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Dalian, China

The Staffing Levels at VTS Centre
--a case study of the Shenzhen VTS centre

By

XIE YUANZHONG

China

A research paper 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 ENVIRONMENTAL MANAGEMENT)

2013

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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 research paper reflect my own personal views, and are not necessarily endorsed by the University.

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Assessor:

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Title: **The Staffing Levels at VTS Centre—a case study of the Shenzhen VTS centre**

Degree: **MSc**

Abstract

This dissertation is a study of the staff levels at VTS centre, as exemplified by Shenzhen VTS centre.

A brief look is taken at present situation of VTS, at the historical developments of it, the definition of VTS, and the role of VTS is examined.

A detailed analysis is carried out on the factors that affect the staff levels at VTS centre from six aspects. Moreover, international instruments and national regulations regarding VTS and staff levels at VTS centre are explored, and major Articles among them are also presented according to a certain principle.

This research takes Shenzhen VTS Centre for a typical example of VTS centre, an introduction to which is discussed in detail, especially the factors that affect the staff level at Shenzhen VTS centre, and the calculation of the staff level at Shenzhen VTS centre.

The concluding chapter gives some recommendations to authorities for determining

the staff level at VTS centre, in other to promote the service given by VTS centre.

KEYWORDS: staff level at Shenzhen VTS centre; the development of VTS; workload of VTS centre

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List of Abbreviations

AIS	Automatic Identification System
CCTV	Closed Circuit TV Cameras
FMCW	Frequency Modulated Continuous Wave
IMCO	inter-governmental maritime consultative organization
GMDSS	Global Maritime Distress and Safety System
IALA	International Association of Marine Aids to Navigation and Lighthouse Authorities
IMO	International Maritime Organization
INS	Information Service
MWL	Mental Workload
NAS	Navigational Assistance Service
OECD	Organization for Economic Cooperation and Development
PWL	Physical Workload
RDF	Radio Direction Finders
SOLAS	International Convention for the Safety of Life at Sea
TOS	Traffic Organization Service
UNCLOS	United Nations Convention on the Law of the Sea
UNCTAD	United Nations Conference on Trade and Development
VTM	Vessel Traffic Management
VTS	Vessel Traffic Service

Chapter 1 Introduction

1.1 Background

As an integral part of international logistics, marine transport is the major conduct of international trade. It can be seen from the Figure 1 that Marine transport is accounts for 80 per cent of the volume of global trade. So it can be said that Marine transport is the backbone of international trade and a key engine driving globalization. Therefore, safety of navigation and protection of the marine environment has been a common concern.

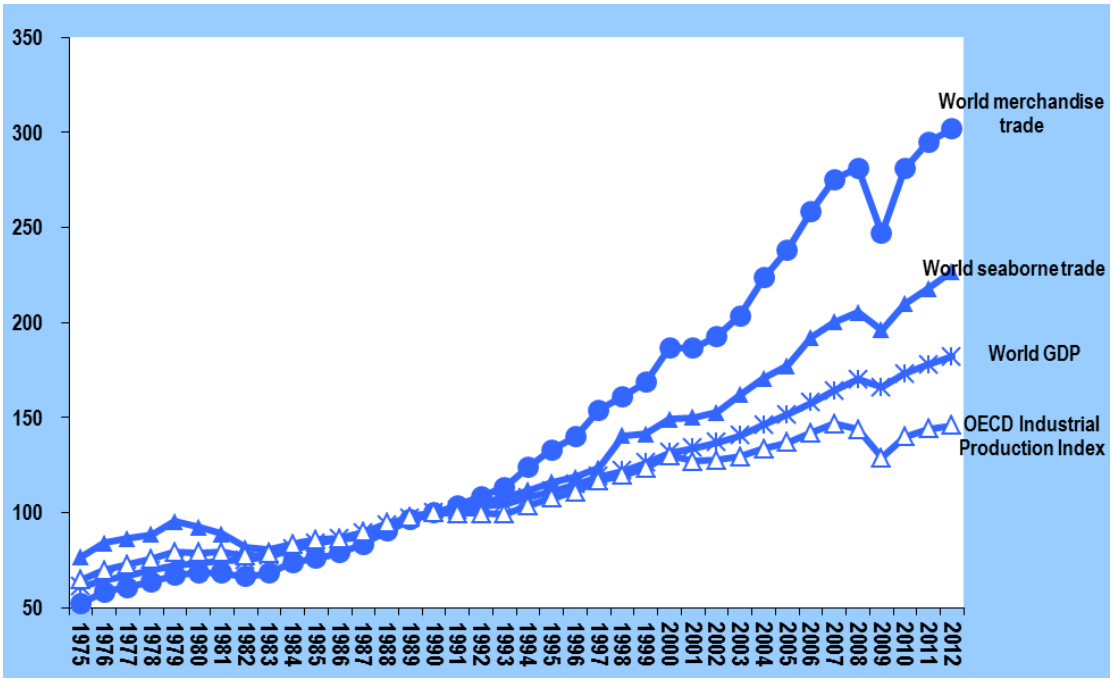

Figure 1 Organization for Economic Cooperation and Development (OECD) Industrial Production Index and indices for world GDP, merchandise trade and seaborne trade (1975–2012) (1990 = 100)

Sources: UNCTAD. (2013). *Recent developments and trends in international maritime transport affecting trade of developing countries.* In Item 5 of the provisional agenda key trends in international transport and implications for development (p5). Geneva: Trade and Development Commission.

It is well known that in the past several decades, in order to make safe, secure and efficient shipping on clean oceans, the shipping industry has been engaged in promoting the ship systems. There are many places has been improved. For example, structure of the ship, advanced navigational equipment, and reasonable legal requirements, etc. So, today's ship systems are technologically advanced and highly reliable (Anita & Rothblum, 2000, p.1). Yet, there were many maritime casualties all over the world. It is because the maritime system is a social-technical system, and ship structure and system reliability are a relatively small part of the safety equation, human factors plays a critical role in this system (Qureshi, 2007).

So the question ahead of us is how to deal with human factors for safe, secure and efficient shipping on clean oceans. As maritime authorities, traffic control is very important tool. It is well known that vessel traffic service (VTS) is a form of traffic control, and it has been playing a very important role in terms of safe, secure and efficient shipping on clean oceans. Therefore, how to plan and implement VTS would become more important. Sound operational procedures and reliable equipment notwithstanding, the most important component of a VTS is its operating personnel (IALA, 2006). So it is imperative that a VTS should be staffed with the appropriate number of highly trained personnel. In other words, what staff level at VTS centre is extremely important.

1.2 Organization of this thesis

The thesis is arranged in a logical sequence to reach the desired objectives of the paper. This paper is consists of seven chapters. Firstly, the background, special explanation**,** literatures and studies relating to staffing levels at VTS Centre will be reviewed in this Chapter.

Chapter 2 introduces the VTS, focused on the sources, development and the function of VTS, and elaborates the influence of staff level at VTS centre.

Chapter 3 is a purely legal part, which mainly introduces the main international conventions, recommendation, resolution and national documents concerning VTS, especially concerning staff levels at VTS centre. Including the documents which from IMO, IALA and other international organization.

Chapter 4 is an introduction to Shenzhen VTS center, which shows a basic picture of Shenzhen VTS centre to the reader. Furthermore, it includes expounding the staff level at Shenzhen VTS centre as well as put forward the problems about staff level at Shenzhen VTS centre.

Chapter 5 is the focus of this paper, which introduces the basic factors affecting the staff level at VTS centre, and then analyzes the specific factors that affect the staff level at Shenzhen VTS centre.

Chapter 6 is also the main part of this paper, which calculates the staff levels at Shenzhen VTS center according to the analysis of Chapter 5.

Chapter 7 provides some possible recommendations proposed by the author on the basis of his work experience, and concludes this research paper.

1.3 Special explanation of the study

IALA has produced a recommendation (IALA 1034 Guideline) on how to determine an appropriate staffing level for a VTS. This paper is based on this guideline to

calculate the staff level at Shenzhen VTS center. But it is well known that it is often difficult to quantify with any degree of accuracy to determining the adequacy of the number of VTSOs on duty (staff levels at VTS centre, 2005)，because there are many factors affecting the workload of VTS, even in IALA 1034 Guideline, there are some factors hard to quantify, such as physical working environment, attention/concentration levels, etc. So, this paper just focuses on the main factors that can be quantified, including traffic volumes and densities, incidents, accidents and other emergencies, navigational complexity associated with the VTS area, operational procedures, navigational assistance service, etc.

The study method of this paper is based on formula given by IALA 1034 Guideline, and the most data used for calculation come from the database of Shenzhen VTS centre. In addition, in order to obtain the more accurate data, the author was working in Shenzhen VTS centre during this time, and also did some investigations, such as the time of target identification, label and recording per ship, see Appendix 1; for the time of replying shipping report per ship, see Appendix 2; for the time of broadcasting the safety information per time, see Appendix 3; for the time for sail planning per time, see Appendix 4; for the time for entry port approved, see Appendix 5; and for the time for telephone issues per time, see Appendix 6.

1.4 Objectives of the study

This paper will provide the reader with an overview of the main current major legal articles in international and national instruments concerning VTS and staff levels at VTS centre. Hence, it will examine the factors that affect the staff levels at VTS centre, and then make an analysis of the Shenzhen VTS situation, using the formula given by IALA 1034 Guideline to calculate the staff level at Shenzhen VTS center,

so as to propose reasonable recommendations from the viewpoint of maritime administrative officer, for ensuring that Shenzhen VTS Centre can continuously provide the best VTS services for sea-going vessels visiting the port of Shenzhen.

1.5 Overview of previous literature

So far, there have been numerous jurists and legislatures which carried out a number of comparative law studies concerning VTS and staff levels at VTS centre. These studies offered many valuable references for the legal system establishment concerning VTS and staff levels at VTS centre in many countries, also the author has benefit of from these law studies for study on staff levels at VTS centre. Such as IMO, IALA and other organizations continuous research and development of documents about VTS and staff levels at VTS centre. As a United Nations specialized agency with responsibility for the safety and security of shipping and the prevention of marine pollution by ships, IMO plays o critical role in the development of VTS, and subsequently formulated the "resolution A.857 (20) Guidelines for Vessel Traffic Services"， which regulates what are the contracting states or the competent authorities should pay attention to when they plan and establish VTS. In addition, IALA has played a leading role in the field of VTS. It has drafted and promulgated a series of documents, such as IALA 1034 Guideline "Staffing Levels at VTS Centers", which provides a comprehensive list of the factors that would influence the workload of VTS centre.

As for in China, due to short development time of the VTS, the problem of staff levels at VTS centre has not got the adequate attention of the relevant government departments (Zhu＆Chen, 2008, p.32). So far, China has no law to adjust staff levels at VTS centre. The legal norms adjusting staff levels at VTS centre are available in

some relevant laws, regulations and rules, and the contents concerning staff levels at VTS centre in these legal norms are very fragmented and incomprehensive, and it just says that every VTS centre should man the appropriate number of highly trained personnel, but it is a pity that there is no article concerning how to determine the appropriate number of highly trained personnel. However, there are some scholars who have issued some research papers on staff levels at VTS centre, for example, "study on staff levels at Ningbo VTS centre" by Ye, P.P, "the preliminary study on staff levels at VTS centre" by Wang,Q, "the staff levels at VTS centre in China" by Liang,X.C, and "the staff levels at Yangtze river VTS centre" by Shi, J.B. Admittedly, the author has benefited a lot from the above studies during the present research.

Chapter 2 An introduction to VTS

2.1The definition of VTS

VTS is vessel traffic service, IMO has defined VTS as following: A VTS is any service by a competent authority, designed to improve safety and efficiency and the protection of the environment. It may range from the provision of simple information messages to extensive management of traffic within a port or waterway. So, A VTS should have the capability to interact with traffic and respond to traffic situations in the area.

2.2 The development of VTS

As for the origins of the VTS, it should go back to the 1950s. At that time, it was clear that short range audio-visual aid to navigation was not sufficient enough to assist ships in their voyage into or from a port in all weather conditions, and there

was a need to be able to keep ports open in all conditions of visibility and traffic density. In addition, the development of radio and radar made it possible for coastal/port States to monitor and track the movement of ships in coastal waters at that time. So, the maritime experts of the time believed that the use of shore-based radar combined with communications to monitor and organize the traffic could be applied to enhance the safety and thereby the efficiency in port areas. The world's first harbor surveillance radar was inaugurated in Liverpool, England, in July 1948, and in March 1950, a radar surveillance system was established at Long Beach, California. All of these could be seen as the origins of VTS (VTS manual, 2012). Since then, VTS has gained in importance in the domain of maritime traffic management in the following decades.

The purpose of these early systems is mainly to avoid traffic delays. However, during the 1960s and1970s, there were some major shipping accidents which caused serious pollution of the marine environment, which aroused the attention of the marine environment, such as the event of Torrey Canyon and Amoco Cadiz. Therefore, the policy maker reconsidered the use of radar surveillance and vessel traffic management. Slowly there was a movement towards a coordinated approach that was to become vessel traffic services. VTS was defined and then the matter was discussed in IMO known as the inter-governmental maritime consultative organization (IMCO). The value of VTS in navigation safety was first recognized by IMO in resolution A.158 Recommendation on Port Advisory Systems adopted in 1968. At that time, IALA also considered the requirement of VTS and a subsequent study was initialed.

With the development of technology, the equipment to track and monitor vessel traffic became more sophisticated, it was clear guidelines were needed on

standardizing procedures in setting up VTS. In particular, it became apparent that there was a need to clarify when a VTS might be established and to allay fears in some quarters that a VTS might impinge on the ship's master's responsibility for navigating the vessel. As a result, in 1985, IMO adopted resolution A.578 (14) Guidelines for Vessel Traffic Services. However, the Organization had not introduced mandatory VTS within the territorial sea into its regulatory conventions, specifically SOLAS 1974, until 1997. In the same year, the Organization updated the former guidelines for VTS to adapt to the new developments in this area.

As technology was developing, the shore-based radar systems evolved from being a quite simple system consisting of radar and communication with the aim of increasing efficiency of shipping in adverse weather conditions, to a highly advanced system with multiple sensors with the aim of increasing safety at sea, improving the efficiency of maritime traffic and to protect the environment. As a result of the improvements in efficiency, safety and the reduction of potential environmental pollution experienced by authorities using a VTS, together with the rapid developments in computer technology, the number of VTS systems worldwide increased rapidly in particular during the last two decades, there have been some 500 VTS systems in use all over the globe and the number will continue to grow as many coastal states wish to be protected from any negative effects of maritime traffic. In a limited number of countries, VTS has been established in inland waters with the same overall objects that apply to the maritime VTS systems.

