Passenger ships, Other Chinese ships more than 300 gross tonnage.

Other Chinese ships less than 300 gross tonnage but join the VTS voluntarily if VHF equipment is available. (p.7)

2.1.4 The manning

There are 40 VTS operators and the majority of them are recruited right after they graduated from universities or colleges. 23 operators majored in navigation while the rest majored in other field back at school. 5 operators among all have experience on board ships. Before being sent to work, the operators need to go through training courses as described in chapter 4.4.

2.1.5 Other facts

According to *Dalian VTS Guide for Users(2015), edition four,*

VHF Working Channels for Dalianwan VTS Area: VHF CH06; for Dayaowan VTS Area: VHF CH08. The center works 24x7 without exception. The working languages are Mandarin and English. Dalian VTS

provide multiple services: the organization of shipping traffic, the providing of navigational aid, the providing of information, the facilitating of search and rescue operation. (p.8)

2.2 Dalian Port

Dalian port situates at the southern tip of Liaodong Peninsula which is in Northeast China. It is a natural deep water port. Dalian port is the biggest port trading grain, crude oil in China. It is the hub port of northeast China. Dalian has liners to Southeast Asia, East Asia, South Asia, North America, Europe as well as liners to other Chinese ports. Shipping routes centered on Dalian port are radiated more than 140 countries and regions. Dalian port area is within Dalian VTS coverage. The area is around 346 square kilometer. Dalianwan area is 186 square kilometer and Dayaowan area is 160 square kilometer. The coast line is 145 kilometers. It has 80 modern specialized berths handling containers, crude oil, product oil, grain, general cargo, charcoal, bulk ore, chemical product, LNG, vehicles, passengers. 40 of them have the capacity of holding merchant ships of more than 10,000 metric tons. One ore berth can take maximum 403,844 metric tons bulk carrier. One crude oil berth can hold 375,000 metric tons VLCC.

2.2.1 Main fairways

See table 2.

Table 2 - Main fairways of Dalian port

Major fairways	Depth (meter)	Width (meter)
Dagang Fairway	-10	270
Xianglujiao Fairway	-8	100

Ganjingzi	-9	180
Xingang Crude Oil Fairway	-17.5	300
Dayaowan Fairway	-10.7	210
Dalianwan Fairway	-9.5	100

Source: http://www.gkj.dl.gov.cn/behavior/index.php?COLLCC=2552012141&. (2016)

2.2.2 Anchorages

See table 3. There are 6 anchorages according to *Dalian VTS Guide for Users (2015), edition four*

Table 3 - Anchorages of Dalian port

Name of Anchorage	Range of Anchorage	Chart Depth (meters)	Area (km^2)	Bottom Character
No.1 Freight Quarantine Anchorage	**38°57′00″N 121°46′00″E** **38°57′00″N 121°41′00″E** **38°56′18″N 121°41′00″E** **38°55′00″N 121°46′00″E**	8.3－17.8	18.023	**Mud**
No.2 Freight Quarantine Anchorage	**38°59′08″N 121°46′55″E** **38°59′08″N 121°42′30″E** **38°57′39″N 121°42′30″E** **38°57′39″N 121°46′55″E**	9.4－12.8	17.461	**Mud**
Oil tanker Quarantine Anchorage	**38°59′08″N 121°42′30″E** **38°59′08″N 121°40′30″E** **38°57′39″N 121°40′00″E**	8－9.5	8.932	**Mud**

	38°57′39″N 121°42′30″E			
Xingang Freight Anchorage	**38º53′00″N 121º57′30″E** **38º55′00″N 121º57′30″E** **38º55′00″N 122º02′00″E** **38º53′00″N 122º02′00″E**	28－33	23.98	**Mud**
Xingang Oil Tanker Anchorage	**38°55′00″N 121°59′00″E** **38º56′48″N 121º59′00″E** **38º56′48″N 122º02′00″E** **38º55′00″N 122º02′00″E**	26.4－33	14.19	**Mud**
Dayaowan Anchorage(Freight only)	**38º59′27″N 122º00′53″E** **38º59′04″N 122º02′52″E** **38º57′44″N 122º02′26″E** **38º58′04″N 122º02′06″E**	19.5－26	7.25	**Mud**

Source: Dalian MSA. (2015). *Dalian VTS Guide for Users*, edition four. Dalian: Author.

2.2.3 Navigation mark and breakwater

There are 54 navigational marks, including light beacons 21, beacons 3, buoys 28, light houses 2. Huangbaizui Lighthouse is at 38°54′14″N/121°42′56″7E. Dasanshandao Lighthouse is at 38°51′51″N/121°49′29″E. There are 9 breakwaters with 7000 meters length altogether.

2.3 Climate, hydrology

2.3.1 Visibility

Visibility is the index of transparency of atmosphere. It means the maximum distance that can be seen by a person with average bare eyesight. There are 10 grades in visibility scales. See table 4.

Table 4 - visibility scale

VISIBILITY SCALE

SCALE	Weather condition	distance	
		Nautical mile	meter/kilo meter
0	DENSE FOG	0-0.03	0-50m
1	THICK FOG	0.03-0.1	50-200m
2	FOG	0.1-0.25	200-500m
3	MODERATE FOG	0.25-0.5	500-1000m
4	MIST	0.5-1.0	1-2km
5	POOR VISIBILITY	1.0-2.0	2-4km
6	MODERATE VISIBILITY	2.0-5.0	4-10km
7	GOOD VISIBILITY	5.0-10.0	10-20km
8	VERY GOOD VISIBILITY	10-30	20-50km
9	EXCELLENT VISIBILITY	>30	>50km

D. Wang (2014) found that long term statistics show that poor visibility and below is around 38 days every year on average with 65 days maximum and 18 days minimum in Dalian Port; poor visibility appears the most in May to July; after August, less poor visibility is experienced; autumn has the least poor visibility days of four

seasons; poor visibility begins most likely in 0200～0800 and 2000-2400, least likely in 1400～1700; poor visibility exists when the wind is from southeast; when the wind veers to north or west, visibility will be clear soon; poor visibility usually lasts 2～8 hours; in very rare occasions (0.3%)， poor visibility lasts for more than 24 hours.

Cao, Shao, & Wang (2011) found that with the pollution to the atmosphere is getting worse due to industrial activities, there are more poor visibility days over time.

> According to the data that covers 38 years (1973-2010), the low visibility (<4km) is below 10 days/year before 1989. After 1989 the low visibility appeared more frequently. The low visibility appeared 40 days in 2008, and 48 days in 2010. (Cao & Shao, 2011, p.45)

Low visibility has profound influence over safe navigation which will be discussed in chapter 3.1.

2.3.2 Wind

Wind is generally described in wind speed and wind direction. Wind speed represents the distance that air moves per unit times. The most common ways of expressing are meter/second, kilometer/hour and nautical mile/hour. Attention should be paid to the wind direction which refers to the direction where the wind comes from. Like south wind means that the wind blows from south to north. In 1805, Francis Beaufort divided wind into 13 grades in accordance with the influence of wind to the ground or sea. See table 5.

