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Research on the effectiveness assessment of ship reporting system

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RESEARCH ON THE EFFECTIVENESS ASSESSMENT OF SHIP REPORTING SYSTEM

By

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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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ABSTRACT

Title of Dissertation: **Research on the Effectiveness Assessment of Ship Reporting System**

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Ship Reporting System has become an important part to ensure navigation safety at sea, for effective reduction of maritime accidents and losses. But, with the establishment of reporting systems, mariners often confuse the differences among the reporting systems, including reporting content, and formats, which results in heavy burden imposed on seafarers. Nevertheless, few studies have been conducted in this field. Therefore, the research paper is a study of effectiveness evaluation of ship reporting system, to facilitate the standardization of establishment and implementation.

A brief overview is taken at present rules and regulations in reporting field, and at the currently typical reporting systems, to analyze functions and characteristics of SRS which provide theoretical supports to the evaluations. The definition of ship reporting systems and impacts of new technologies are examined.

Through the analysis of the application of reporting system, existing problems and countermeasures are provided for more fully taking into account the impact of factors in the evaluation. Indexes affecting ship reporting systems are examined by AHP and fuzzy evaluation method which are investigated, according to the survey method. Finally, limitations conclusions and expectations are provided for future study.

KEY WORDS: ship reporting system, standardization, evaluation, AHP, Fuzzy evaluation method

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LIST OF ABBREVIATIONS

AIS	Automatic Identification System
AMSA	Australian Maritime Safety Authority
AMVER	Automated Mutual-Assistance Vessel Rescue System
ASP	Application Service Provider
AUSREP	Australian Ship Reporting System
BDS	Beidou Navigation Satellite System.
CSP	Communication Service Provider
DC	Data Center
DG	Dangerous Goods
DR	Deviation Report
DSC	Digital Selective Calling
ETA	Estimated Arrival Time
FR	Final Report
GMDSS	Global Maritime Distress And Safety System
HS	Harmful Substances Report
IMO	International Maritime Organization
JASREP	Japanese Ship Reporting System
LOA	Length Over All
LRIT	Long Range Identification And Tracking Of Ships
MASTREP	Modernised Australian Ship Tracking And Reporting System

MMSI	Maritime Mobile Self-Identification
MOT	Ministry Of Transportation
MSC	Maritime Safety Committee
MSQ	Maritime Safety Queensland
PCA	Principal Component Analysis
PR	Position Report
RCC	Rescue Coordination Centre
REEFREP	The Great Barrier Reef And Torres Strait Ship Reporting System
SAR	Search And Rescue
SOLAS	Convention On the Safety Of Life At Sea
SOTDMA	Self Organizing Time Division Multiple Access
SP	Sailing Plan
SURPIC	Surface Picture
UNCTAD	United Nations Conference On Trade And Development
UNCTAD	United Nations Conference On Trade And Development
USCG	United States Coast Guard
VHF	Very High Frequency
VTS	Vessel Traffic Service
STRAITREP	Mandatory Ship Reporting System In the Straits of Malacca And Singapore
FCE	Fuzzy Comprehensive Evaluation method

CHAPTER 1
INTRODUCTION

1.1 Background information

World seaborne trade, which has accounted for over 80 percent of total world merchandise trade in volume (UNCTAD, 2016) and over two thirds of total merchandise trade in value terms (IHS 2016), has been developing for almost 5000 years (Stopford, 2009). In 2016, due to the overall impact of the world economic downturn, Chinese shipping development has slowed down, but the importance of seaborne trade in Chinese economy has been rising. (Bo, 2014）

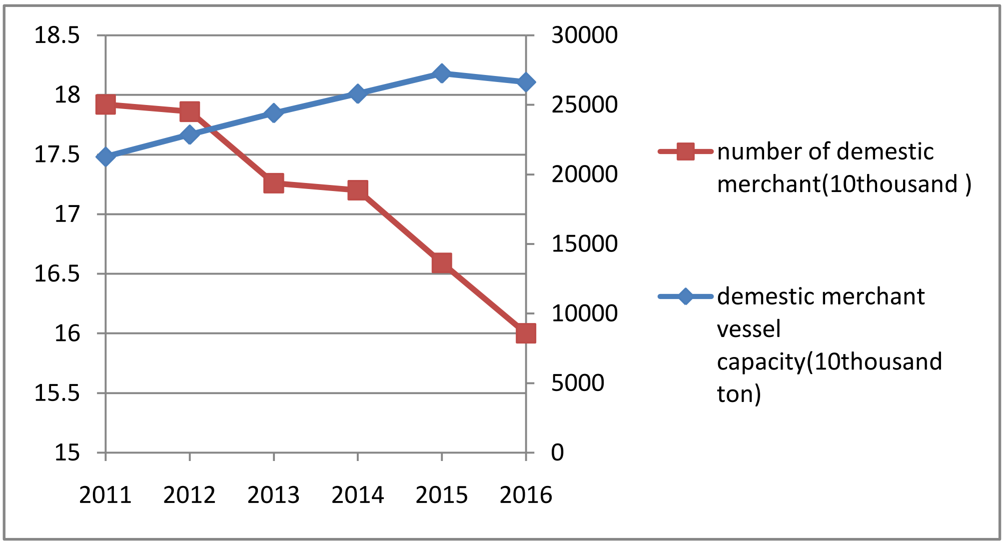

Figure 1.1 Chinese capacity of waterway transportation (2011-2016)
Source: compiled by author based on China MSA