As for China, the construction of VTS is relative late. It can be roughly divided into three stages (Liang, 1999, pp76-77): the first stage was the stage of study and preparation, which happened before 1978. At that time, China rose of the large-scale port construction boom, the vessel traffic density of port increases. So Ministry of

Transport organized relevant departments to foreign countries for investigating the VTS and learning the experience of establishing VTS. On the basis of the test, he set up development plan of Shanghai and Qingdao VTS. The second stage was the initial stage, which happened in the 1980s. It successively built 5 VTS center, such as Ningbo VTS centre, Dalian VTS centre, etc. During this period it was unprecedentedly active study on the theory about VTS in China. But generally speaking, it was still relatively superficial understanding of the role and function of VTS in these periods. The third stage was overall development stage, which happened after 1990. It successively built more than 10 VTS centers, such as Guangzhou VTS centre, Shenzhen VTS centre, etc. From the legal provisions of the function and status of VTS, to strengthen the maintenance and management of VTS, gradually benefit of the VTS.

The development of VTS is still very much ongoing and at the time of writing, there are processes that aim to develop a concept called Vessel Traffic Management (VTM) which is an enhanced VTS service that aims to incorporate more services into the VTS systems. Currently, it is likely that VTM would comprise VTS as a central component and would include other activities such as AIS, LRIT, enforcement of laws and treaties, and search and rescue (SAR). A pictorial representation of the concept was shown in Figure 2.

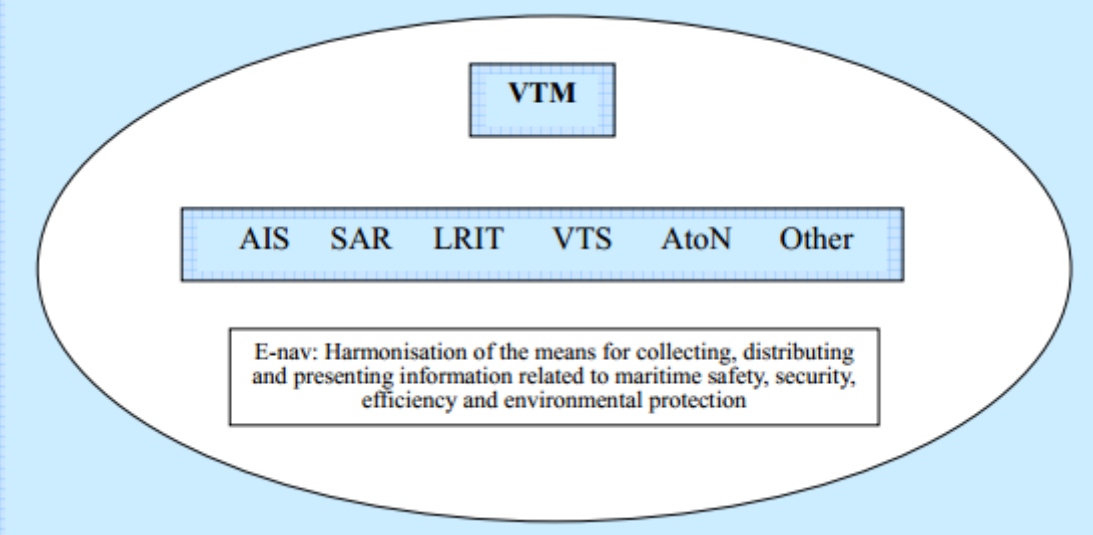

Figure 2 Potential Future Developments that impact VTS
Sources: VTS manual 2008.

It is envisaged that development of this concept will be considered in detail at IALA and incorporated into the work programmer with a view to developing proposals that will form the basis of consultation with IMO and other interested bodies.

2.3 The role of VTS

According to Resolution A.857 (20) produced by IMO, there are two different kinds of VTS, one is the Port or Harbor VTS and the other one is a Coastal VTS. The Port VTS is mainly concerned with ship traffic to or from a port, while a Coastal VTS is mainly concerned with ship traffic passing through the VTS area. The primary task of a VTS is to monitor the movements of maritime traffic within the VTS area and to share information with navigator on-board vessels in the fairways, providing them with up-to-date information of current and near-future events, which in any way can hamper the safe passage of a vessel.

The VTS functions can be subdivided into internal and external functions (Guidelines for Vessel Traffic Services, 1997). Internal functions are the preparatory

activities that have to be performed to enable a VTS to operate. These include data collection, data evaluation and decision-making. External functions are activities executed with the purpose of influencing the traffic characteristics. They relate to the primary traffic management functions of rule-making, allocation of space, routine control of vessels and maneuvers to avoid collisions, as well as to other management functions such as enforcement, remedial and ancillary activities. The main function of VTS was reflected through the following three services given by VTS.

2.3.1 Information Service (INS)

Information service is the most basic service that VTS can provide. Generally speaking, VTS endeavors to deliver information that is timely, relevant and accurate. He could receive processes and disseminates information about conditions and events important to shipping and safety at sea, such as the position of vessel, visibility or weather, other ships dynamic, or any other information that could impact a vessel's safe transit. It could provide information at regular broadcast intervals, on request or whenever circumstances so require.

2.3.2 Traffic Organization Service (TOS)

A traffic organization service is a service to prevent the development of dangerous maritime traffic situations and to provide for the safe and efficient movement of vessel traffic within the VTS area (Wikipedia, 2013). Generally speaking, the traffic organization service involves the operational management of traffic and the forward planning of vessel movements, the purpose of which is prevent congestion and dangerous situations. It is particularly important to in times of high traffic density or when the movement of special transports may affect the flow of other traffic. In VTS centre, these services may include VTS sailing plans, routes to be followed, speed

limits to be observed, mandatory reporting of movements in the VTS area, and other appropriate measures which are considered necessary by the VTS authority.

2.3.3 Navigational Assistance Service (NAS)

A navigational assistance service is a service to assist on-board navigational decision-making and to monitor its effects. The navigational assistance service is especially important in difficult navigational or meteorological circumstances or in case of defects or deficiencies. This service is normally rendered at the request of a vessel or by the VTS when deemed necessary. This may include bearing and range to a nearby danger or landmark, a course to make good to a waypoint, advice on a course to steer, or assistance in determining a vessel's position. Information to assist navigation decision making must be provided in a timely manner, and must be clearly understood by both parties and not open to misinterpretation.

2.4 The influence on staff levels at VTS centre

VTS personnel should be capable of providing information, traffic organization and/or navigational assistance service in the area specified by the relevant VTS Authority. The number of operators at any time should be based upon safe and efficient operations in the VTS area to meet the operational needs and should be reflected in the human resource planning, including staff rotation and rest period arrangements within any given shift or watch.

When staff level is at high levels that would lead to boredom, reduce the attention and lose the situation awareness. When the operator capacity is not enough to perform the task due to low staff level, operator may not succeed in handling task demands. Furthermore, this situation tends to cause the operator to feel stress and to

make an error. That's why, the acceptable staff level can be determined so as not to impede the operator, but to manage the system safely and effectively.

Chapter 3 International documents and National documents concerning VTS

With the global development of VTS, it generates a need for international or domestic agreement as to how VTS centre can be successfully established and operated. So far, there are many documents concerning VTS, some of them is convention, some of them is recommendation or guideline and so on. However, it is the purpose of this chapter to just demonstrate the main international and national documents concerning VTS, more importantly, through the review of these main international and national documents, understanding the legal role of VTS and finding out the provision concerning staff levels at VTS centre in these documents.

3.1 International documents concerning VTS

3.1.1 United Nations Convention on the Law of the Sea (UNCLOS, 1982)

United Nations Convention on the Law of the Sea (UNCLOS) was adopted in 1982, which was based on the international jurisdiction of the ocean territory. It defines the rights and responsibilities of nations in their use of the world's oceans, establishing guidelines for businesses, the environment, and the management of marine natural resources (UNCLOS, 1982). Between 1992 and 1993 the Legal Committee and an ad hoc informal working group reported to the Committee considered legal issues regarding the adoption of mandatory ship reporting to VTS, bearing in mind the basic framework established by UNCLOS. These deliberations paved the way for the adoption of a new SOLAS regulation on mandatory ship reporting. In addition, in this convention, it states that with regard to the authority that may be given to a VTS, a State retains the right to control its territorial waters and all vessels that are subject

to the jurisdiction of the State, also beyond territorial waters, a State's authority with regard to VTS is substantially reduced, noting that participation is not mandatory outside of territorial waters. In addition, in straits used for international navigation, a VTS Authority cannot restrict or impede the innocent passage of vessels. Therefore, as far as the enforcement jurisdiction of coastal States is concerned, VTS is poised to challenge the limits of coastal State competence as delimited in UNCLOS (Yang, 2006, p.211). However, this convention has no provision about staff levels at VTS centre.

3.1.2IMO documents

There are many documents from IMO related to VTS. From my personal view of point, the main documents as follows.

3.1.2.1 International Convention for the Safety of Life at Sea (SOLAS), 1974

At first, the 1974 SOLAS Convention is not expressly mentioned in vessel traffic services, but in June 1997, IMO Maritime Safety Committee added a new provision in Chapter V (Safety of Navigation), which specifies when to implement of VTS. Regulation 12, which came into force in July 2002, contains five paragraphs. It states that the function of VTS, the governments when and how establish VTS, etc (International Convention for the Safety of Life at Sea, 1974). Furthermore, it requires that when the contracting governments planning and implementing VTS, it shall follow the Guidelines for Vessel Traffic Services (IMO resolution 857 (20), in which there are some provisions concerning staff levels at VTS centre, more detail will be discussed in the following.

3.1.2.2IMO Resolution A.857 (20) - Guidelines for Vessel Traffic Services (1997)

The IMO - Resolution A.857 (20) are Guidelines for Vessel Traffic Services, which was adopted in 11 27 1997, this resolution regulates what are the Contracting States or the competent authorities should pay attention to when they are planning and establishment of VTS, it plays a key role in national planning and establishment of VTS. It claims that the Contracting Government or Governments or the competent authority should ensure that the VTS authority is provided with sufficient staff. But it is no provision claim what sufficient staff at VTS centre is.

3.1.3 IALA documents

Since the original development of VTS, IALA has been committed to study about VTS. He recognized that VTS systems were uncoordinated and differed from country to country, so it should be a forum at which similar problems could be discussed and experiences could be shared. Consequently, IALA established a VTS Committee to undertake these tasks in 1980. Since then the VTS Committee has grown steadily and has developed into the foremost forum on Vessel Traffic Services in the world. Also IALA recognized that it is important association with other maritime consultative to the development of such documents, for example, he associated with International Maritime Pilots' Association (IMPA), International Harbor Masters' Association (IHMA), International Federation of Shipmasters' Associations (IFSMA), International Association of Ports and Harbors (IAPH) and The Nautical Institute (NI) to development of VTS manual.

The IALA documents concerning VTS consist of recommendations, guidelines, manuals and pamphlets, which are shown in Figures 3, 4, and 5.

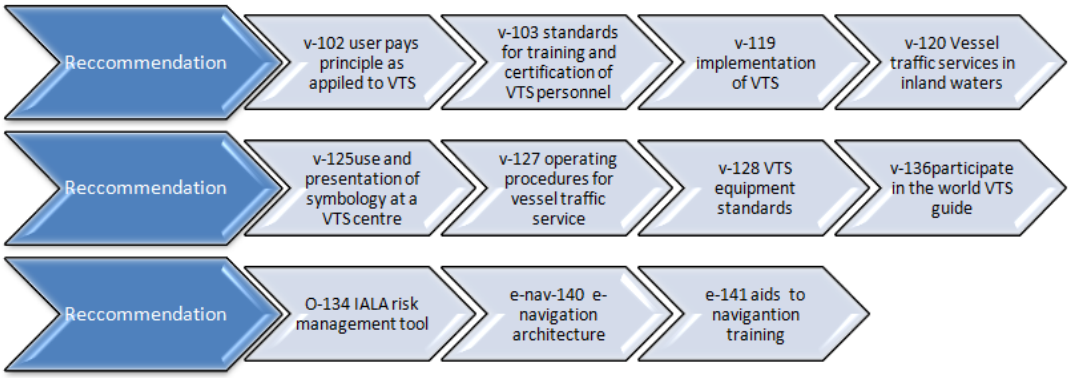

Figure 3the IALA recommendation concerning VTS

Sources: compiled by the author.

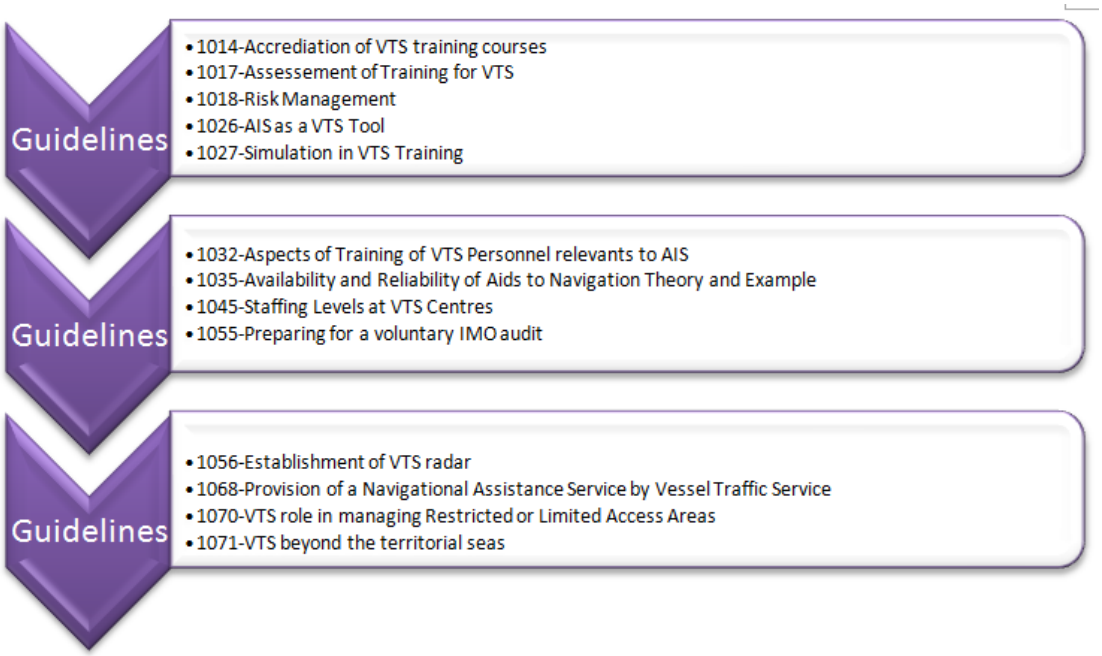

Figure 4 the IALA guidlines concerning VTS

Sources: compiled by author.