Table 5 - Beaufort Wind Scale

Beaufort Wind Scale

Scale	name	m/s	nm/h
0	CALM	0.0-0.2	＜1
1	LIGHT AIR	0.3-1.5	1-3
2	LIGHT BREEZE	1.6-3.3	4-6
3	GENTLE BREEZE	3.4-5.4	7-10
4	MODERATE BREEZE	5.5-7.9	11-16
5	FRESH BREEZE	8.0-10.7	17-21
6	STRONG BREEZE	10.8-13.8	22-27
7	NEAR GALE	13.9-17.1	28-33
8	GALE	17.2-20.7	34-40
9	STRONG GALE	20.8-24.4	41-47
10	STORM	24.5-28.4	48-55
11	VIOLENT STORM	28.5-32.6	56-63
12	HURRICANE	≥32.7	≥64

Dalian belongs to East Asia Monsoon Area. The wind directions and force change according to seasons. During the winter, when the cold anticyclones come one after another, the northern wind is strong and constant. This is the main threat for ships' safety. During the summer the wind is normally gentle and from the south. The spring and autumn are the seasons when the wind shifts directions in general. The

typhoon has very little influence of this area except for very rare occasions.

X. Shi (2013) pointed out that the wind in Dalian area possesses the characters of monsoon of continental temperate zone; there are 80 days every year on average with wind stronger than wind scale Beaufort 6 and 70 days on average every year with wind stronger than wind scale Beaufort 8; the strong wind is mostly seen in December to February; the most likely strong wind direction is northwest. The wind is a serious threat to navigational safety as will be discussed in chapter 3.2.

2.3.3 Other environmental characters

According to Guide to Port Entry, 2013/2014, Dalian port,

> Temperature: Annual average 10.4℃, July warmest averaging 23.5℃ and coolest January -5.9℃. Rainfall: Annual average 600 mm. Two thirds of the annual rainfall falls during July to September. Ice: Possible ice period early January to March, lasting approximately 60 days. Port may be partially frozen, thickness of ice 5–20mm. No effect to navigation or mooring. (p.584)

Tide: Mixed type tide. With highest recorded tide 4.6 meters, lowest recorded tide 0.66 meter. Average tide 2.14 meters. The average sea surface is 1.63 meters.

Current: The current in Dalianwan and Dayaowan area is basically reversing tidal current. The outbound and inbound current speed are 0.64～0.32 meter/second and 0.57～0.29 meter/second. The extreme tide range is 2.9 meters and the minimum tidal range is 2.3 meters.

Wave and swell： Dalianwan area is surrounded by coast line except for the south.

Berths and anchorages inside this area are well protected from wave and swell. Dayaowan area is protected from north coast. Wave and swell from south and east may affect anchorages and berths seriously.

2.4 Accidents in Dalian VTS area

According to the statistics from DLMSA, there are respectively 22848, 23562, 24124, 23553, 20675 ship-times entering the reporting lines of Dalian VTS area in 2011 to 2015. Most of the ships are free of accidents well unfortunately small amount of ships had accidents during that period.

2.4.1 Overall description of accidents

According to statistics of accidents in Dalian VTS area, there are 109 accidents from the beginning of 2011 to the end of 2015. The causes of the accidents are as table 6. The table shows that collision is the most common kind of accident. According to the statistics, among all collision accidents, merchant ships/fishing ships collision is most common kind of collision. Ships with Gross Tonnage less than 3000 like fishing ships, service ships, construction ships and tugs are more often seen in the collision accidents than ships with Gross Tonnage more than 3000. Contact damages rank the second among accidents. According to statistics, the most common kind is contacting with sea farming facilities. There are totally 155 ships involved in the 109 accidents, 125 ships are Chinese nationality.

Table 6 - Types of accident

Type of accident	Number of accident
collision	43
Contact damage	18
Grounding	12
Sink because of own reason	8
Fire/explosion	7
Stranding	2

Operational pollution	1
Other reasons	18
	109

Source: author compiled the data from accident investigation reports provided by DLMSA

2.4.2 Loss

The accidents happened in Dalian VTS area between 2011 and 2015 had led to huge loss. See table 7. The total casualties are 6 death, 3 missing and 7 injury. The direct economic loss is 93,419,400 CNY (about 12,733,064.22 EUR).

Table 7 - Loss

Minor accident	77
Accident	17
Larger accident	10
Major accident	5
Extremely large accident	0
	109

Source: author compiled the data from accident investigation reports provided by DLMSA

According to *Water Traffic Accident Statistical Method* that went into force in china on January 1 2015, water traffic accidents are divided into following categories according to casualties, direct loss and pollution to the environment.

Extremely large accident: more than 30 deaths, more than 100 injuries, spilling oil more than 1000 metric tons or more than 100,000,000 CNY loss.

Major accident: 10 to 30 deaths, 50 to 100 injuries, spilling oil 500 to 1000 metric tons or 50,000,000 to 100,000,000 CNY loss

Larger accident: 3 to 10 deaths (missing is included), 10 to 50 injuries, spilling oil 100 to 500 metric tons or 10,000,000 to 50,000,000 CNY loss.

Accident: 1 to 3 deaths (missing is included), 1 to 10 injuries, spilling oil 1 to 10 metric tons or 1,000,000 to 10,000,000 CNY loss.

Minor accident: loss less than accident.

1CNY≈0.1357EUR

2.4.3 The accidents that are contributed by wind

See table 8 for ships underway and table 9 for ships at anchor. In table 8, there are 17 accidents for underway ships. Under the influence of wind, contact damages are the most common kind of accidents in table 8. There are three kinds of contact damage according to the objects that ships collide with. Collision with other ships had 5 cases due to strong wind. There are 3 sinking cases because of strong wind and rough sea which are significant loss. There are one lost cargo case, one ground case and one strand case.

Table 9 gives the accident statistics for ships at anchor. 5 cases of collision and 1 case of stranding due to dragging anchor. The 23 cases in table 8 and 9 are accidents that have strong wind as contribution factor among total 109 accidents. This means wind had great contributed the happening of accidents.

Accident investigations show that the majority of the accidents happened because of insufficient preparation for the wind or no preparation for the coming wind.

Table 8 - Accidents that are contributed by wind for ships underway

Type of accidents for Ships under way	Accident number
Collision with other ships	5
Contact with berth or loading machine	3
Contact with sea farming facilities	2
Contact with breakwater	1
Lost equipment or cargo	1
sink	3
grounding	1

stranding	1
	17

Source: author compiled the data from accident investigation reports provided by DLMSA

Table 9 - Accidents that are contributed by wind for ships at anchor

Type of accidents for Ships at anchor	Accident number
Collision with other ships	5
Grounding	1
	6

Source: author compiled the data from accident investigation reports provided by DLMSA

2.4.4 The accidents that are contributed by poor visibility

In table 10, there are 21 accidents in which poor visibility is major contribution factor. Collision is the most common kind of accidents in poor visibility. The collision between merchant ships and fishing ships is 15 cases out of 21 cases in total. The collisions between merchant ships involve 7 ships under 3000 GT, only one ship is over 3000 GT. Accident investigations indicate that in poor visibility, visual lookout is limited, RADAR lookout is heavily depended. But most RADARs are not good at picking up small fishing ships not to mention the sea farming facilities which is basically in the water. Ships should be stopped running by VTS in VTS area when visibility deteriorates to certain figure for the sake of safe navigation.