Figure 1.1 illustrates that the number of ships in China has declined rapidly since 2011, but the overall ship capacity has risen, because the scraped ships are mainly small ships and inland ships, and the large-scale ship has become a main trend of maritime development, which not only reduces the cost of shipping companies, but also contributes to environmental protection.(Nakazawa, 2017; Bi, 2012; Li, 2011,) Of course, the large size of ships and the high density of ships in some waters also bring great potential danger to the safety of navigation（Yin, 2015; Xiang, 2014）

Ship safety and security at the sea is ensured by various maritime systems working together simultaneously. From tracking ships to ensuring immediate help in time of distress, these systems keep the shipping industry on the right track all the time.

In order to better make the role of the ship reporting system (SRS) into full play in terms of the safety of life at sea, navigation safety and efficiency and protection of marine environment, International Maritime Organization(IMO) has adopted the SOLAS 1974 Convention, the Maritime International Search and Rescue Convention 1979(hereinafter SAR 1979), Resolution A.851 (20) guidelines and rules which have been developed for the establishment of reporting system principles, reporting requirements and content of different aspects of the norms.(IMO, 1997) Currently, China has built 33 SRSs managed by VTS centers, and 18 SRSs to be implemented in the waters of routeing systems.(China MSA, 2017) However, there are no uniform standards for the compiling methods, contents, formats and procedures of each reporting system, and also is a gap between international requirements and practice. To some extent, it has affected the standardization development of SRS in China, and has also influenced the construction of national reporting system.

1.2 Objectives of research

The reporting system has strengthened maritime traffic safety, improved traffic efficiency, and effectively protected lives and property at sea; however, too many reporting systems are stressful for captains and mariners who easily confuse different content, formats, and requirements. Thus, the objectives of this research paper are listed as followed:

a) Critically review the related provisions of ship reporting systems and typical reporting systems;

b) Analyze the application of SRS, put forward the existing problems，and provide some feasible solutions;

c) Put forward how to make a comprehensive evaluation of a reporting system.

1.3 Methodology

(1) Data analysis: extensive collection of relevant international conventions and rules, domestic laws and regulations, domestic and international reporting information and other data for analysis and research.

(2) Typical case: analysis and research on typical cases of reporting system.

(3) Survey: questionnaires, interviews and surveys are used to investigate facts, opinions and needs. Conclusions and relevant solutions are obtained through professional analysis and research.

(4) System comparison method: using contrast, analogy analysis of similar problems.

1.4 Structure of the research paper

The research paper consists of seven chapters: Chapter one presents background information, objectives of research, and methodologies; Chapter two concentrates on the provisions about ship reporting systems, including conventions and guidelines; Chapter three highlights characteristics of SRS by analyzing currently typical systems, and offers impacts of new technologies which would promote the development trend of reporting network, data sharing; Chapter four concentrates on the application analysis of SRS including functions, and the process of establishment and operation, conclusions the problems existing in current SRS and countermeasure; Chapter five emphasizes functions of evaluation, provides constructing principles of evaluation systems, and scrutinizes the methods of AHP and fuzzy evaluation; Chapter six discloses evaluation indexes by analyzing the influenced factors, details the calculation of weights and defuzzification, according to the conclusion in the former chapter; finally, Chapter seven makes final conclusion, and outlines limitations and expectation of this research paper.

CHAPTER 2
REVIEW OF RELEVANT PROVISIONS OF SHIP REPORTING SYSTEM

2.1 Introduction

Ship Reporting Systems (SRS), which means that ships (ship-owners or shipping operators), in the prescribed manner, provide or report the ships' dynamic information to a competent authority. (i.e. MSA, VTS centers) （SOLAS,2009）, are used for conducting dynamic monitoring and management of navigation safety of ships.