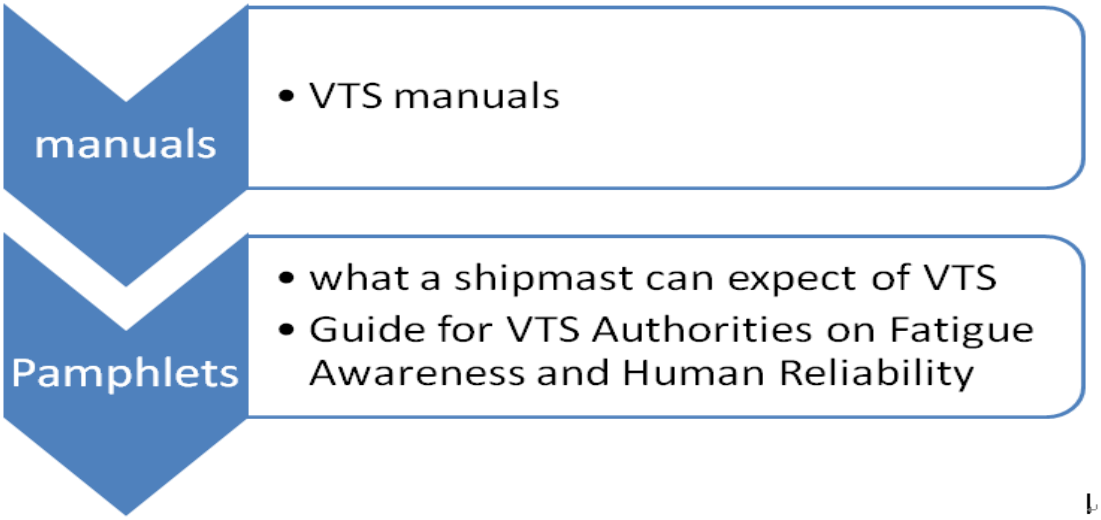

Figure 5 the IALA manuals and pamphlets concerning VTS
Sources: compiled by the author.

This list of VTS related legislation is by no means comprehensive. However, it does cover the main points concerning the guidelines for VTS. From my point of view, the follow documents should receive attention.

3.1.3.1IALA - Recommendation V-103 (2009)

Recommendation V-103 is Standards for Training and Certification of VTS Personnel, which lays the foundation for training and qualification standards for the VTS personnel. Having such standards should ensure an efficient career structure and enhance the quality and determination of the VTS personnel concerned (Standards for Training and Certification of VTS Personnel, 2009). If VTS personnel is trained through these standards, the VTS centre would likewise enhance the quality and professionalism of the waterways management itself. Such qualifications mean that a common performance standard can be achieved both nationally and internationally. In other words, this is a proposed requirement for the staff levels at VTS centre from the quality of personnel.

3.1.3.2 IALA - Recommendation V127 (2004)

IALA - Recommendation V127 is operational procedures for vessel traffic services, which was adapted in June 2011. This Recommendation has been prepared as to assist VTS authorities in identifying key aspects that should be considered when developing operational procedures for a VTS centre. A clear distinction is made in this document between internal and external procedures, and a further distinction is made between routine and emergency procedures. It requires that the number of operators at any time should be based upon safe and efficient operations in the VTS area to meet the operational needs and should be reflected in the human resource planning, including staff rotation and rest period arrangements within any given shift or watches (Operational Procedures for Vessel Traffic Services, 2004).

3.1.3.3 IALA Guideline No. 1045 (2005)

IALA Guideline 1045 is Staffing Levels at VTS Centers, which is the most important document concerning staff levels at VTS centre. The purpose of this Guideline is to assist authorities in determining an appropriate staffing level for a VTS Centre. Conferring with the existing VTS Authorities will provide a general idea of how VTS Centers are staffed. It provides many factors that affect the workload of VTS centre. But just say in Charter 1 some of these factors are hard to quantify. So, this Guideline is not intended to be prescriptive; rather it presents factors that should be considered in determining staffing levels.

3.1.3.4 VTS Manual (2012)

The Edition 5 of VTS manual was adapt 2012, which is now acknowledged by the VTS community as being the most comprehensive guide to Vessel Traffic Services (VTS) as well as a point of reference for further detailed study. The contents are

aimed at a wide readership to encompass all who are in any way involved with the policy for provision, operation and effectiveness of VTS, including those with management responsibility at national level and those who deliver services to the mariner. In this document, there is a specialized provision to regulate the staff level at VTS centre.

3.2 Domestic Documents

Since the 1980s, the Chinese Government has accelerated the construction of ports and development of shipping industry to satisfy the increasing growth of shipping economy and foreign trade. The financial input was increased to expedite the infrastructure construction of waterways and marine aids to navigation, and great efforts made on the innovation and application of marine aids to navigation technology as well as the improvement of administration of marine aids to navigation along the coastal ports areas. There are more than 25 VTS centers (including three state-of-the-art VTS centers in Yangtze River inland waterway) with 80 or more radar stations, operating in China. All these VTS centers are integrated with the advanced national AIS network, covering the entire sea area along Chinese coast. Also there are some documents concerning VTS.

3.2.1Maritime Traffic Safety Law of the People's Republic of China (1984)

It was adapted at the second meeting of the standing of the sixth national pople's Congress, promulgated by Order No. 7 of the President of the People's Repub lic of China on September 2, 1983, and effective as of January, 1, 1984. It is the first law of maritime traffic safety management in china. This law formulated in other to strength the control of maritime traffic, and ensure the safety of vessels, installations, human life and property, and safeguard the rights and interests of the state (Maritime Traffic Safety Law of the People's Republic of China,1984). However, this

law does not have provision about staff levels at VTS centre.

3.2.2 Safety Management Regulations of Vessel Traffic Service of the People's Republic of China (1998)

Safety Management Regulations of Vessel Traffic Service of the People's Republic of China came into force on 1 Sep 1998. The purpose of it is to strengthen the vessel traffic management, protection of vessel traffic safety, improve the efficiency of vessel traffic and protect the aquatic environment (Safety Management Regulations of Vessel Traffic Service of the People's Republic of China, 1998). He includes ship reporting, vessel traffic management, vessel traffic services and legal responsibilities, etc. However, this regulation does not have provision about staff levels at VTS centre.

3.2.3 Regulations of the Shenzhen Municipality on Maritime Traffic Safety (2005)

It was adopted at the Thirty-Eighth Meeting of the Standing Committee of the Third Shenzhen Municipal People's Congress on April 29, 2005, approved by the Eighteenth Meeting of the Standing Committee of the Tenth Guangdong Provincial People's Congress on May 26, 2005, promulgated on June 2, 2005, and put into force from September 1, 2005. The purpose of it is to strengthen the administration of maritime traffic safety, to ensure the personal security and property's safety, and to promote the economic and social development of Shenzhen (Regulations of the Shenzhen Municipality on Maritime Traffic Safety, 2005). However, this law does not have provision about staff levels at VTS centre.

3.2.4 Vessel Traffic Safety Management Regulations in Shenzhen VTS Area

Vessel Traffic Safety Management Regulations in Shenzhen VTS Area came into force on Sep 1 2005. The purpose of it is to strengthen the vessel traffic management, to protection of vessel traffic safety, to improve the efficiency of vessel traffic and to protects the marine environment (Vessel Traffic Safety Management Regulations in Shenzhen VTS Area, 2005). It includes something about ship reporting, traffic management, traffic services, communication, and legal liability, etc. However, this law does not have provision about staff levels at VTS centre

Chapter 4 An introduction to Shenzhen VTS

4.1 The development of Shenzhen VTS

The Shenzhen VTS is a VTS provided by Shenzhen Maritime Safety Administration of the People's Republic of China since October 2000. It was established to support the provision of VTS services within the Shenzhen VTS coverage. In 2006, the Shenzhen VTS System was replaced / upgraded to the existing Shenzhen VTS System (i.e. the 2nd generation) since the majority of the 1st generation's equipment had reached the end of its serviceable life.

4.2 The hardware and software of Shenzhen VTS centre

There is much hardware and software in Shenzhen VTS centre. The Shenzhen VTS system is ATLAS VTS9760 system. In brief, the existing Shenzhen VTS System includes equipment and facilities as shown: radar and radar data processing system, a computer module, Closed Circuit TV Cameras (CCTV) system, Long Range Communication, meteorological and hydrographical sensors, a VHF communication subsystem, Radio Direction Finders (RDF), Automatic Identification System (AIS), VTS Data System, GMDSS system, Traffic data processing systems and traffic

management information.

4.3 The coverage of Shenzhen VTS

Shenzhen VTS is a mandatory VTS. It consists of two Sectors: Eastern Sector (E) and Western Sector (W), the Languages available there are Mandarin, Cantonese or English, and the clients are merchant ships of 500 gross tonnages and up and all passenger ships.

4.3.1 Eastern Sector (E)

Eastern Sector (E) shown on Figure 4, it is an area between the coast and the reporting line L1 connecting Tai Long Tsui of Hongkong (22 ℃24.800′N, 114°24.300′E) and Heiyanjiao of Shenzhen (22°27.000′N, 114°30.133′E). The working channel is VHF 74.

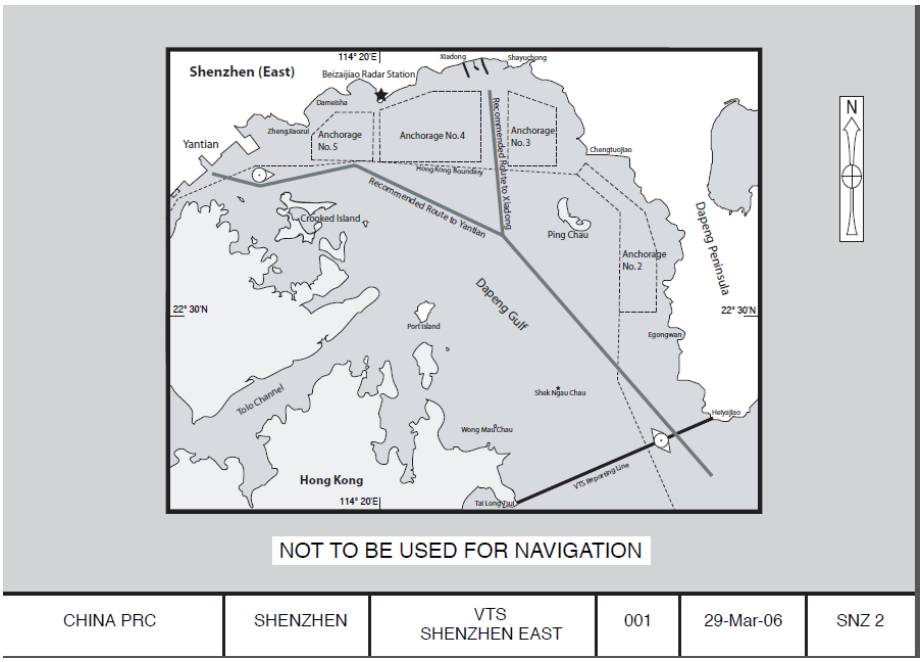

Figure 6 the Eastern Sector of Shenzhen VTS

Sources: World Vessel Traffic Services Guide

4.3.2 Western Sector (W)

The Western Sector (W) shown in Figure 5 is an area enclosed by the coast and the following four reporting lines. The first reporting line is south reporting line L2, which is the parallel of latitude of Lungkwuchau light beacon (22º22.832′N). the second reporting line is southwest reporting line L3,The line connects Lungkwuchau light beacon (22º22.832′N, 113º52.625′E) and Niulijiao light beacon of Neilingding island (22º25.017′N , 113º46.930′E). The third reporting line is west reporting line, The meridian of longitude of Niulijiao light beacon (113º46.930′E). the last reporting line is north report line L5, The parallel of latitude of 22º31.200′N. The working channel is VHF 69. In addition, in order to strengthen the management of high-speed passenger, when the high-speed passenger passes through the point E, it must report to Shenzhen VTS, the working channel is VHF 01.

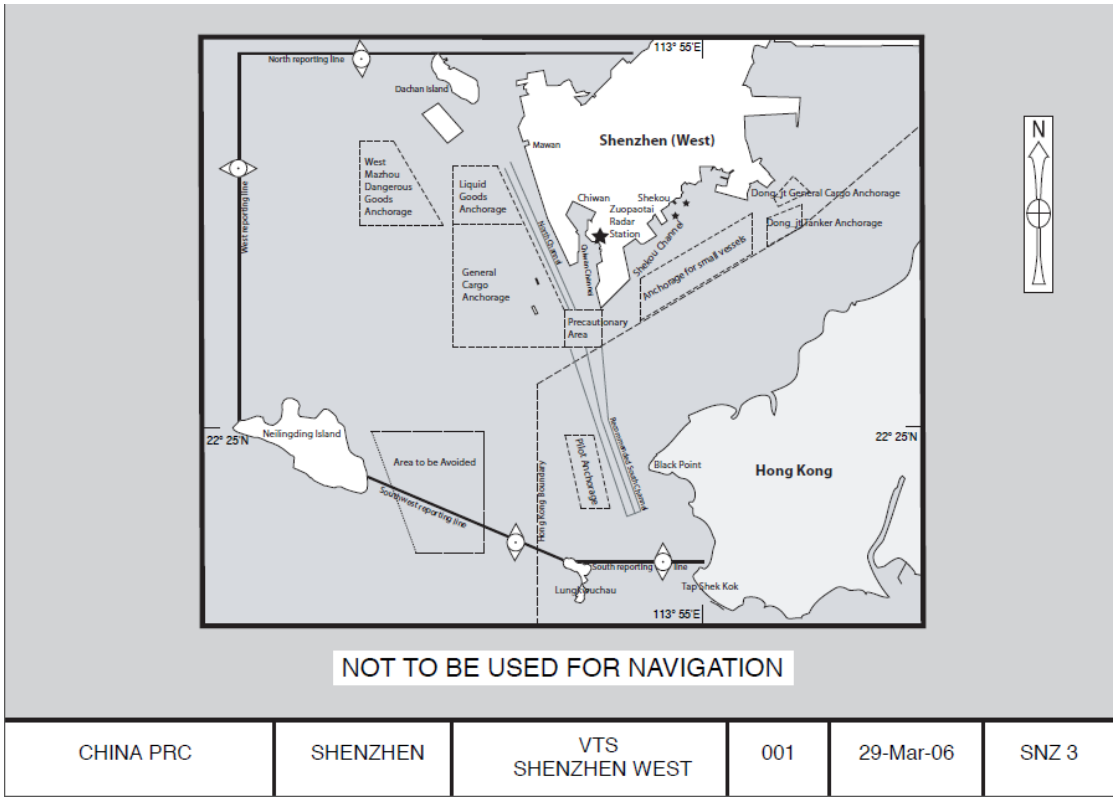

Figure 7 the Western Sector of Shenzhen VTS

Sources: World Vessel Traffic Services Guide

4.4 The main work of Shenzhen VTS centre

The main objective of the Shenzhen VTS and the Shenzhen VTS System is to improve navigation safety and traffic efficiency as well as the protection of the marine environment. They also aim to facilitate ocean-going vessels to conduct their business quickly in Shenzhen.