Table 10 - Accidents that are contributed by poor visibility

Type of accidents in poor visibility	Number
Damaging sea farming facilities	2
Collision between merchant ships underway	4

Collision between merchant ship and fishing ships.	15
	21

Source: author compiled the data from accident investigation reports provided by DLMSA

2.4.5 The accidents happened to unregistered ships

See table 11. There are 8 sunk cases of all 109 accidents, 3 of them involved unregistered ships. That is very high percentage considering the number of the unregistered ships is less than 10 percentage of all ships. There are one collision case with merchant ship, one grounding case and one stranding case. The total casualties involved in unregistered ships were 2 missing and 2 injured. The casualty rate is also too much higher than average considering the small number of seafarers working on unregistered ships comparing the total number working on other ships. The statistics show that accidents happened to unregistered ships are general severe accidents involving casualties and other loss. There might be more accidents involving unregistered ships that are not reported. To avoid punishment and responsibility, the owners of such ships normally hide the facts of accidents and desert the ships if the loss is too huge. In most cases the 'seafarers' are hired through agents. Those agents hire migrant workers on website or by passing fliers on the streets. Many of those migrant workers are not trained in any kind before being sent to those unregistered ships and they do not understand they need to report to MSA when accidents happen. Even if they want to report, they might not be allowed to do so by the owners. So the actual figure of accidents should be more than the figure listed.

Table 11 - Accidents happened to unregistered ships

Type of accidents happened to unregistered ships	Number

sinking	3
Collision with merchant ship	1
grounding	1
stranding	1
	5

Source: author compiled the data from accident investigation reports provided by DLMSA

CHAPTER3

Contribution factors of accidents

Through the analysis of accident reports provided by DLMSA for Dalian VTS area between the beginning of 2011 to the end of 2015, together with analysis of questionnaires finished by representatives from ships, Dalian VTS center, Dalian Maritime Safety Administration, shipping companies, Dalian port authority, Dalian pilot, the main accident contribution factors that are distinct for Dalian VTS coverage are identified. Top 5 of those factors are chosen to be analyzed to establish the influence to safe navigation.

3.1 Poor visibility

Visibility has profound effects on safe navigation. X.J. Zhang (2007) argued that 60% of all accidents occurred in poor visibility. It is not unanimous between the shipping community and legal community as at what stage visibility should be considered importance to safe navigation. Generally speaking, when visibility is below 5 nautical miles, it affects navigation in the following aspects.

A. For ships underway, poor visibility increases the difficulty of identification of small crafts especially those made of wood that have very poor RADAR echo reflection.

B. In poor visibility, ships have to reduce their speed to allow more time for emergency response. The lower speed undermines ships' ability of maneuvering especially when the ships are under the influence of sea current and wave/swell. The applying of lower speed increases sailing hours, adds fatigue to navigators which in turn reduces the vigilance of the crew.

C. For navigators: poor visibility increases the difficulty of fixing ships' positions and navigating with fairway buoys.

D. Y. L. Liu (2009) pointed out that the proper controlling of ships' maneuvering by navigators is undermined because of shortened responding time. "In good visibility, a navigator can be aware of 30 degrees course change of a target with speed 16 knots within 1 minute. In poor visibility, the same navigator needs more than 6.5 minutes to identify the same course change in RADAR." (p.18)

E. After the poor visibility is clear, the traffic density increases dramatically due to each delayed ship wants to get underway ASAP. This may lead to chaos if the traffic is not controlled properly.

Liang's research (2014) indicates that major international sea ports have safety precautions for poor visibility. Visibility figure needs to be measured before the application of those safety precautions. It should be noticed that visibility is dynamic. For **one** given **palace,** visibility changes over time. Visibility is not necessarily the same for different locations in one port. When and where a VTS Center should apply safety measures become very important.

3.2 Strong wind

Strong wind is very harmful for the safety of ships. For ships underway:

A, Under the influence of strong wind and rough sea introduced by the wind, a ship may roll and pitch heavily. In some cases, the loosing parts that are not properly fasted may become loose and lost, such as lifeboat, life raft, anchor, deck cargo, etc. If cargo or water in half full water tanks moves inside a ship, the ship may list and capsize.

B, When a ship is rolling and pitching in rough sea, the propeller frequently emerges out of water, the workload of the main engine changes dramatically. This may lead to the failure of main engine. Without propulsion, a ship's longitudinal length will eventually become vertical to the wind and wave. This is extremely dangerous for a

ship because the ship may be capsized by the force of wind and wave.

C, For some ships, sea wave pouring down at main deck may enter the cargo holds if the watertight is breached. The loss of buoyancy will sink a ship.

D, When a ship is supported by two wave crests on both ends or by one wave crest in the middle, the strong uneven shearing force may damage the structure of the ship or may even break the ship into halves.

E, There are other harms such as damaging deck equipment, increasing the fatigue of crew members, increasing maneuvering difficulty, etc.

For ships at anchor

When the force of wind and/or current are too strong for a ship's anchor(s) to hold the ground, the ship will drag anchor. Normally when the wind is strong, the anchorages are full of ships sought for shelter. Once a ship is dragging anchor, it takes only a few minutes before collision with other ships happening. Ships dragging anchor may also collide with breakwaters or run aground. The consequences include: human lives loss, pollution, damaging to the local ecosystem, damaging of ships, sinking of ships, delaying of cargo delivery , blocking the fairways and endangering the safe passage of other ships.

For ships at berth.

Strong wind and rough sea shake ships that are alongside. Ships' colliding with berth heavily may damage the ships, the wharf and the port facilities. Under the influence of violent strong external force, a ship may also break its mooring ropes and float away out of control forming threat to its own safety and others' around it.

For the sake of their own safety and the sake of others', ships need to prepare themselves for the coming wind **beforehand**. Ships need to be manned with competent crew, maintain/test their main engine/rudder/anchor, close their water tight doors/hatch covers, lash their loosing parts/cargo, adjust their stability, choose a suitable shelter, make anchor arrangement, supply sufficient fuel/provision, etc. All the preparation work **needs time** to be done and **being aware** of the coming wind in

advance is essential. However, with the recession of shipping market, many ships are left idle. Those ships drop anchor or berth long time with minimum crew on board. The receiving of the weather forecast is not monitored closely both by the owners and the crew in many cases. Quite a few service ships and construction ships are also not as alert as merchant cargo ships to the weather forecast. It becomes an vital important task for the VTS Center to make sure that those ships are aware of the coming wind and make suitable preparation for it.

3.3 Unregistered ships

There are two kinds of unregistered ships: ships without name, certificates, registry port and ships that copy other ships' name, certificates, registry port. The unregistered ships are usually small ships and mainly designed to deliver cargo or retrieve sand from river bottom which is rather profitable business. As illegal ships, unregistered ships widely spread in many ports and change their locations among ports frequently. The unregistered ships are not seaworthy ships. Most unregistered ships are either disused ships beyond repair or ships built illegally by the side of river without proper design, facilities, material, safety arrangement and eligible workers. The fire fighting and life saving equipment are ignored in many cases. The RADAR, VHF telephone, compass, navigational lights are not installed sometimes. To make it worse, the crew members hired are not qualified seafarers and they have not been properly trained for their work on board. G. F.Ye concluded that "most of the crew working on unregistered ships have little understanding of navigational or operational procedures and will take shortcuts as long as it is possible." (Ye, G. F., 2008, p. 44)

All those characteristics lead to poor safety records of those ships. There is considerable loss involving unregistered ships (see chapter 2.4.5). The unregistered ships are serious threat to safe navigation and have notorious reputation for poor behavior in operation and navigation. Some unregistered ships retrieve sand in the

fairways, make it difficult for other ships to pass. Some unregistered ships compromise the safe sailing of other ships by discarding cobblestones which is the byproduct of sand retrieving on the fairway. The unregistered ships usually do not follow stipulated routes designed by authority, do not avoid collision according to COLREGS, do not show proper navigational lights, do not keep proper navigational watch and VHF watch in VTS area. Almost for certain, after an accident, the owner and the crew of an unregistered ship are no where to be found. The desertion of the ship after an accident makes it very difficult for the carrying out of accident investigation and the dealing of aftermath. For public interest, it is important for the MSA and other authorities to catch those ships and scrap them before they jeopardize public safety.

3.4 The VTS operators are lack of nautical knowledge

There are complaining from ships and shipping companies about VTS operators' improper practices that hamper the safety of navigation. One improper practice is to interrupt ship's operation at the wrong time. It is extremely intense for the bridge team when a ship is engaging in berthing/departing operation. The bridge team has to monitor ship's position in various methods and control the ship carefully with the rudder, propeller, tugs, mooring ropes with consideration of wind/current effect. Any distraction may hold bridge team from functioning properly and lead to accidents. Some VTS operators, however, contact ships at that moment for information that absolutely can be asked later on, such as: "Have you departed yet?" "what is your next port of call?" It takes at least 30 seconds for a member of bridge team to answer the call and go back to what he was doing. This clearly is not creating safe operational environment for ships engaging in berthing/unberthing operation. Also, when a ship is sailing within port limit, it needs to maintain radio watch on at least three VHF channels: VTS working channel, pilot working channel and channel 16.

There are only two VHF telephones on board most cargo ships. Sometimes VTS channel is switched to other channels by a bridge team to contact ship chandler, agent, wharf, tugs or mooring gang. When some VTS operators can not contact the ship on VTS channel at that moment, they make angry telephone calls to the ship asking why without knowing that they need only to wait for a few seconds before the bridge team to come back to VTS channel. A telephone call consumes bridge team's valuable time as much as a VHF call if not more. After communication is established with ships, some operators require immediate answers without allowing time for the ships to respond or to figure out the situation. This adds a lot anxiety to navigators which is not good for the navigators to make the right decisions.

According to *Dalian VTS Center Standard Working Manual (2013)*, VTS center should "broadcast certain safety related information on VHF in appropriate intervals, such as fishing boat warning, poor visibility warning, gale warning." (p.41)

Some VTS operators broadcast such information on VTS working channel without confirming the channel is clear or not. They sometimes broadcast information on VTS channel even when two ships are negotiating passing intentions. VTS Center's signal is much stronger than ships', any communication between two ships will be interrupted by the broadcast. Quite a few VTS operators have poor understanding of ships' operation and ships' maneuvering characteristics. They do not understand the importance of sufficient time and sufficient safe distance. They do not understand it takes time to change a ships course and speed to avoid collision. Some VTS operators ask a ship why the ship has not changed its course/speed that is ordered 1 minute ago having no idea that a ship needs more time to respond to the wheel/engine order especially in loading condition. Some VTS operators give direct maneuvering orders to ships not knowing that they are not qualified to do so. Sometimes when a pilot asks for permission to board a ship a little further inside the pilot station in rough sea, some VTS operators are very reluctant to grant that request not knowing it is extremely dangerous to board a ship in rough sea.

The reason behind those poor practices is that some VTS operators have little knowledge of ships and ships' operation. Proper training must be carried out and on board experience must be acquired by VTS operators.

3.5 Trial ship factor

Dalian shipyards sent 408 trial ships (Number acquired from DLVTS Center) for trial in 2011 to 2015. Although, there is no accident related to trial ships yet, according to incident records provided by DLVTS, there were many incidents involving trial ships every year. Most common kinds of incidents are not under command and drifting of trial ships. Trial ships are vulnerable because following reasons:

Trial ships have very little ballast water on board due to construction limitation of the shipyards. After a trial ship leaves a shipyard, it usually takes hours for the ship to take in sufficient ballast water to maneuver properly with its own rudder and propeller. During that time the trial ship has very poor maneuvering capability because part of its propeller and rudder are out of water. The light ship also means that the ship is under substantial influence of wind both in its stability and maneuvering capability. He & Lu (2009) believed when the wind is more than 10 m/s, a trial ship without enough ballast should not commence its trial or should postpone its time to return shipyard from open sea. Many of the trial ship's equipment such as main engine, rudder, generator, RADAR, compass, AIS, echo sounder, telegraph, wheel and anchor, etc are not reliable and may need test and adjustment. It is very common for some of these equipment to fail which leads to a trial ship less seaworthiness or completely out of control. The individuals working on board are divided into different groups following their job description. It takes effort to coordinate with each other to get the ship running properly. Normally, those people work for different ships at different time and each time a trial only lasts for a few days. It is challenging to be familiar with the equipment that they are current working

with during short period of time. This would surely increases the error rate. Many of the professionals on board are not trained seafarers. They have little understanding of lifesaving and other emergency arrangement. In case of emergency, it is difficult to evacuate the trial ships by themselves.

The vulnerability of trial ships asks for safety arrangements such as: choosing favorable weather to carry out trial, making evacuating plan in advance, choosing safe route, the arrangement of escort, etc. Among those safety arrangements, escort arrangement is essential. An escort tug can provide assistance in case of emergency and provide an additional evacuation option when needed. For a trial ship coming out from Dalian shipyard, during the outbound trip, several tugs are arranged to escort the vulnerable trial ship to the open water where it is safe to maneuver. According to *Dalian Shipyard Trial Ship Safety Management Methods (2016)*, the escort may leave the escorted after the escorted clears H0 buoy. In reality, the escorting tugs often leave the trial ships before H3 buoy when the trial ships are not properly ballasted. It is extremely dangerous to leave a trial ship on its own when it is still in the fairway and the sea farming ground is nearby.

CHAPTER 4

Improving current safety measures of Dalian VTS

Dalian VTS Center has relevant safety measures to address the accident contribution factors described in Chapter 3.1-3.5. However there is room for improvement. In this chapter, the current safety measures corresponding to the factors in chapter 3.1-3.5 are to be described and improving methods are given.

4.1 The improving of the safety by improving current safety measures related to visibility

According to *Dalian VTS Center Standard Working Manual(2013),* Current safety measures enforced by Dalian VTS Center in Dalian VTS areas,

Visibility >1 nautical miles. No restrictions

1 nautical miles > visibility >500 meters. Oil tankers, chemical tankers, LNG and bulk carrier with Deadweight more than 200,000 metric tons are not allow to sail. Other ships are allowed to sail.

500 meters > visibility> 100 meters. Passenger ships and container liners are allowed to sail, other ships are not allowed to sail.

100m > visibility. All ships except search and rescue ships are not allowed to sail. (P.54)

Those measures are proven to be working over years of enforcement. However, the visibility may be different from one location to another and the visibility in one given palace may change dramatically over time. It is a challenging work to decide when and where to apply those measures by VTS Center.