The Shenzhen VTS is primarily a port VTS. Within Shenzhen waters, the Shenzhen Vessel Traffic Centre continuously provides information service and traffic organization service, and navigationa1 assistance service at the request of a vessel participating in the Shenzhen VTS. In addition, the Shenzhen VTS is in compliance with the requirements, guidelines and recommendations promulgated by the IMO and the IALA. Currently, the Shenzhen VTS contributes to continuous monitoring the merchant ships of gross tonnage 500 and up and all passenger ships and their movements within the Shenzhen waters and its approaches, early prediction of the possible development of dangerous situations (close encounters, leaving of the fairway), identifying all VTS participating vessels, collecting and evaluating data on their movements and interaction with other vessels, coordinating and regulating their movements within Shenzhen waters, provides meteorological and hydrological information, and Co-operation with other services, such as participation in marine search and rescue actions, etc.

Since the establishment of Shenzhen VTS, it was accelerated the turnaround of ships, increased volumes and densities, it also solved the contradiction between large ship and port construction projects for using waterway, reduced the accident, and

provided better services.

4.5 The current staff levels and problems at Shenzhen VTS

Nowadays, The Shenzhen VTS Centre comprises VTS Operators, VTS Supervisors and a VTS Manager. The total number of staff is 39, including three VTS Managers, 36 VTS Operators (include Supervisors), and the number of manned VTS workstations is three: the western workstation, the eastern workstation and high-speed passenger ship workstation. The VTSOs has served between 1.5 and 12 years as VTSOs, with an average of 4.5 years, three VTSO had sailed as master on board his own vessel, one VTSO had previously served as a seagoing pilot for 2 years in the VTS areas, 10 VTSOs had sea of experience, and the age span is 23 up to 48 years, with an average of 32 years of age.

From my experience working in Shenzhen VTS centre for 6years, there are some problems about staff levels at Shenzhen VTS centre. Firstly, serving period is too short. Although the average period is 3.5 years, but many of them served for 1-2 years, and many operators serving over 3 years have left the VTS centre to another departure. Secondly, many of them have no experience at sea. When they are faced with the situation of emergence, it is hard to cope with it. Thirdly, when I talk with them, many operators say it is hard for them to meet the requirements as the workload is too heavy. Last but not least, as for training, it is difficult to meet the requirement of IALA V-103 (Liang, 2008, p.1).

Chapter 5 Factors affecting staff levels at VTS centre

5.1 The general factors affecting staff levels at VTS centre

The availability of trained VTS staff is an essential resource without which VTS operations cannot be managed. It is often difficult to determine the adequacy of staff levels and difficult to quantify with any degree of accuracy. Invariably this will be a balance between a number of factors which a VTS authority will need to keep under periodic review, not least of which will be their acquired experience both collectively and at individual level. According to the IALA guide 1045, combined with my personal experience, there are at least six criteria that may be considered as follows.

5.1.1 Mission statement or service level agreement

Once a VTS is established, it should have a mission statement or service level agreement, which includes what types of service are offered. All these factors affect the workload of VTS centre. Because they affect response times to calls and enquiries to the VTS, interaction with allied services and adjacent VTS centre and number of targets that each VTS operators has to plot at any one time, etc.

5.1.2 The optimum time that a VTS operator/supervisor should spend at a workstation (Hu＆Fang, 2012, p.66)

The period of duty is another important factor that the VTS authority should consider when determining the staff level. In other words, different periods of duty requires a different number of people. So, the optimum time that a VTS operator should spend at a station plays a key role in operating VTS. In determination of a optimum period of duty, there are several considerations, such as the number of interventions expected of the VTS personnel for every ship movements, healthy and safety requirement when working with visual display units, comfortable situation in the working environments, and the ability to development and maintain situational awareness, etc. In turn, these considerations affect the staff levels at VTS centre.

5.1.3 The extent of machine assistance available to the operator/supervisor

It is well known that the equipment or system design can significantly ease the workload of the VTS personnel. It can relieve the VTS personnel of repetitive or mundane tasks, and effective man-machine interfaces. It also allows the VTS personnel to take on more work or modify a potentially unacceptable workload to something much more achievable.

5.1.4 Communication requirements

Radio communication between ship and shore are an essential component. Each item of communication handled by the VTS operator demands interpretation and action, it generates a workload.

In addition, currently, the VTS centre is at the hub of complex web of information, which can result in the reception of a large number of enquiries by telephone not directly connected with the primary mission, and each telephone call made or received generates a workload of the VTS operator.

5.1.5 The ability of the staff on duty to deal with emergencies and unplanned events

Any emergencies within the VTS area will create additional workload for the staff on duty, and the more serious the emergency is, the greater the rise in workload.

5.1.6 Stress related workload

Workloads, too high or too low, can affect efficiency, operational safety, personal health and/or motivation. When the authority determines the staff levels at VTS centre, it should considerate the stress related to the workload (Xu, 2011, pp.24-25).

5.2 The main factors affecting workload of Shenzhen VTS

Because the Shenzhen VTS servicing the ship that the GT is 500 tons and up of merchant ship and all passage ships, so the following statistical data are related to the merchant vessels of 500 gross tonnage and up or all passage ships. In addition, the statistical data per year below review in the database of Shenzhen VTS centre, and the data per day calculated by author.

According to the IALA Guideline No. 1045, combined with the actual situation in Shenzhen, I think the main factors that influence staff level at Shenzhen VTS centre are as follows.

5.2.1 Traffic volumes and densities

With the rapid economic development, Shenzhen has become the fourth largest container port all over the world. The rapid increase in the traffic volumes and densities brought greater pressure to Shenzhen VTS centre. Because it is mean that the Shenzhen VTS centre has to provide more information services, traffic organization service and navigational assistance service. Admittedly, it increases the workload of Shenzhen VTS centre.

5.2.1.1 The Traffic volumes and densities of Western Port

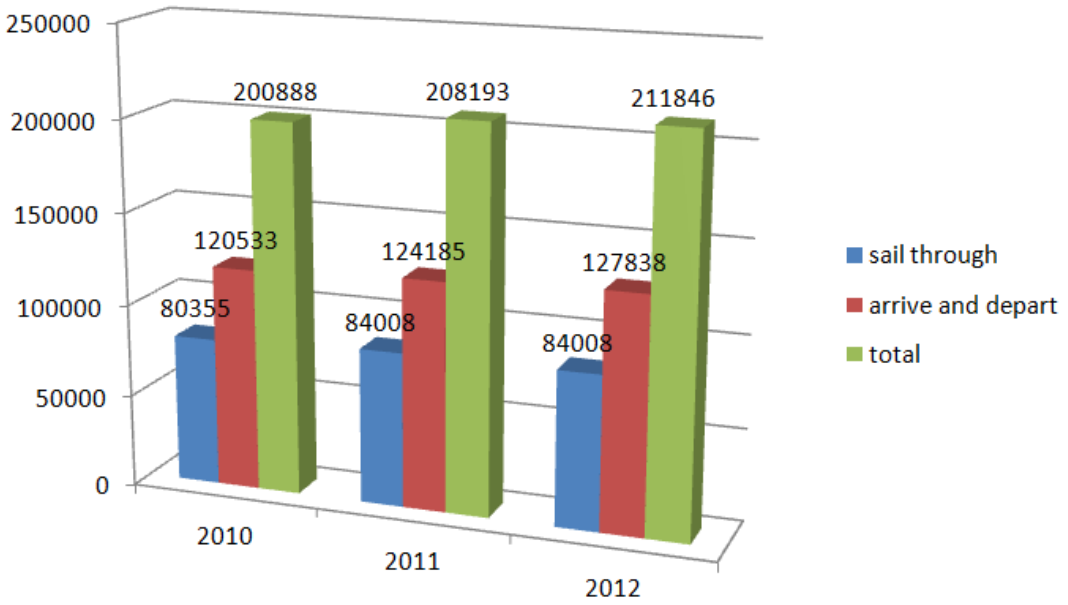

Figure 8 the traffic volumes and densities of Western Port per year (merchant ship, 2010-2012)

Sources: compiled by the author, data come from the database of Shenzhen VTS centre

Figure 9 the traffic volumes and densities of Western Port per day (merchant ship, 2010-2012)

Sources: compiled by the author

It can be seen from the Figure 8 and Figure 9 that the traffic volumes and densities of Western Port in the pass three years. The average number of vessels sailing through the Shenzhen water area is 226 per day, the average number of vessels arriving and departing the Shenzhen Port is 340 per day, the average number of total vessels is 566 per day.

5.2.1.2 The numbers of high-speed passenger ships

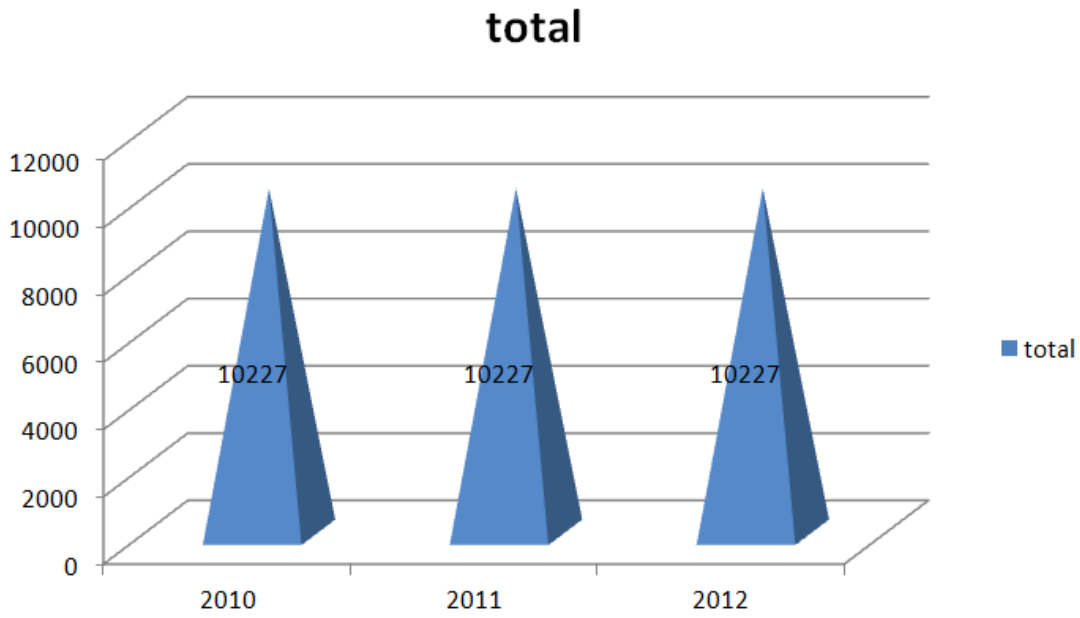

Figure 10 the numbers of high speed passenger ships per year (2010-2012)
Sources: compiled by the author, data come from the database of Shenzhen VTS centre

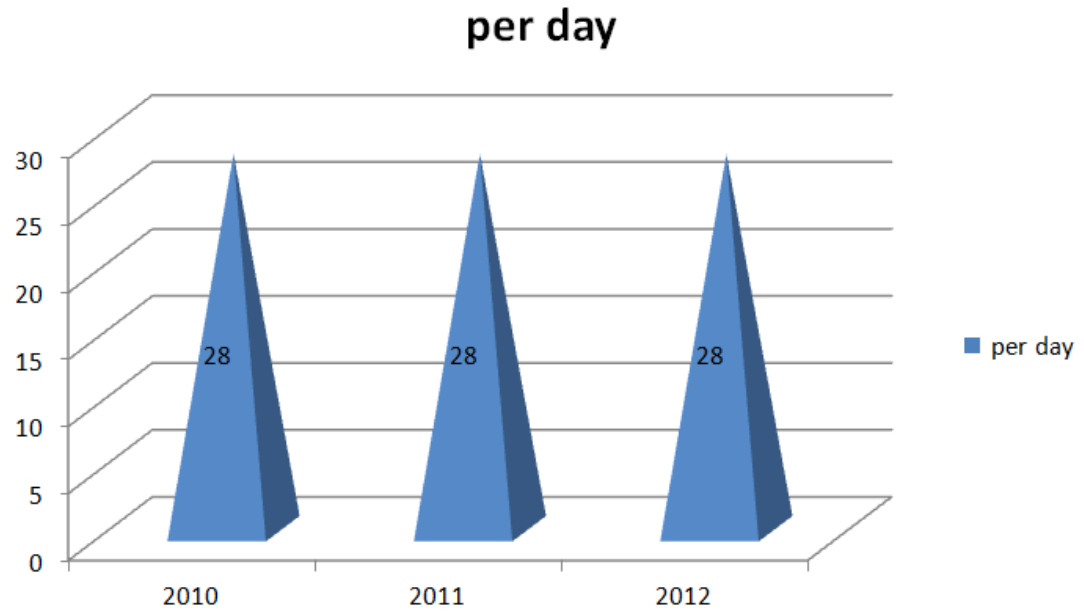

Figure 11 the numbers of high speed passenger ships per day (2010-2012)
Sources: compiled by the author

It can be seen from the Figure 10 and Figure 11 that the traffic volumes and densities of High speed passenger ships in the past three years. The average numbers of vessels is 28 per day.