4.1.1 Where to apply poor visibility rules

Dalian VTS Center has CCTV cameras at major berths. These cameras can tell visibility roughly. For the area away from the berths, visibility figure has to be delivered by other parties. The most frequent way of acquiring visibility figure is through asking a ship that applies for shifting positions. As the ship is the interest relevant party, the visibility figure given may deviate from actual figure. Most common situation is that a ship wishing to leave its berth will tell VTS center the visibility is good enough to go when it is not. VTS center has to judge the figure given and make decisions. To guarantee safety of navigation and also make things simple, a VTS operator may simply apply the rules according to the worst visibility within VTS area. For instance, an oil tanker that intends to proceed to open sea at Shiyou berth may find that the visibility around its berth is more than 1 nautical miles yet the visibility around H0 buoy is below 1 nautical miles. If the tanker applies to leave the berth and proceed, a VTS operator may not grant the departure fearing the visibility is not good enough in the way out. This creates two problems: lowering of port operational efficiency and depriving the chances of ships' movement within partial good visibility area. When eventually visibility is clear enough, the traffic will mount up to a very high density because every ship being delayed wants to go somewhere. It is easy to develop accidents at this stage due to high density of traffic.

In my point of view, ships should be allowed to move within partial good visibility area. It is good for efficiency of port operation and the safety of navigation. If the visibility of part of VTS area is clear, ships should be allowed to shift within that part. The example tanker should be allowed to proceed to the Oil Tanker Quarantine Anchorage if the visibility is good enough between its berth and the anchorage.

4.1.2 When to apply poor visibility rules

As mentioned in chapter 4.1.1, visibility figure acquired from interest relevant ships is not always reliable. Other ways of confirming visibility should be used besides asking the ships who apply for shifting positions. One way for VTS Center is to send patrol ships to check visibility in VTS area. However, there are not enough ships and budget to cover everywhere. Another way is to inquire Meteorological office who has monitoring sensors around the area and can predict visibility tendencies. The problem is that they can only provide data on shore and the prediction is not always reliable. New ways of judging visibility are needed. From my personal perspective, one way is to confirm with the Ships that are not interest relevant parties, such as: tugs, service ships, pilot boats, anchoring ships without berthing schedule. For instance, in order to confirm the visibility figure around H3 buoy, anchoring ships in No.1 Freight Quarantine Anchorage and No.2 Freight Quarantine Anchorage can be inquired. Only after multiple inquiries, the visibility figure can be decided.

Visibility figure provided by ships is measured by RADAR or judged by experience. Those traditional methods of determining visibility are rather primitive. The accurate measurement of visibility using equipment is available a long time ago in other industries. Now, relevant technology is seen in maritime domain. Liang's research (2014) indicates that infrared visibility measure system is available. Infrared visibility measure system is a system that can directly measure visibility within port area. The system consists of shore based remote control center, shore based monitor stations and ship based monitor stations. Shore based remote control center holds control panel, screen, data processing function. Ship/shore based monitor stations

hold fixed and portable detecting devices. All the visibility data collected by monitor stations can be transferred to control center through network. The maximum working distance is 20 kilometers, the precision is ± 5 meters. The intelligent receivers in monitor stations can receive remote control orders from control center and control their sensors with automatically changing direction, altitude, focus length, infrared ray strength. With remote control system, control center can remotely control every station to detect different direction and location. With reasonable distribution of monitor stations, accurate visibility figure can be acquired for VTS Center to make decisions. Of course, the deployment of such a system needs serous consideration over budget and cost/benefit evaluation which will not be discussed in this dissertation.

4.2 The improving of safety practices of Dalian VTS Center in strong wind

According to *Dalian VTS Center Standard Working Manual (2013)*, in case of strong wind, "VTS Center should broadcast strong wind warning in appropriate VHF channels." (p.41) There is no mention of other obligations of VTS Center in wind warning promulgation. However, in many cases, accidents happened because ships are not aware of the coming strong wind as mentioned in chapter 3.2. It is not adequate for VTS Center to monitor and warn ships when accidents loom in strong wind. The relevant parties must be informed of the strong wind beforehand and some parties need reminding more than others. According to experienced VTS operators as well as accident investigators, ships dropping anchor and waiting cargo for a long time have the tendency of negligence. This may be different from ship to ship, but anchoring ships generally are not as alert as ships underway. Anchor watch may not be kept properly, navigational warning are not handled properly and the strong wind warning may be omitted by responsible person on board. On some cargo ships anchoring for a long time for further operational instruction due to various reasons, only minimum hands are kept on board. Watch keeping is hardly kept due to lack of

manning not to mention the receiving of navigational warning. Some small ships designed for service purposes or underwater construction purposes have very poor understanding of wind threat. Some of them have no manning at all when no operation is undergoing. If the owners are not informed before strong wind approaching, accidents are expected. Also, ships need to be warned before the wind coming because they **need time** to manning the ships, make safety arrangement as described in chapter 3.2. Beside the VHF warnings Dalian VTS Center normally release, in my personal point of view, the following information promulgation work needs to be done as well.

A, Relay strong wind warning to the owners of ships in Dalian VTS area. In China, when ships are registered in China MSA, they need to register their responsible individuals' mobile phone number. Because Dalian VTS Center is part of Dalian MSA, it has the access to the registered information. Through public telecommunications operator, Dalian VTS Center can send group messages to the individuals who represent the owners. The strong wind warning to be sent may include the prediction of wind scale, direction and time of occurrence. Foreign registered ships are not applicable to this method.

B, Relay strong wind warning to the masters of ships through telephone calls. According to *Dalian VTS Guide for Users(2015), Edition four*, "Ships (fishing ships are not included) intending to enter Dalian VTS area are required to forward their relevant information to Dalian VTS Center 24 hours beforehand. The information includes: ship's name, call sign, Gross tonnage, last port, ETA, maximum draft, name of cargo, master's name and hand phone number, etc." (p.9) Dalian VTS Center obtains the mobile phone numbers of the sea captains in this way.

Of course, it is unnecessary to make telephone calls to each and every ship. Dalian VTS Center may classify ships in different groups. Ships with excellent safety records and operating normally will not need to be called. Ships dropping anchor or berthing for a long time should be made priority. Foreign registered ships should be

informed through their local agents or writing email directly. Those ships that are to be called to inform forthcoming wind are **target ships**.

C, A few hours before the approaching of wind, the **target ships** should be called through VHF telephone to confirm that proper VHF watch is kept and safety precaution work is done on board for the coming wind. For most **target ships**, proper safety arrangement should be available at that stage. For various reasons, some target ships may not be properly manned and safety precautions are not ready. The confirmation calls through VHF can identify those ships, the owners should be contacted immediately for the reasons and safety arrangement should be made available by Dalian MSA if necessary.

D, Inform the ships that are to sail from Dalian VTS area to the open sea about the coming wind. This is usually done through VHF telephone right before the departure of a ship. At this stage, Dalian VTS Center may confirm with the departing ships to see if the ships are aware of forthcoming strong wind and if safety arrangement is available. A ship should be allowed to change its sailing plan if the ship decides that the coming wind will put serous threat to its safety.

4.3 The improving of safety practices in handling unregistered ships by Dalian VTS Center

The unregistered ships are mostly small cargo ships without AIS. Two usual ways that Dalian VTS Center can find them are through CCTV and RADARs. Over years, the unregistered ships have developed strategies of dodging CCTV cameras which are distributed in limited number of places along coast line. Once those ships are far away from coast line, only RADARs can detect them. Since they are about the size of big fishing ships and there are numerous fishing ships in Dalian VTS area, it is very difficult to know which one is unregistered ship. In case of uncertainty, VTS Center may send patrol ships to confirm. But there are only several patrol ships available, they are not able to cover the whole VTS area. Dalian VTS Center may

also use RADARs to follow the suspicious targets to their berths and inform shore branches of Dalian MSA and relevant authorities to investigate. The problem is when a target is near coast, it is hard for RADAR to lock the target without losing it. In Mianhuadao area where is the unregistered ships' favorite berthing place, there are numerous locations to load/unload their cargo. It is impossible to search the whole area in time given that the unregistered ships normally stay very short time before they flee away. So the most difficult part of addressing unregistered ships is to catch them. Other ships are encouraged to report unregistered ships in VTS area. However, in most situations, ships only mind their own business. Merchant ships prefer to report unregistered ships after having accidents with them which is normally too late for the unregistered ships will be deserted by the crew. So VTS Center needs new way to catch unregistered ships besides RADAR monitoring. Drones are very promising alternatives. With the popularity of the drones, more drones with affordable prices are introduced. Through wireless services provided by telecommunications operator, actual time vision can be transferred back to VTS Center from the cameras fitted on the drones. Drones can be used to monitor the area that has most frequent activities of unregistered ships or to identify a potential target found by RADAR. They can help to discover an unregistered ship at early stage and follow it throughout its way in VTS area allowing more time for MSA together with other relevant authorities to catch and tackle them.

Besides, drones can be used to identify minor targets. For instance, there are one-man wooden boats fishing around fairways from time to time. It is extremely dangerous for the boats to enter the fairways where multiple ships are sailing within all the time. Due to cluster effect of RADARs, it is very difficult to identify a wooden boat. If a drone is deployed, the drone on site will tell the VTS operators if there is a wooden boat or not. Even more, the drone may warn the wooden boat with visual/audio signal to stay away from danger. Further more, the drones are very useful to help to find survivors at the very beginning of the search and rescue operation. It has the

overall vision of the area and responses much faster than the helicopters which take at lease one hour to reach the scene.

Of course, the deployment of drones needs serious consideration. The flying range, the number of drones needed, the location of the bases, the training of operators and the budget need further and deeper analysis. Also, Q. W. Hu (2010) concluded that the unregistered ships have their complicated origin and obstinate reality. The addressing of those ships is far beyond the capability of MSA along. This chapter only suggests a possible way of finding them. To eliminate the existence of all unregistered ships, local government and other authorities besides MSA need to work hard together for a long time.

4.4 The training of VTS operators should be improved by enriching their nautical knowledge

The operators in Dalian VTS center come from different backgrounds. Several of them studied shipboard communication at school who know little about ships and navigation. Some majored in navigation at school but possess little experience about ships and navigation. Most of the VTS operators joined Dalian VTS Center right after university or college. Before being sent to work, VTS operators are trained in two forms. First is experience passing by among operators. A new recruit has to sit next to a veteran to watch and learn. Second is formal training in Shanghai MSA. As per arrangement of Dalian VTS Center, each operator has to go through formal VTS related training in Shanghai MSA that lasts for a month. Because the participants have different backgrounds, the main context of training is basic introduction of COLREGS, standard English for VTS, ship's routing, the responsibility of VTS operators, report and recording, VHF knowledge, etc. Little is mentioned about navigation and ships. This kind of training can hardly achieve the goals of training competent VTS operators in accordance with IMO *A.857(20), Guideline for Vessel Traffic Services*.

To improve the understanding of ships and navigation, Dalian VTS Center has sent operators to visit ships once every year and sail with passenger ships for several days once every a few years. It turned out that operators did have some idea of ships and their operations but not in a systematic way. In 2010, Dalian VTS Center recruited 3 sea captains hoping that the captains would pass their experience to other operators. The arrangement might have helped to improve the knowledge of operators about ships and navigation but it is not enough without formal training and acquiring personal experience of their own.

Experience should be acquired on board before formal training. Arrangement should be made to send VTS operators who possess no on board experience aboard to see for themselves the operations of ships. The ships engaging coastal voyages along China's coast line are good choices. This kind of ships sail in dense traffic, cross different VTS areas and call different ports frequently. Through on board training, VTS operators will learn bridge activity, navigation aids, ship construction, ships maneuvering characters, COLREGS, etc. They will also have good understanding of what kind of vessel traffic services are needed, what ships do in VTS area and the reason behind this. The arrangement will improve the understanding between seafarers and VTS operators, and improve the service in Dalian VTS area. The building of experience needs time. It is safe to say one month on board is not sufficient. Dalian VTS Center has to plan its training program after thorough research. Also, Zhang & Zhai's research (2005) claimed that sending VTS operators to work together with pilots is proven to be a proper way of gaining experience on board. After training on board, systematic knowledge should be taught to operators about nautical knowledge. Dalian Maritime University is a reputable university for training in maritime domain in China. Dalian VTS Center may delegate the experts from DMU to write a training course with reference to *IALA V-103-1 part E, course Module 4.1 nautical knowledge*. The teachers of the training course should be chosen properly as per Module 4.1 description "instructors for this module should have good

knowledge of ship bridge activities as well as a recognized marine qualification." (p.67)

4.5 The improving of safety measures of Dalian VTS Center in safety arrangement of trial ship

The current safety arrangement for trial ship according to *Dalian VTS Center Standard Working Manual(2013)*, *2.11, The Monitoring of Trial Ships,*

> The inbound/outbound process of a trial should be at daylight and the weather should be appropriate for the safety of the trial ship. Following areas should be avoided to carry out trial operation: fairways, dense traffic area, sea farming area, fishing ground. Listening watch should be kept on VTS working channel and VHF channel 16 all the time. Any other ships approaching should be alerted if necessary. Trial ships should be manned with sufficient and eligible seafarers. The right signal should be displayed. Flags 'R', 'U', 'I' should be displayed during daytime and white, green, red lights should be displayed during night time or in poor visibility. The life saving arrangements as well as emergency plans for the ships should

be at place. The official contact persons both on board and at shipyard should be available. (p.31)

Nothing is mentioned about escorts. In fact, a trial ship may need escorts during the whole process of trial because the reasons mentioned in paragraph 3.5. According to *Dalian Shipyard Trial Ship Safety Management Methods (2016)*, the escort tugs can leave the escorted at H0 buoy. After that, trial ships need to sail through Sanshandao Fairway (which is very busy with crossing traffic and the sea farming area is nearby) by themselves. The Sanshandao Fairway is under the influence of wind and strong current. The wind and current have significant impact to the maneuvering of trial ships when the maneuvering area is limited. The assistance of escorting tugs is still needed for trial ships to remain in the fairway.

A permanent escort is needed in life saving point of view. According to the crew lists provided by the shipyards to DLMSA, on average, there are more than 100 individuals working on board a trial ship. However, for most trial ships other than passenger ships, the capacity of life saving equipment is only 25 or so. The arrangement of life saving capacity is not enough for the people on board. And, many of the individuals on board are experts in different area but not necessarily in life saving which requires special training. When evacuation becomes necessary, whether they are able to use life saving equipment properly is in doubt. If there are escorts around, the individuals can be evacuated to the escorting tugs and the potential disaster will be avoided. So, escort ships are good arrangement for life saving. Of course, the number and form of escorts need further debates.