5.2.1.3 The number of ship in Eastern Port of Shenzhen

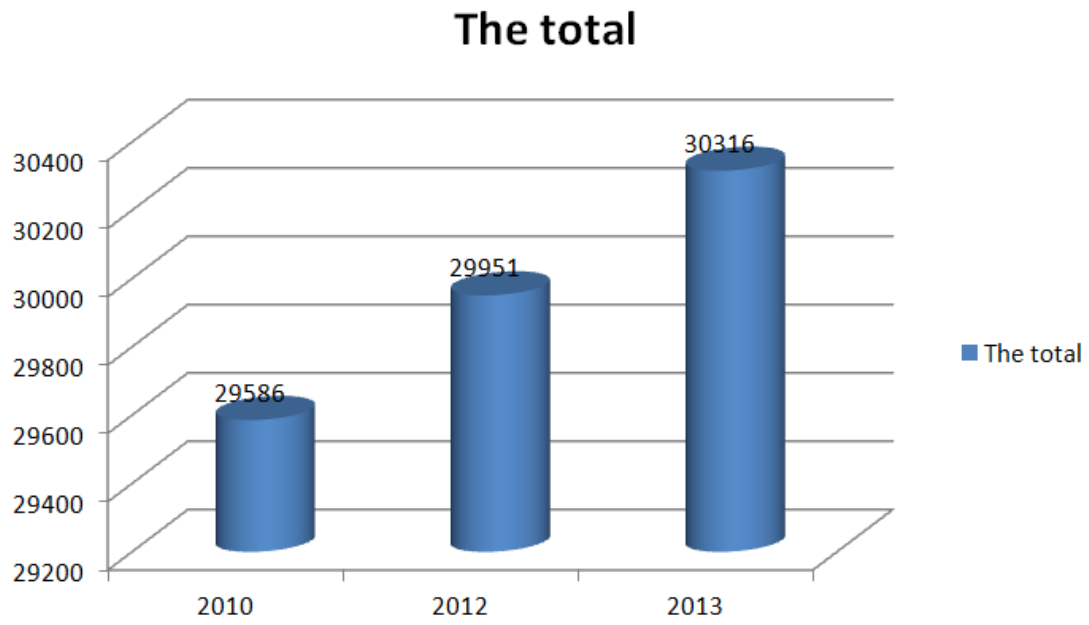

Figure 12 the number of ship in Eastern Port of Shenzhen per year (2010-2012)

Sources: compiled by the author, the data come from the database of Shenzhen VTS centre

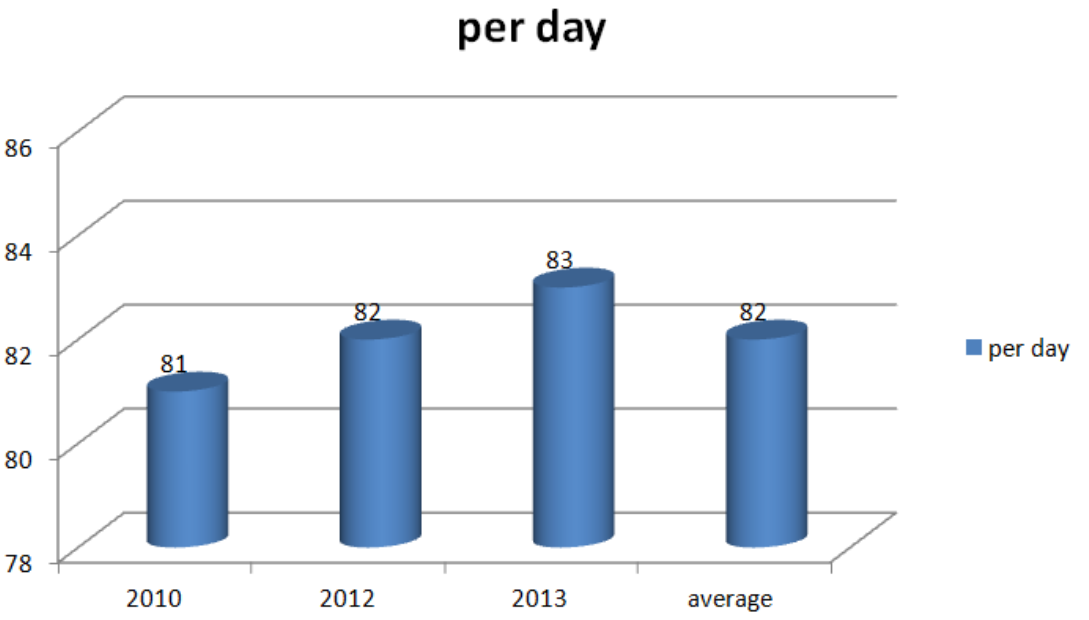

Figure 13 the number of ship in Eastern Port of Shenzhen per day (2010-2012)

Sources: compiled by the author

It can be seen from the Figure 12 and Figure 13 that the traffic volumes and densities

of Eastern Port in pass three years. The average numbers of vessels is 82 per day.

5.2.2Navigational complexity associated with the VTS Area

On January l 2010, Tonggu Channel was formally put into use. The length of channel is 12.8Kn, which is unidirectional channel for 10,000 tons and up container ships. So the Shenzhen Port owned an all-weather sea channel for the sixth generation container safety sailing, which would be advantageous to solve the large container liner restricted by air clearance of TsingMa Bridge on the Hong Kong MaWan channel. It's of critical importance to improve the navigation capabilities of the Western Port, to enhance the potential for the port development and to promote the port competitiveness, as well as to increase the workload of VTS, because it is a one-way navigation, VTS personnel should make sailing plan, and supervised by a specified staff when the ship goes through the channel (Zhang, 2010). The speed of ship passing through the channel was about 10kn, so it should spend 1.3 hours per ship.

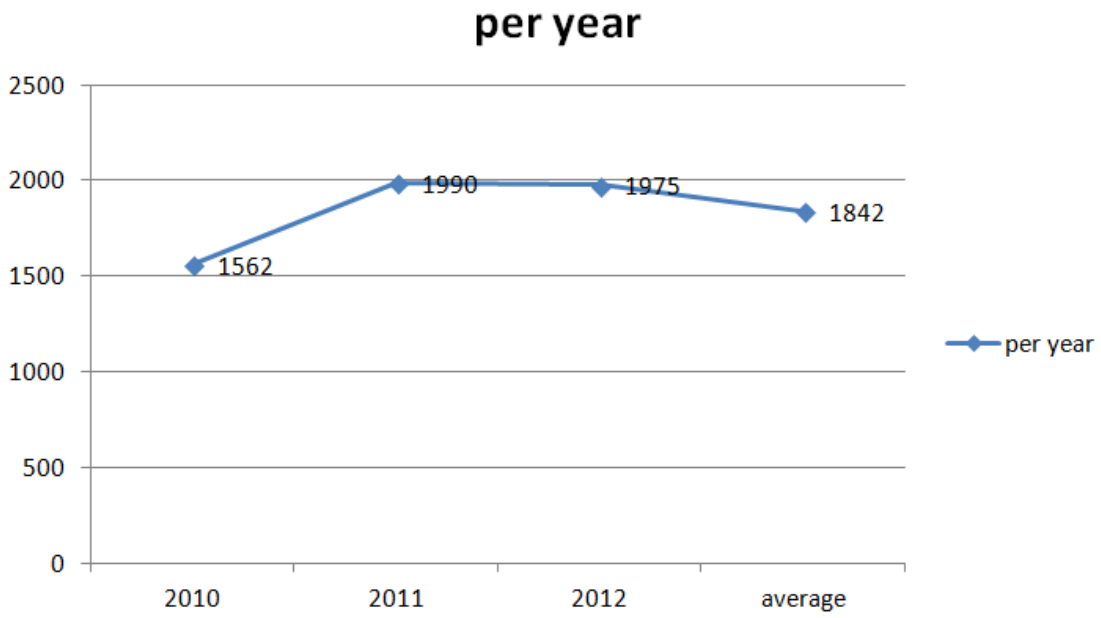

Figure 14 the number of vessels passing through the Tonggu Channel per year

(2010-2012)

Sources: compiled by the author, the data come from the database of the Shenzhen VTS centre

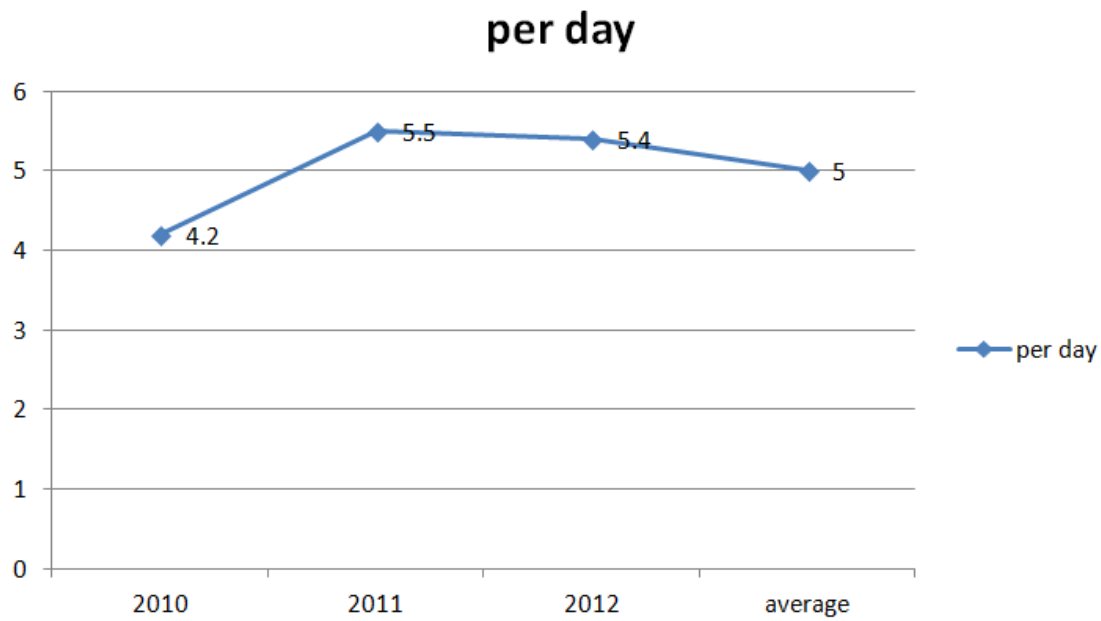

Figure 15 the number of vessels passing through the Tonggu Channel per day (2010-2012)

Sources: compiled by the author

It can be seen from the Figure 15 that the average number of vessels passing through the Tonggu channel is 5 per day. So, the time spent is 5 *1.3=6.5 hours.

5.2.3 Navigational Assistance Service (NAS)

The port of Dapeng LNG is located eaten of the Shenzhen Port, which was put into use in 2006. According to relevant regulations，when the LNG vessel comes in and goes out, the VTS centre should provide Navigational Assistance Service (NAS). The distance from the port to pilot station is 6Kn, the speed of LNG vessel is 12Kn, so it should spend 0.5 hours per ship. During this time, the Shenzhen VTS centre should arrange a specified staff for supervision.

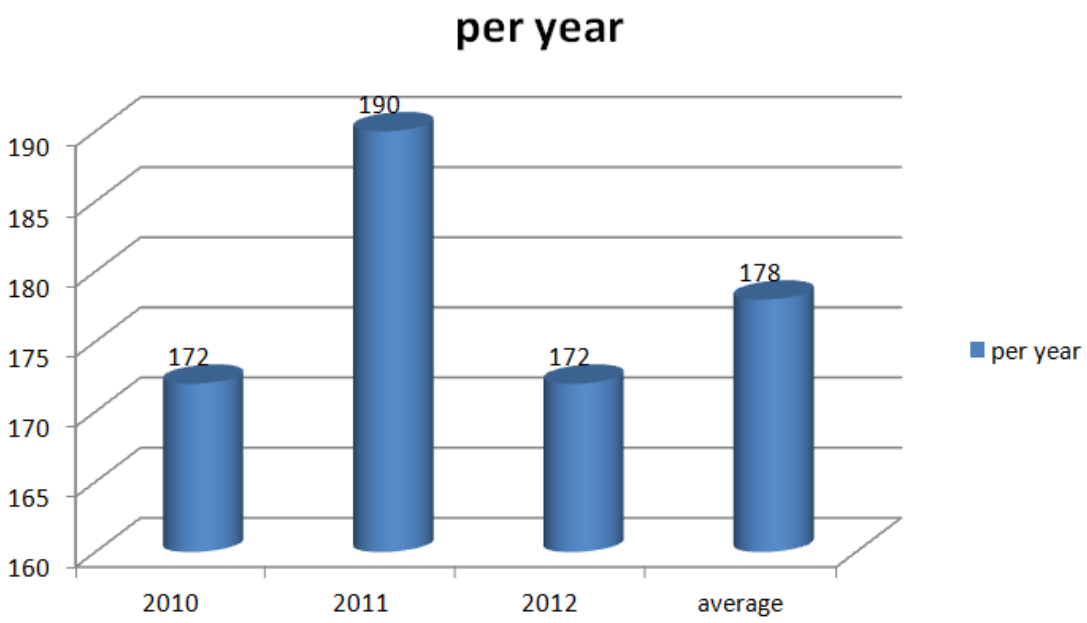

Figure 16 the number of LNG vessels per year (2010-2012)

Sources: compiled by the author, the data come from the database of Shenzhen VTS centre

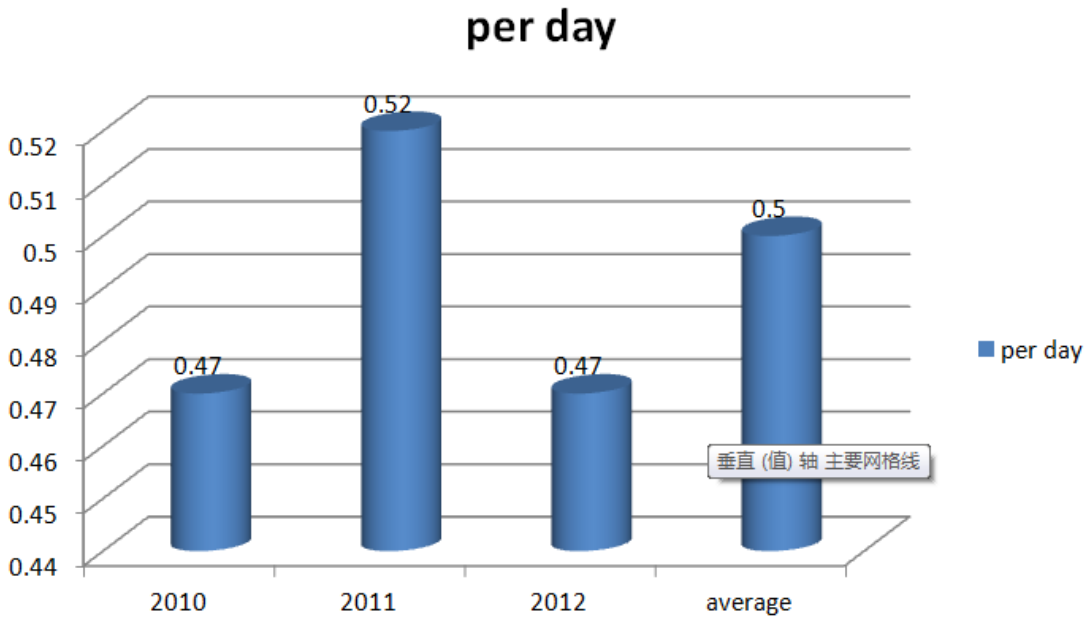

Figure 17 the number of LNG vessels per day (2010-2012)

Sources: compiled by the author

It can be seen from the Figure 17 that the average number of LNG vessels is 0.49 per

day. So, the time spent is 0.49 *0.5=0.24 hours.