CHAPTER 5

CONCLUSIONS

5.1 Conclusions

Through the analysis of accident investigation reports provided by DLMSA for Dalian VTS area between the beginning of 2011 to the end of 2015, together with the analysis of questionnaires finished by representatives from ships, Dalian VTS center, Dalian Maritime Safety Administration, shipping company, Dalian port authority, Dalian pilot, etc, the main accident contribution factors that is distinct for Dalian VTS coverage are identified. Top 5 of those factors are chosen to be analyzed to establish the influence on safe navigation. The corresponding safety measures of Dalian VTS are analyzed. The deficiencies of those safety measures are described and improved methods are proposed.

First, point out that the most common reason behind accidents that is strong wind relevant is lacking of awareness of the coming wind. Multiple ways of reminding are recommended to inform the ships and owners by Dalian VTS Center.

Second, point out that visibility data acquiring is deficient and visibility rules are not enforced in a way to facilitate port efficiency in Dalian VTS area. A reasonable way of acquiring visibility figure with ruling out interest relevant party is recommended. Another option of acquiring visibility figure with infrared equipment is mentioned. Organizing of traffic is improved by introducing new practice of allowing ships to move within partial area with relatively good visibility.

Third, point out that the existing ways of identifying unregistered ships are feeble due to technical and resource limitations. A new way of using drones as assistance to catch unregistered ships is introduced. The complication of eliminating unregistered

ships is mentioned.

Fourth, point out that current training arrangement for VTS operators is deficient. VTS operators need to gain experience through on board training. They also need to learn nautical knowledge in formal class training carried out by eligible instructors.

Fifth, point out that current safety measures treat the escorting of trial ships with indifference. Point out that trial ships may need to be escorted all the time instead of part of their journey due to safety reasons and the need of rationalizing lifesaving arrangement.

5.2 Other accident contribution factors that are severe threats to navigation safety

According to the questionnaires, following two factors are listed in position 6 and 7. Those two factors need further research for safety arrangement.

5.2.1 Unauthorized sea farming is great threat to safe navigation

Illegal sea farming is extremely profitable business. There are illegal sea farming from near coast to open sea. When a ship approaches Dalian Port, it has to be extra vigilant because the ship can never know when and where it will encounter floating sea farming devices. Those devices can seriously damage ships' propellers and rudders and the repair of such damage will cost lots of money and time.

There is illegal sea farming around Sanshan Islands. Any ship sailing around the islands should keep well clear of them. The problem is that the sea farming is very random, it is very difficult to tell what distance is the safe distance. Due to the area around Sanshan Island is very busy fairways, it is not favorable both for the heath of the food and the safety of navigation.

The sea farming east of Dayaowan Anchorage and Xingang Freight Anchorage is big problem, too. Much of those sea farming is not authorized and grows out of control in every direction. Sometimes, when a ship with every right to sail safely around the anchorages hits the illegal sea farming facilities, it has to pay for the damages done

to the sea farming facilities in several cases ruled by the maritime court which is rather bizarre. There were reports on the deliberate captures of merchant ships by setting sea farming devices in front of the merchant ships. The suspects waited in boats equipped with AIS, when they detected a ship approaching, they would deploy their trap made of strong net and rope accordingly. The ships captured have to pay the suspects to be free. Sometimes the wreckage from illegal sea farming nearby drifts into the anchorage which poses great danger for the propellers and rudders of ships. The Ocean Bureau who is the responsible authority for sea farming cleared the illegal sea farming once every several years, it did not work very well. The illegal sea farming always comes back. The situation is turning from bad to worse. Also, most service boats working for the sea farming do not display proper light signals during night and cross fairways with little consciousness about safe navigation. Like the unregistered ships mentioned in chapter 4.3, the illegal sea farming is a very complicated problem as well. The MSA and Ocean Bureau can not handle this problem along. The local government and other authorities need to work together to solve the problem.

5.2.2 The background is too bright for the navigators during night in Dalian Port

Weng & Zhou (2013) established that the mixture of targets' navigational lights with background lights may create new color of lights which will cause trouble for navigators to make the right judgment. Also the bright background leads to the fatigue of eyes which obviously is not preferable for safe navigation. It is difficult to identify light buoys in bright background which makes it difficult to use light buoys to navigate. The background light comes in two forms: the light from the city, the light from illumination of the berths and anchoring ships. It is no easy task to control background light. The controlling of background light needs help from the National Environmental Agency who is responsible for the controlling of city illumination. The problem is complicated and needs further researches.

References:

Cao, D. S. (2014). *Performance Evaluation of VTS and Location of Radar Stations in China.* (Master's Thesis). Retrieved from http://www.cnki.net/

Cao, X. C., Shao, L. M. & Wang, X. X. (2011). Analysis of climate characteristics of low atmospheric visibility at Dalian. *Marine Forecasts, 28-5, 44-49.*

Chen, C. M. & Tang, M. H. (2015). The improvement of VTS Efficiency. *Zhujiangshuiyun, 201507, 54-55.*

Chen, G. H. (2015). *Research on Evaluation and Regulation for the Safety of Vessels Navigation in Fog of Qingdao VTS Water Area.* (Master's Thesis). Retrieved from http://www.cnki.net/.

Chen, X. L. (2013). *Study on Promotion Countermeasure of VTS Public Services Level.* (Master's Thesis). Retrieved from http://www.cnki.net/.

Dalian Maritime Safety Administration of P.R.China. (2015). *Dalian VTS Guide for Users, 4th Edition.* Dalian: Author.

Dalian Maritime Safety Administration of P.R.China. (2013). *Dalian VTS Center Standard Working Manual.* Dalian: Author.

Dalian Shipyard. (2016). *Dalian Shipyard Trial Ship Safety Management Methods.* Dalian: Author.

Deng, Z. B. (2014). *The Study on Safety Management of Gale Weather Mooring Ships in Yantai Northern Waters.* (Master's Thesis). Retrieved from http://www.cnki.net/.

Guo, H. L. (2013). How to Establish a First-Rank Team of VTS Operators in China. *China Maritime Safety, 201301, 16-18.*

He, C. H., Wang, J. S. & Liu, M. (2013). Safety Precautions to Be Taken for Trial Ships. *China Water Transport, 201310, 15-16.*

He, L.J. (2014). The Study of Management Strategies for Non-certified Ships. *Journal of Guangzhou Maritime Institute, 201401, 1-4.*

He, W. & Lu, Y. M. (2009). Safety Practices of Trial ships. *Marine Technology, 200904, 21-23.*

Hu, Q. W. (2010). The Status of Unregistered Ships and Management. *Zhujiangshuiyun, 201006, 54-55.*

Hu, W. D., Zhou, F. & Liu, J. X. (2012). Reginalization and Frequency Allocation of VTS and Its Supervision Mode. *Navigation of China, 201212, 80-84.*

Huang, D. X. (2014). The Night Shift of VTS Watch. *Zhujiangshuiyun, 201419, 57-59.*

Huludao MSA. (2014). Discussion on the Establishment of an Integrated Supervision Model for New Building Ships' Sea Trial. *China Maritime Safety, 201401, 45-47.*

International Association of Lighthouse Authorities. (2008). IALA VTS Manual.

International Association of Lighthouse Authorities. (2013). *IALA Recommendation V－103 On Standards for Training and Certification of VTS Personnel*. France: Author.

International Maritime Organization. (1997). *Guideline for Vessel Traffic Services, A.857(20)*. London: Author.

Kang, W. M. (2014). The Application of Risk Control in VTM. *Marine Technology, 201404, 75-77.*

Lang, F. W., Zhou, L. J. & Cheng, M. H. (2015). The Influence of Wind to Ships. *China Water Transport, 201506, 5-9.*

Li, G. C. (2014). *The Strategy Research of Vessel Traffic Services to the Public.* (Master's Thesis). Retrieved from http://www.cnki.net/.

Li, H. W. (2010). *Study on the Assessing the Economic and Social Impact for Vessel Traffic Services.* (Master's Thesis). Retrieved from http://www.cnki.net/.

Li, H. X., Zhang, L.F. & Sun, M. L. (2014). The Establishing and Promoting of VTS Training Course. *Maritime Education Research, 201402, 56-58.*

Li, J. Z. (2013). The Management of Traffic in Fairway by VTS. *Technological Pioneers, 201305, 134.*

Li, X. Z. (2015). Navigation Safety in Poor Visibility. *Navigation, 201502, 49-51.*

Li, Z. B. & Jin, H. (2013). Incompatible Collision Avoidance Intentions and VTS Guidance. *Marine Technology, 201306, 2-6.*

Liang, C. (2014). *Safety of Navigation in and out of the Harbor under the Poor Visibility Situations.* (Master's Thesis). Retrieved from http://www.cnki.net/.

Liu, C. Z. (2014). *Research on Safety Assessment Model of Mooring Vessels under the Condition of Strong Wind.* (Master's Thesis). Retrieved from http://www.cnki.net/.

Liu, M. Y. (2014). *Incentive Problems Research on VTS Operator --Taking Guangzhou VTS Center as Example.* (Master's Thesis). Retrieved from http://www.cnki.net/.

Liu, Y. L. (2009). The Impact of Restricted Visibility on Collision Avoidance Behavior. *Journal of Qingdao Ocean Shipping Mariners College, 200902, 16-19.*

Qi, Q. & Yu, T. (2013). The Development of VTS. *China Radio, 201304, 36-38.*

Shi, S. Y. & Wang, S. Z. (2015). The current VTS Simulators and Its Future. *Marine Technology, 201501, 61-64.*

Shi, X. (2013). *Statistical Analysis and Windy Weather Forecast Methods in Dalian.* (Master's Thesis). Retrieved from http://www.cnki.net/.

Sui, Y., Lin, J. & Wu, X. R. (2015). Protection Technology in VTM. *Network Security Technology & Application, 201509, 81-83.*

Sun, M. & Lan, P. Z. (2015). Research on Ship Grounding Risk Alerts by VTS. *Journal of Jimei University, 201501, 33-36.*

Tang, W. J. (2013). *The Application of VTS on Ship Emergency Response.* (Master's Thesis). Retrieved from http://www.cnki.net/.

Tu, T. K. (2013). *The Study of the Improvement and Enhancement VTS's Functions.* (Master's Thesis). Retrieved from http://www.cnki.net/.

United Kingdom Hydrographic Office. (2013). *Guide to Port Entry, 2013/2014* London: Author.

Wang, D. (2014). *The characteristics of fog near Dalian.* (Master's Thesis). Retrieved from http://www.cnki.net/.

Wang, R. L. (2014). VTS and Seafarers. *Zhujiangshuiyun, 201419, 26-27.*

Wang, X. W. (2015). The Safety of Night Sailing of Big Size Container Ships. *China Water Transport, 201512, 35-36.*

Water Traffic Accident Statistical Method, The Transportation Ministry of P.R.China, (2015).

Weng, J. J. & Zhou, Y. (2013). Analysis of Impact of Light Pollution at Sea upon Ships' Navigation Safety at Sea and Countermeasures. *Journal of Wuhan University of Technology, 201306, 549-552.*

Xie, L. M. (2014). The Organization of Traffic of VTS. *Journal of Guangdong Maritime Institution, 201405, 56-57.*

Xu, R. X. & Li, Zheng. (2015). The Effect of Psychology of Pilot to Safety During Night Sailing. *World shipping, 201511, 15-18.*

Xu, T. T. (2012). *Study on New Technology of Vessel Tracking and Track Prediction in Vessel Traffic Services System.* (Master's Thesis). Retrieved from http://www.cnki.net/.

Yang, S. (2016). Discussion on the Expanded Application of WeChat Public Platform for VTS Operation Management. *China Maritime Safety, 201602, 53-54.*

Ye, G. F. (2008). Safety Control of the 'Three non-compliance' vessels. *China Maritime Safety, 200801, 43-44.*

Zhang, C. (2014). VTS Operators. *Zhujiangshuiyun, 201419, 24-25.*

Zhang, C. & Wu, L. G. (2014). VTS, A Safety Revolution. *Zhujiangshuiyun, 201419, 17-19.*

Zhang, X. J. (2007). In the VTS Supervising and Managing Work Should Grasp

Three Key, Three Limitations and One Degree. *China Water Transport, 200711, 56-57.*

Zhang, Y. K. (2015). *Research on the Application of Satellite Information Sources for Maritime Administration in VTS Centers.* (Master's Thesis). Retrieved from http://www.cnki.net/.

Zhang, Y. W. & Zhai, H. L. (2005). The Investigation of Training of VTS Operators. *Annual Meeting of China Maritime Communication Committee 2005 (pp31-36).* Dalian: China Maritime Communication Committee.

Zhao, F. Y. (2014). Discussion on the Judgment of the Nature of the Behavior of the VTS Operator on Duty and Related Responsibility Analysis. *China Maritime Safety, 201407, 56-58.*

Zheng, H. X. (2015). *Study on Building the VTS Public Service Quality Evaluation System in Our Country.* (Master's Thesis). Retrieved from http://www.cnki.net/.

Zhu, J. S. (2015). *Study on the Impacts and Countermeasures of Light Pollution at Sea on Ship's Navigation Safety at Night.* (Master's Thesis). Retrieved from http://www.cnki.net/.

Zhu, Y. J. (2014). Risks' Analysis on Safety and Pollution Prevention of Sea Trials Ship. *Journal of Qingdao Ocean Shipping Mariners College, 201401, 48-50.*

Appendix 1

Assessment of Risk Contribution Factors of Navigational Environment in Dalian VTS Area

To whom it may concern,

I am a student of World Maritime University, I am currently working on a dissertation 'The Study on Promoting of Dalian Vessel Traffic Services'. In the dissertation, several risk contribution factors are to be discussed. Please kindly finish the following table and choose the top 5 factors that you believe are the most important risk contribution factors of external environment of navigation safety in Dalian VTS area. You are welcomed to write down other factors if there is any. Thanks for your time.

Risk contribution factors of external navigation environment	Please put X after five items
Poor visibility	
Strong wind	
Strong current	
Water depth, shallow point	
Narrow fairway breadth, aids to navigation、obstructions	
Dense traffic	
Pilot service	
Background light is too bright	
VTS practice	

Anchorage is congested	
Poor behavior of unregistered ships	
Fishing and fishing boats	
Sea farming	
Poor behavior of certain type of ships	Type of ship
Speed limitation rules	
Poor design of fairways, anchorages, berths	What is wrong?
Local regulations	Which one？
Other factors	

Your occupation or expertise in:

Date:

Thanks for your cooperation, have a nice day!