5.2.4 Incidents, accidents and other emergencies

When incidents, accidents and other emergencies happen, the Shenzhen VTS centre should try to provide some useful information. So it would increase the workload of the Shenzhen VTS centre. It is to be noted that the workstation of high-speed passenger ship is not participate in these situation.

5.2.4.1 The number of incidents, accidents and other emergencies (Western Port)

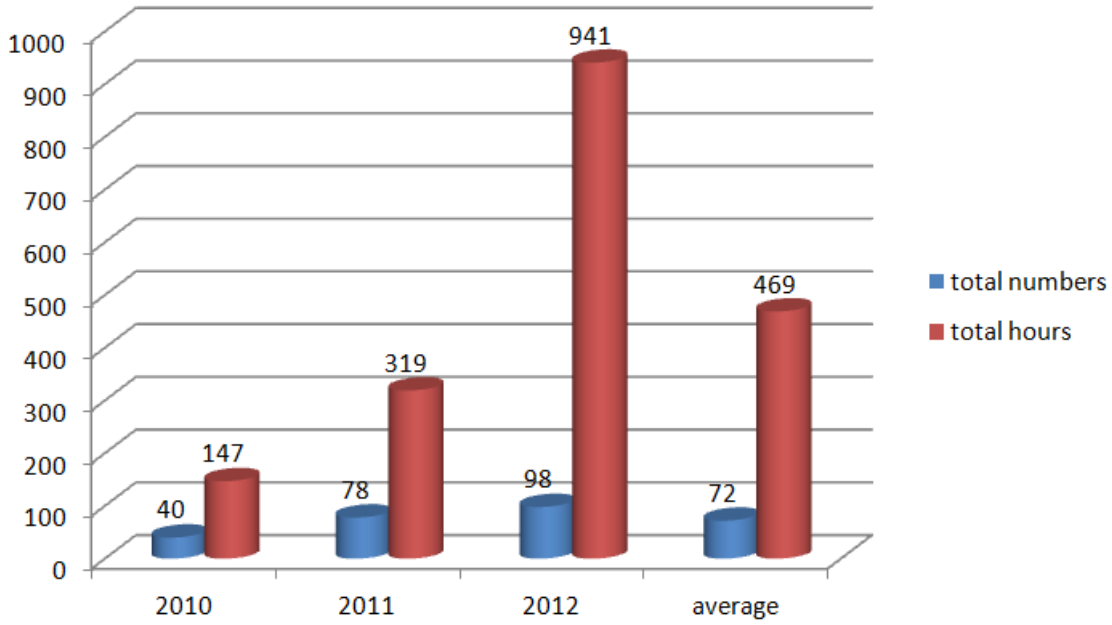

Figure 18 the number of incidents, accidents and other emergencies (western, 2010-2012)

Sources: compiled by the author, data come from the database of Shenzhen VTS centre

It can be seen from the Figure 18 that the average time of incidents, accidents and other emergencies is 469 hours per year, so, it is 1.28 hours per day in Western Port in the pass three years.

5.2.4.2 The number of incidents, accidents and other emergencies (Eastern Port)

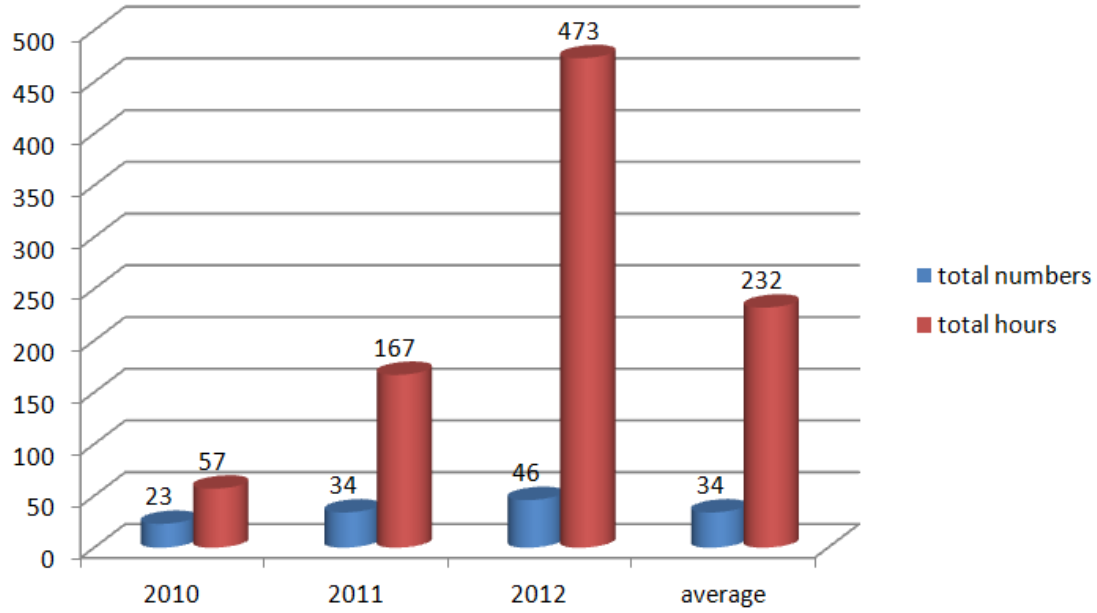

Figure 19 the number of incidents, accidents and other emergencies (eastern, 2010-2012)

Sources: compiled by the author, the data come from the database of Shenzhen VTS centre

It can be seen from the Figure 19 that the average time of incidents, accidents and other emergencies is 232 hours per year, so it is 0.65 hours per day in Eastern Port in the past three years.

5.2.5 Operational Procedures

According to the Shenzhen Maritime Safety Administration of Quality Management System, the VTS personnel need to regularly update their knowledge by training and regular broadcast navigational information in every working channel. All these tasks would increase the workload of the Shenzhen VTS centre.

5.2.5.1 Training

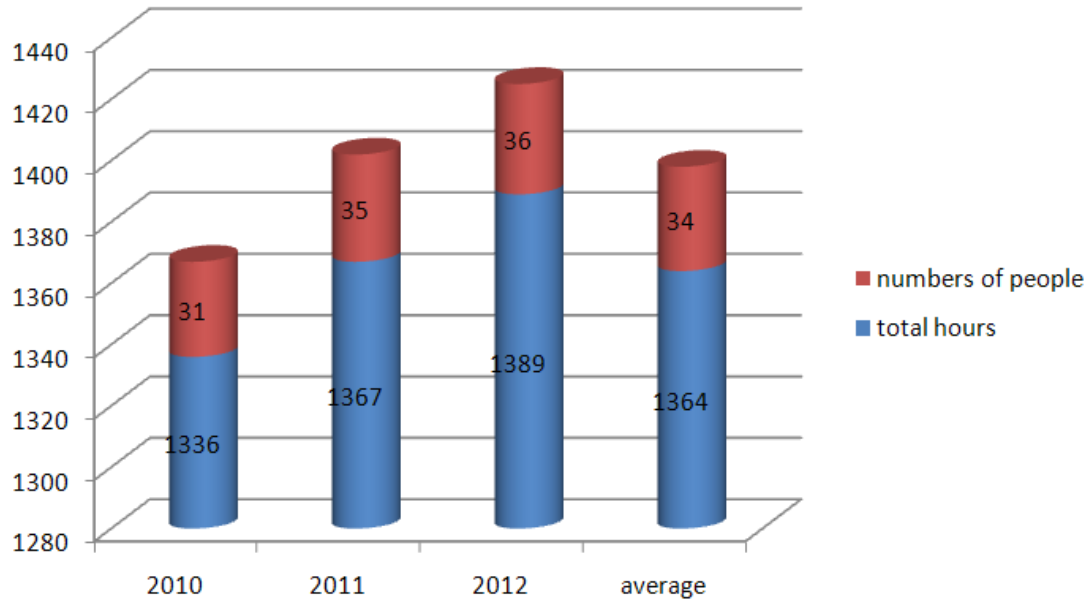

Figure 20 the time of training (2010-2012)

Sources: compiled by the author, the data come from the database of the Shenzhen VTS centre

When VTS personnel participles in training, it should level the station, during this time, the total number of VTS operator on duty would decrease. In other works, it would increase the workload of the VTS centre. These trainings include internal and external training; it also includes updating of knowledge, the use of new equipment, etc. It can be seen from the Figure 20 that the average time of training is 1364 hours, and the average number of people is 34, so the average time of training is 40 per people in the past three years.

5.2.5.2 Broadcast navigational information

The VTS centre should broadcast navigational information in each working channel every day, such as broadcast weather conditions, navigational warnings, other ship dynamic, and meteorological and hydrological conditions to assist safe navigation of the ship, or to give such information services to the port and maritime search and

rescue and other relevant departments. In addition, every time it should spend about 1 minute, see Appendix 3.

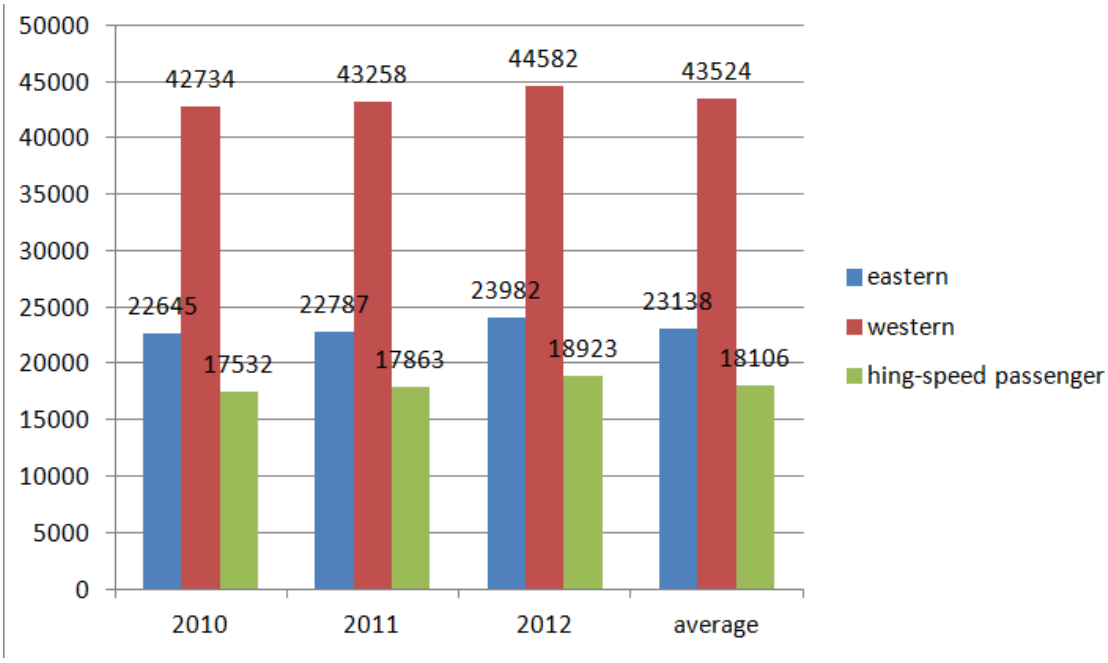

Figure 21 the time of broadcast navigational information

Sources: compiled by the author, the data come from the database of the Shenzhen VTS centre

It can be seen from the Figure 21 that the average times of broadcast navigational information is 43524 times in Western Port working station, 23138 times in Eastern Port working station and 18106 times in high-speed passenger working station per year. So the average time that spends on broadcast navigational information is 2.01 hours in Western Port working station, 1.06 hours in Eastern Port working station, and 0.83 hours for high-speed passages ships working station per day.

5.2.6 Others

The Shenzhen VTS centre is also in charge of sailing planning，approved for international ship arrival and telephone issues. All these would increase the workload

of Shenzhen VTS centre. It needs to be noted that these businesses are conduct in Western Port and Eastern Port working station, and it does not need do in high-speed passage station.

5.2.6.1 Sailing planning

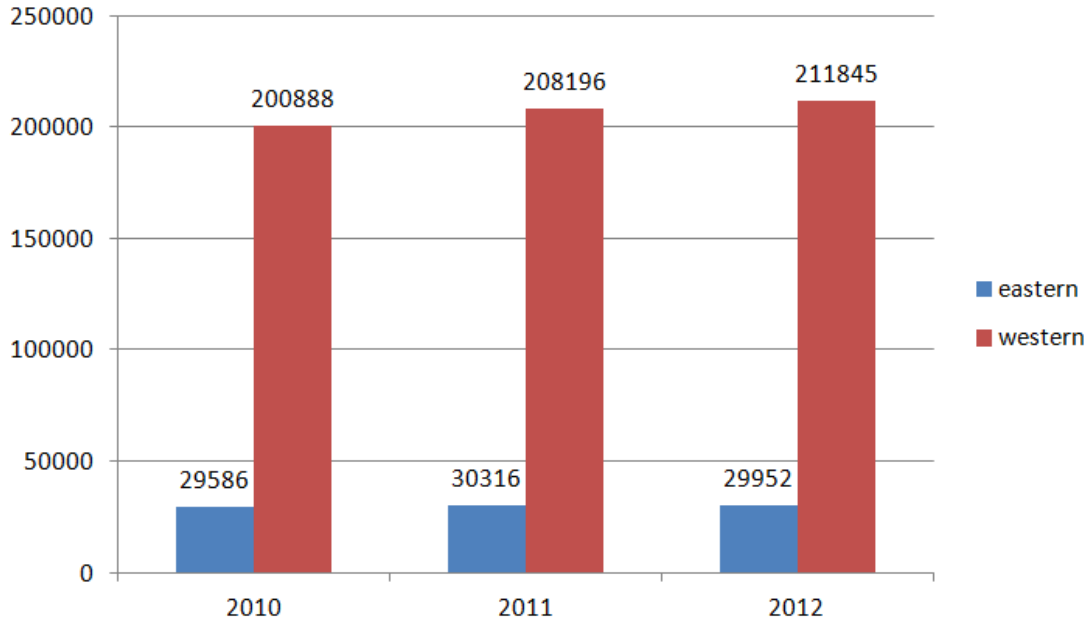

Figure 22 The times of sailing planning

Sources: compiled by the author, the data come from the database of the Shenzhen VTS centre

It can be seen from the Figure 22 that the number of vessels that should make sailing planning is 29951 in Eastern Port and 236976 in Western Port per year, so the number of vessels that should make sailing planning is 82 day in Eastern Port and the numbers of vessel that should be navigation planning is 566 per day in Western Port. And each vessel should spend 30 seconds for sailing plan, see Appendix 4, so the time of sail planning. In Eastern Port workstation, the time for sail planning is W_{e6}＝82×30 /3600＝0.68 hours. In Western Port workstation , the time for sail planning is W_{w6}＝566 ×30 /3600＝4.71hours.

5.2.6.2 Entry port approved for international ship and telephone issues

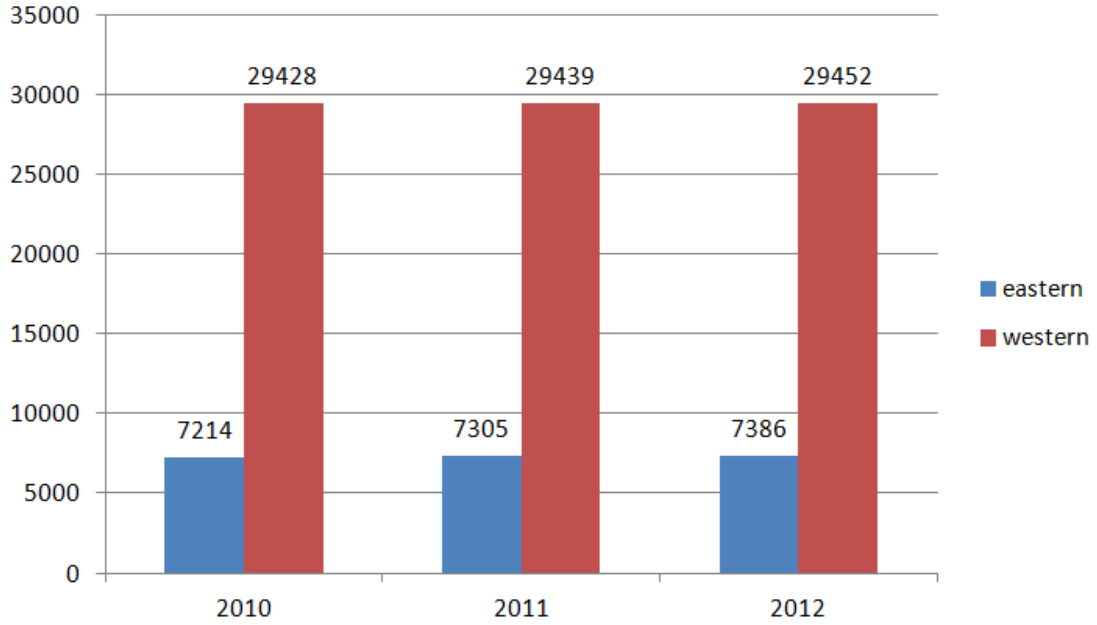

Figure 23 the number of entry port approved for international ship (2010-2012)
Sources: compiled by the author, the data come from the database of the Shenzhen VTS centre

It can be seen from the Figure 23 that the number of entry port approved for international ship is 7301 in Eastern Port and 9440 in Western Port per year, so the numbers of entry port approved for international ship is 20 in Eastern Port and 80.6 in Western Port per day. And each vessel should spend about 2minuts, see Appendix 5. So the time for entry port approved is 0.67 hours in Eastern Port and 2.69 hours in Western Port.

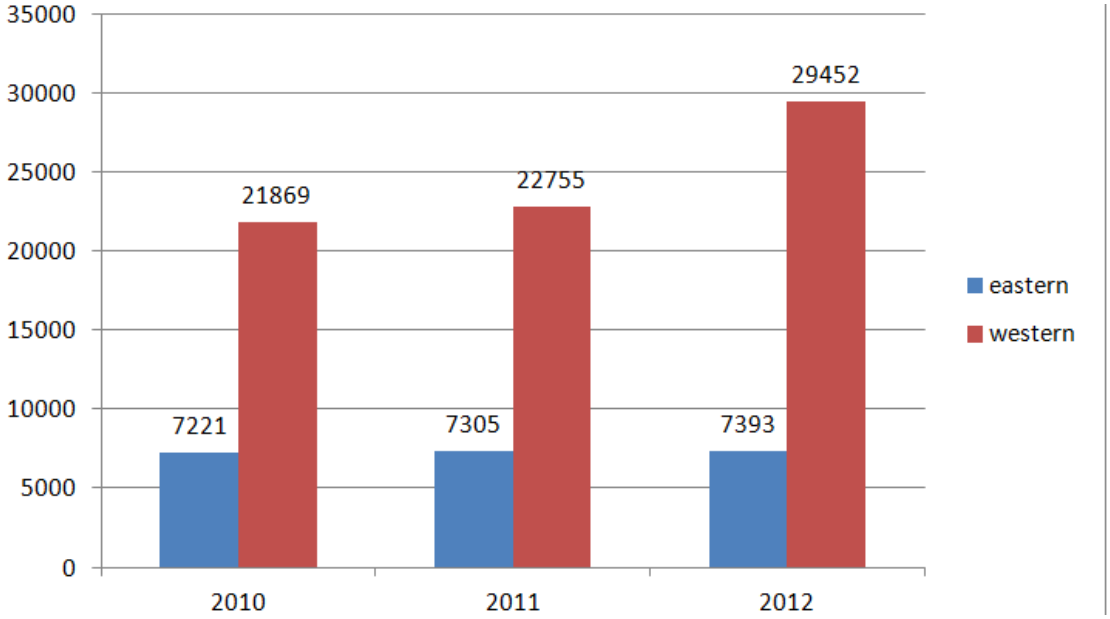

Figure 24 the number of telephone issues (2010-2012)

Sources: compiled by the author, the data come from the database of the Shenzhen VTS centre

It can be seen from the Figure 24 that the number of telephone is 7306 in Eastern Port and 24682 in Western Port per year, so the numbers of telephone is 20 per day in eastern, and the numbers of telephone is 67 per day in western. And each time should spend about 1minuts, see Appendix 6. So the time for entry port approved is 0.33 hours in Eastern Port and 1.11 hours in Western Port per day.

5.2.7 VTS operators' mental workload

The concept of mental workload has become an important issue for all kinds of industry since the 1960's. The main reason for this is "computer"; it has become an indispensable component of life. It consisted of multiple aspects of operators' mental workload such as ergonomics, occupational stress, physical and social conditions and environmental aspects, etc.

According to the international standards such as ISO 10075 (1991) and ISO 10075

(2004), the evaluation of mental workload is a key point for the usability enhancement of the components of a technical system and for the quality improvement of a design. Moreover, in the report of U.K. Maritime Coastguard and Agency-MCA Report (2006), three hundred and eleven maritime accidents (from the four different accident databases) are examined to determine whether the MWL is a factor in these accidents or not. Some of them are demonstrated in the example of accidents due to high/low levels of MWL, and it is also pointed that MWL levels are indeed related to the occurrence of human errors. So the VTS operators' mental workload also contributes to the staff levels at the Shenzhen VTS centre.

Charter 6 Calculation of the staff levels at the Shenzhen VTS centre

Workload has a multidimensional scale and it is generally classified into Physical Workload (PWL) and Mental Workload (MWL). PWL means how much effort should be made expended for the physical resources while performing the task and it can be measured by physical resources. On the other hand, MWL is defined as the level of processing capacity while performing the task, or the difference between the capacity to affect the usable real performance and human-information processing system (Eggemeier and Wilson, 1991). MWL is also considered as the demand on the brain and sensory system (eyes, ears, and skin) because of the tasks (Zhang and Luximon, 2005). The following calculation is based on the IALA guide 1045, which does not consider the Mental Workload (MWL), because it is hard to use numerical measure.

6.1 The number of manned VTS workstations

The number of manned VTS workstations is determined by the partition and workload of the VTS center. VTS partition is the result of a combination of factors, such as geographical features, the traffic volumes and densities, the traditional

practices that operating over many years and is widely accepted, etc. at present, due to the geographical conditions, the Shenzhen VTS centre must be divided into western and eastern sector, in addition, because there are many high-speed passenger ships in western, according to the related regulation, it should strengthen the management of the high-speed passenger ships, so it increase one channel for high-speed passenger ships in the western. So the number of manned VTS workstations is three, the Western workstation, the Eastern workstation and high-speed passenger workstation.

6.2 The number of VTSOs required per VTS workstation

The number of VTSOs required per VTS workstation is depends on the average workload of VTS workstations（W）per day. W measures in hours. Number of manned VTS per workstations (K) is W divided by 24 hours. That is K=W/24 (Shi, 2009, pp.23-24).

6.2.1 The average workload of VTS workstations per day（W）

The average workload of VTS workstations per day（W）= the time for target identification, label and recording (W1) + the time for replying shipping report (W2) + the time for tracking monitoring (W3)+ the time for broadcasting the safety information (W4) + the time fortreating emergency situation (W5) + the time for sailing planning (W6) + other business work time(W7) (Ye＆Zheng, 2011, pp.9-10)

6.2.1.1 The time for target identification, label and recording (W1)

The time of target identification, label and recording (W1) = $Q_{id} \times T_{id}/3{,}600$. Q_{id} on behalf of the number of the object that you need to identify or recording, T_{id} representatives the time that is spent on one vessel when you identify and label the

ship, which includes the time that is spent on the MIS system and handling VTS system alarm. Based on actual operating experience, the T_{id} is 20 seconds, see Appendix 1.

In the Eastern Port, there are about 82 vessels to identification, so the time of target identification, label and recording (W1) in eastern (W_{e1}) = Q_{id} × T_{id} / 3600=82×20/3600=0.45 hours.

In the Western Port, there are about 566 vessels to identify, so the time for the target identification, label and recording (W1) in eastern (W_{w1}) = Q_{id} × T_{id} / 3600＝566×20/3600=3.14 hours.

In high-speed passenger ships workstation, there are about 28 vessels to identification, so the time of target identification, label and recording (W1) in high-speed passenger ships workstation (W_{h1}) = Q_{id} × T_{id} / 3600＝28×20/3600=0.15 hours.

6.2.1.2 The time for replying shipping report (W2)

$W2=Q_e \times M_e \times T_e/3{,}600$, Q_e represents the numbers of vessels that it should report to VTS center when arrival or departure to the Shenzhen water, M_e represents the number of reporting point in VTS coverage area, T_e on behalf of the time that is spent on communication between the ship and VTS centre every time, it is 20 seconds, see Appendix 2.

In the Eastern Port, there are 4 times that the vessels should report to the VTS centre, every time it should spend 20 seconds, so W_{e2} ＝Qe × Me × Te / 3600＝

82 ×4 ×20/3600=1.82 hours.

In Western Port, as for vessels that arrive or depart, the number of reporting line is 4, in addition, the vessels should report to the VTS centre in one place except reporting line, so Me = 4 + 1 =5, and every time it should spend 20 seconds, $W_{w21} = Q_e \times M_e \times T_e / 3600 = 340 \times 5 \times 20/3600 = 9.44$ hours, as for the vessels that sail through the Shenzhen water, it just reports when passing through the report line, $W_{w22} = Q_e \times M_e \times T_e / 3600 = 226 \times 2 \times 20/3600 = 2.51$ hours. So the time for replying shipping report W_{w2} is 9.44+2.51=11.95 hours.

As for high-speed passenger ships, there are 3 times that the vessels should report to the VTS centre, every time it should take 20 seconds, so $W_{h2} = Q_e \times M_e \times T_e / 3600 = 24 \times 3 \times 20/3600 = 0.40$ hours.

6.2.1.3 The time for tracking monitoring (W3)

The time for tracking monitoring $W3 = F \times Q_d \times C/S$, F represents the weighted value of result, a Port VTS should be between 0.2 and 0.3, Shenzhen VTS is a port VTS, so F is 0.2, Q_d represents the number of vessels that should be monitored in VTS coverage area annually, C represents the average length of the channel (knots), S representatives the average speed of vessels (knots).

In the Eastern Port, except LNG vessel, there are about 81.5 vessels for monitoring, the average length is 13 knots, the average speed of vessels is 13 knots/hours, so $W_{e31} = 0.2 \times 81.5 \times 13 / 13 = 16.3$hours, the time for monitor LNG vessels W_{e32} is 0.25 hours, so W_{e3}= 16.3+0.25=16.55 hours.

In the Western Port, except the vessels that pass through the Tonggu channel, there are about 333.43 vessels that arrive or depart the from Shenzhen Port, the average length is 5 knots, the average speed of vessels is 10 knots/hours, so W_{w31}＝0.2×340×5 / 8＝41.68hours, as for the vessels that pass through, the average length is 10 knots, the average speed of vessels is 10 knots/hours, so W_{w32}＝0.1×226×10 / 10＝22.6 hours, as for the vessels the pass through the Tonggu channel, the time W_{w33} is 9.86 hours. So the W_{w3} =41.68+22.6+9.86=74.32 hours.

In high-speed passages workstation, the average length is 12 knots, the average speed of vessels is 20 knots/hours, so W_{h3}＝0.2×24×12 / 20＝2.88hours.

6.2.1.4 The time for broadcasting the safety information (W4)

Every workstation should broadcast the safety information, and the charter 5 has calculated the time. In eastern workstation, W_{e4}＝1.06 hours, In eastern workstation, W_{w5}=2.01 hours, as for high-speed passenger ships station, W_{h4}=0.83 hours.

6.2.1.5 The time for treating emergency situation（W5）

The charter 5 has calculated the time of treating emergency situation. In the Eastern workstation, W_{e5}＝0.65 hours, in the Western workstation, W_{w5}=1.28hours.

6.2.1.6 The time for sail planning (W6)

The charter 5 has calculated the time of sail planning. In the Eastern workstation, the time for sail planning is W_{e6}＝82×30 /3600＝0.68 hours. In the Western, the time for sail planning is W_{w6}＝566 ×30 /3600＝4.71hours.

6.2.1.7 Other business work time (W7)

The other main business work time is that for telephone issues and entry port

approved, etc.

In the Eastern workstation, the time for telephone issues W_{71e} is 0.33 hours, and the time for entry port approved is W_{72e} 0.67 hours, so the other business work time is W_{7e}=0.33+0.67= 1 hours.

In the Western station, the time for telephone W_{71w} is 1.11 hours, and the time for entry port approved is W_{72w} 2.69 hours, so the other business work time is W_{7w}= 2.69+ 1.11=3.80 hours.

6.2.1.8 The average per day workload of VTS workstations (W)

According to the above calculation, we can know that **t**he average workload of VTS workstations per day（W）.

As for the Eastern workstation:

W_e =0.45+1.82+16.55+1.06+0.58+0.68+1=21.14 hours,

As for the Western workstation:

W_w =3.14+11.95+74.32+2.01+1.28+4.71+3.80=101.21 hours.

As for high-speed passenger ships workstation:

W_h=0.13+0.40+2.88+0.83+0+0+0=4.24hours.

6.2.2 The number of manned VTS per workstations (K)

According to the above calculation, we can know that the number of manned VTS per workstations. As for the Eastern workstation, the number of manned VTS workstations K_e is W_e /24= 21.24/24 ≈ 1. As for the Western workstation, the number of manned VTS workstations K_w is W_w /24 = 101.21/24 ≈ 5. As for high-speed passenger ships workstation, the number of manned VTS workstations K_h is W_h /24 = 4.24/24 ≈ 1. So the number of manned VTS in Shenzhen VTS centre K= K_e+ K_w+

K_h= 1+5+1=7.

6.3 The number of VTSOs required per VTS workstation

6.3.1 Determination of the relevant data

According to the actual situation in China, the normal hours per working week a = 40 hours, normal hours per working day b = 8hours, actual days per week e = 7 days, actual days per year f = 365.25days, actual weeks per year g=52, hours per day h=24hours, as for hours leave per year x (vacation, holidays, sick leave etc), in china, there are 12 days for statutory holidays and another 5 days for paid holidays, so x = 8*(12+5) = 136 hours. As for individual minutes lost per working day ww (meals, handovers, position breaks etc), based on experience, it takes about 110 minutes, hours training per year y = 40hours.

6.3.2 Calculation of the number of VTSOs required per VTS workstation

The following step of calculation is based on the formula given by IALA guide 1045.
Step 1: maximum working hours per year (c)= normal hours per working week (a) (actual days per year(f) / actual days per week (e)) = 40（365.25/7）=2,087.14 hours

Step 2: hours available per year (z) = maximum working hours per year (c)-(hours leave per year x + hours training per year y) = 2087.14-(136+40) =1911.14 hours

Step 3: working days per year d = hours available per year z / normal hours per working day b = 1807.14/8=238.89 days

Step4: total hours lost per working day yy = total minutes lost per working day xx /

60 = 110/60= 1.83hours

Step5: total hours lost per year zz = working days per year d * total hours lost per working day yy = 238.89*1.83=437.17 hours.

Step 6: total duty hours per year cc = (hours available per year z - total hours lost per year zz) =1911.14 - 437.17=1473.97 hours

Step 7: hours duty and watch keeping per week ee = total duty hours per year cc / actual weeks per year g = 1473.97/52=28.35 hours

Step 8: actual hours per year ff = hours per day h * actual days per year f = 24×365.25=8766

Step 9: number of VTSOs required per VTS workstation v = actual hours per year ff / total duty hours per year cc = 8766/1473.97=5.95

6.4 The staff level at Shenzhen VTS centre

According to the formula by IALA guide 1045, the staff level at VTS centre = total number of VTSOs required for staffing a VTS Centre * number of VTSOs required per VTS workstation. So the staff level at the Shenzhen VTS centre is 7*6=42.

Chapter 7 Recommendations and Conclusions

7.1 Recommendations

There is no doubt that VTS is a key role in reducing the maritime accidents for maritime agency, and the most important component of a VTS is its operating personnel. In this paper, by the study on international and national documents, the

calculation of staff level at the Shenzhen VTS centre, the author has provided some possible, practical recommendations for further development of the Shenzhen VTS centre.

7.1.1 Legislation

7.1.1.1 International legislation

So far, there is no international regulation governing the staff levels at the VTS centre. Although the IALA 1034 Guideline provides a great reference value on staff levels at VTS centre for parties, first it is just a recommendation, so it does not have mandatory effect. Second, this model leaves details of the staffing decision to the VTS Authority, and some details are difficult to quantify, such as attention/concentration levels, stress related workload, etc. In addition, the IMO, which is the United Nations specialized agency with responsibility for the safety and security of shipping and the prevention of marine pollution by ships, it does not have some details on how to determine the staff levels at VTS centre. Furthermore, it is well known that the physical working environment and human resources are factors affecting the staff levels at VTS centre, and the main aims of the ILO are to promote rights at work, to encourage decent employment opportunities, to enhance social protection and to strengthen dialogues on work-related issues. But so far there is little work about VTS personnel. So, here the author appeals that an international convention regarding staff levels at VTS centre could be formulated by IALA, IMO and International Labor Organization (ILO) for the sake of giving better service by VTS centre in the future.

7.1.1.2 National legislation

In China, currently, there are not some detailed documents about staff levels at VTS

centre. If possible, China MSA or its branches should formulate a special regulation about staff levels at VTS centre based on collecting current laws, administrative regulations, rules etc. In addition, China MSA or its branches might recommend alternatives for these industries to address staff levels issues, including good physical working environment, reasonable operational procedures, good human resources, and establishes some mechanisms for incentives, etc. Also, if possible, the Shenzhen MSA may publish a VTS manual of Shenzhen VTS centre, which provides staff with guidance in the form of standard operating procedures and must be administered in accordance with the Shenzhen MSA Safety Management System. Last but not least, all these instruments are subject to constant development and improvement, aimed at supporting the operator.

7.1.2 Technologies and facilities

It is doubtless that technology is very important tool for human beings to decrease the workload of the VTS centre. In recent years, under the auspices of IMO, the research on e-navigation is in the ascendance. E-navigation is a concept to support and improve decision-making by maritime information management. It could reduce the possibility of human errors and contribute to more efficient work methods, and also it could provide harmonized and coordinated solutions adapted for users. So the Shenzhen VTS centre could introduce the e-navigation for better services. In addition, the Shenzhen VTS centre could introduce the Integrated Vessel Traffic Control System, which realizes fusion of data received from the shore-based station of the Automatic Identification System (AIS) and pulse and Frequency Modulated Continuous Wave (FMCW) radars and presenting information on Electronic Navigational Chart. Additionally on the Observation Post is installed Multi Camera System consisting of daylight and thermal cameras showing automatically object

tracked by radar and selected manually by operator (Kwiatkowski＆Popik＆Buszka, 2012, 323). Also, it can strive for economic and policy supports from Shenzhen Municipal Government, such as a good physical working environment, construction of the radar station, etc.

7.1.3 Personnel training and education

The staff levels based on the IALA 1034 Guideline is mainly on the number of standard, but the staff levels should not only quantitative criteria, but also include personnel structure, quality standards, etc. in addition, no matter how well the management system documents were compiled, no matter how advanced technologies and facilities were equipped with, all VTS centre activities should be implemented by men. So, human quality, personnel training and education might be the most important element among all factors. So the Shenzhen VTS centre should train the personnel in accordance with the IALA documents, and also it should consider the structure of age and experience of personnel.

7.1.4 The staff levels at Shenzhen VTS centre

Based on the calculation above, the number of Shenzhen VTS operator is 42, but at present, the number of Shenzhen VTS operator is 36, so 6 operators should be added to the total, and these operator should be train by IALA documents. In addition, if possible, these operators might have experience of sea, such as master or mate. besides, this number should be up dated as conditions change.

7.1.5 Fatigue Management

Working in the VTS centre, the man should experience work shift and unsociable hours. He should have intensive concentration all the time and should have sufficient

capacity to deal with critical and/or emergency situations. Therefore, he will inevitably experience fatigue. Fatigue management is a form of human resources management, in other words, it will affect the workload of VTS centre. In addition, it is well known that fatigue on the part of VTS personnel can present a disastrous risk to the safety of human life or damage to the environment and property. So, it should strengthen the fatigue management at VTS centre, and it should take some measures to avoid and reduce fatigue, for example, by introducing a fatigue management programmer, offering fatigue information for VTS personnel, re-evaluating policies, practices and procedures that may no longer be valid, and keeping the schedule of duties under review to ensure that the hours of work continue to be realistic and workable, etc.

7.1.6 Assessment of VTSOs' mental workload

Discussed as Charter 5 and 6, the VTSOs' mental workload contributes to the staff levels at VTS centre. So, if possible, the Shenzhen VTS would conduct an assessment of VTSOs' mental workload in Shenzhen VTS centre, because understanding and assessment of VTSOs' mental workload could provide useful information that might be obtained during the design of VTS such as workload bottlenecks, operators overload conditions, etc. Also this assessment should determine factors to cause (especially tend to increase)mental workload of VTS operators, obtain the impact levels of mental workload factors based on subjective assessment, and achieve an approach for predicting and assessing the level of VTS operators' mental workload. Doing that will more accurately calculate the staff level at the Shenzhen VTS centre.

7.2 Conclusions

Based on the IALA 1034 Guideline, combined with the actual situation of Shenzhen VTS centre, the author studies the main factors that affect the staff level at Shenzhen VTS centre, and then calculate the staff levels at Shenzhen VTS centre, which should man 42 operators at the Shenzhen VTS centre. It is noted that this number is the minimum standard, and also it should amend continuously, because the some factors might be changed, such as the number of incidents, accidents and other emergencies, traffic volumes and densities, etc.

The Shenzhen VTS centre has developed only for a short period of time, i.e. more than 10 years, it is still in its infancy, management and service level is not high. However, it is well known that the reality is that modern shipping is large-scale, port congestion, dangerous goods and the potential harm to the environment, so it should require the use of advanced methods to reduce risk. The establishment of VTS system is an effective response to this request, and it is imperative that a VTS should be staffed with the appropriate number of highly trained personnel. In order to reach the international advanced level of management as soon as possible, the Shenzhen VTS centre should man staff reasonably for continuously providing the best VTS services for sea-going vessels visiting the port of Shenzhen.

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Appendix

Appendix 1: Investigation of the time for replying shipping report per ship

time	Name of operator	the time for replying shipping report per ship(second)
10, 06,2013	Li Zhiyun	18
10, 06,2013	Tong Fei	21
10, 06,2013	Dai Ping	21
10, 06,2013	Wang Qiang	19
10, 06,2013	Jin Jiajia	21
10, 06,2013	Qin Yongxiang	20
12,06, 2013	Cui Changhao	19
12,06, 2013	Jiang Ping	20
12,06, 2013	Tong Fei	20
12,06, 2013	Xia Ji	21
12,06, 2013	Qiang Wei	18
12,06, 2013	Wu Xiaoxiao	22
Average time	20	

Appendix 2: Investigation of the time for replying shipping report

time	Name of operator	the time for replying shipping report per ship(second)
10, 06,2013	Li Zhiyun	19
10, 06,2013	Tong Fei	19
10, 06,2013	Dai Ping	22
10, 06,2013	Wang Qiang	21
10, 06,2013	Jin Jiajia	20
10, 06,2013	Qin Yongxiang	20
12,06, 2013	Cui Changhao	19
12,06, 2013	Jiang Ping	20
12,06, 2013	Tong Fei	20
12,06, 2013	Xia Ji	21
12,06, 2013	Qiang Wei	18
12,06, 2013	Wu Xiaoxiao	21
Average time	20	

Appendix 3: Investigation of the time for broadcast navigational information

time	Name of operator	the time for broadcast navigational information (second)
10, 06,2013	Li Zhiyun	67
10, 06,2013	Tong Fei	60
10, 06,2013	Dai Ping	57
10, 06,2013	Wang Qiang	58
10, 06,2013	Jin Jiajia	58
10, 06,2013	Qin Yongxiang	62
12,06, 2013	Cui Changhao	64
12,06, 2013	Jiang Ping	61
12,06, 2013	Tong Fei	57
12,06, 2013	Xia Ji	58
12,06, 2013	Qiang Wei	58
12,06, 2013	Wu Xiaoxiao	57
Average time	60	

Appendix 4: Investigation of the time for sailing plan per time

time	Name of operator	the time for sailing plan per time
10, 06,2013	Li Zhiyun	31
10, 06,2013	Tong Fei	31
10, 06,2013	Dai Ping	30
10, 06,2013	Wang Qiang	28
10, 06,2013	Jin Jiajia	29
10, 06,2013	Qin Yongxiang	28
12,06, 2013	Cui Changhao	32
12,06, 2013	Jiang Ping	30
12,06, 2013	Tong Fei	30
12,06, 2013	Xia Ji	29
12,06, 2013	Qiang Wei	32
12,06, 2013	Wu Xiaoxiao	29
Average time	30	

Appendix 5: Investigation of the time for Entry port approved for international ship per time

time	Name of operator	the time for Entry port approved for international ship per time (second)
10, 06,2013	Li Zhiyun	112
10, 06,2013	Tong Fei	121
10, 06,2013	Dai Ping	123
10, 06,2013	Wang Qiang	124
10, 06,2013	Jin Jiajia	115
10, 06,2013	Qin Yongxiang	123
12,06, 2013	Cui Changhao	120
12,06, 2013	Jiang Ping	120
12,06, 2013	Tong Fei	121
12,06, 2013	Xia Ji	121
12,06, 2013	Qiang Wei	120
12,06, 2013	Wu Xiaoxiao	120
Average time	120	

Appendix 6: Investigation of the time for telephone issues per time

time	Name of operator	the time for telephone issues per ship(second)
10, 06,2013	Li Zhiyun	60
10, 06,2013	Tong Fei	61
10, 06,2013	Dai Ping	62
10, 06,2013	Wang Qiang	59
10, 06,2013	Jin Jiajia	58
10, 06,2013	Qin Yongxiang	60
12,06, 2013	Cui Changhao	60
12,06, 2013	Jiang Ping	60
12,06, 2013	Tong Fei	61
12,06, 2013	Xia Ji	61
12,06, 2013	Qiang Wei	58
12,06, 2013	Wu Xiaoxiao	60
Average time	60	

Appendix 7: Layout of the Tonggu Channel