SRS originated in 1912, when the catastrophe (Titanic) happened in the Atlantic. The US became the first to establish the Atlantic Merchant Vessel Emergency Reporting System (AMVER) in 1958 for avoiding such accidents happening again. With the development of communication technology, this system expands from a regional system to a global system, which is Automated Mutual-Assistance Vessel Rescue System currently. (Shapiro, 2009)

As the SRS has been popular in the shipping industry for its navigation safety, search efficiency and marine environment protection, various SRS has been developed and the purpose of system changed from search and rescue to comprehensive purposes including monitoring ships' dynamic information and reducing the loss of property and lives.(Zhu, 2015)

Particularly, large-scale, professional trends of ships are obvious. (Nakazawa, 2017) For reduction of risk in shipping industry, on the one hand, design standards, manufacturing processes and configuration specifications are continuously improved by rules and regulations to increase safe factors. On the other hand, ship traffic management and post-accident rapid response can be strengthened to reduce the probability and risk of accident.(Trbojevic, 2006; Jacobsen, 2003)

IMO is actively encouraging ships to report their information while sailing in the waters covered by the SRS, and recognizes that States should provide appropriate facilities to ships including harmonized standards of reporting format and procedures. (SAR, 1979)

2.2 Relevant Provisions of SRS

The successful operation of the AMVER system in the United States has made the shipping industry fully aware of the great benefits of SRS to ships and human lives. (Wang, 2003)Therefore, as mentioned above, many SRS entered into force; however, due to the different characteristics and conditions of each country (different report formats, procedures and requirements), the conflicts are unavoidable. Therefore, the need to unify the ship reporting contents is becoming more and more urgent.

2.2.1 International Convention on Maritime Search and Rescue 1979

There are simple rules on the ship report format and procedure, as the basis of harmonized standards, in Chapter 5 of SAR convention. But provisions of the convention on the reporting are limited to purposes of search and rescue; even so, it also provided a reference for the ships' report, and a blueprint for general principles for ship reporting system and the ship's reporting requirements.

2.2.2 SOLAS 1974 Convention

IMO adopted the amendments to SOLAS 1974, in accordance with resolution MSC.31 (63), convened by the 63rd MSC in May 1994, with the addition of regulation V/8-1, on the ship reporting system, (i.e. amended by MSC 73 Article V/11) which establishes the legal status of IMO as an international body for the development of an international guide, standards and rules for SRS.

SRS, only in accordance with the guidelines and criteria, which is approved by IMO, can apply to all ships or certain types of ships or ships carrying certain goods that shall comply with the SRS. Meanwhile, contracting governments are encouraged to be as follow the guidelines and criteria set by the organization set up their own report system or common interests in specific waters to establish a unified application and operation of the ship reporting system coordination.

IMO fully recognizes that the SRS is gradually converging with advanced maritime management practices such as ships' routeing and VTS, resulting in inconsistencies in procedures, standards, reporting content and format, and consequently imposed burden on captain.

2.2.3 Guidelines and criteria for ship reporting systems

Guidelines and criteria for ship reporting systems (hereinafter guidelines) detailed that, a) Factors which contracting governments shall be considered, in accordance with prescribed purposes when planning SRS; b) SRS and its amendments should be submitted to the IMO for review and approval; c) Responsibilities and obligations of States Parties in the implementation of SRS should be taken; d) The specific report content required by SRS can be increased for the purpose of the actual situation.(IMO, 1994)

2.2.4 General principles for ship reporting systems and ship reporting requirements, including guidelines for reporting incidents involving dangerous goods, harmful substances and/or marine pollutants

The introduction of Guidelines regulates the establishment of SRS to a certain extent, but IMO quickly realized that different procedures and reporting formats may confuse captains with different reports. Thus, IMO approved the general principles (hereinafter general principles) on 27 November 1997, by resolution A.851 (20). General principles provide guidance to the dangerous goods, harmful substances and other marine pollution accidents. The highlights of general principles not only provide clear rules for SRS, but also formulate a standard format for SRS, contributed to the establishment of SRS standardization. (IMO, 1997)

Ship reporting message is identified by report System Name / type of report, including sailing plan(SP), position report(PR), final report(FR), dangerous goods report (DG) and harmful substances report(HS) etc.. The content of the specific message is represented by 26 letters in order, which provides the corresponding report items. The specific item is shown in Appendix A. (IMO, 1997)

2.3 Chapter Summary

This chapter summarizes the international requirements of the ship reporting system and some recommended guidelines. Although IMO has set standards for reporting system, it is not binding because it is recommended. In addition, because the reporting system is effective in protecting the safety of life at sea and the marine environment, many countries are also actively established; however, which has increased the burden on seafarers resulting in a negative impact. Therefore, it is necessary to enhance the legal effect of the uniformity of the reporting system.

CHPTER 3
REVIEW OF CURRENT SHIP REPORTING SYSTEMS AND NEW TECHNOLOGIES

The SRS, which is aimed at improving the efficiency of search and rescue, started early, spread over a wide area and developed the most mature. For instance, AMVER, AUSREP, and JASREP etc..

However, the extensive use of SRS is combined with ships' routeing and VTS to ensure the safe navigation of ships, to enhance the local navigation efficiency, to reduce the risk of environment pollution, and to promote the local economic development. For example, CALDOVREP, STRAITREP, REEFREP etc..

In the meanwhile, a number of countries have established SRS dedicated to a particular use, for example, Mandatory Ship Reporting System for North Atlantic Right Whales, MAREP to improve the marine warnings and forecasts, The MAREP Hydrographic Programme in Canada etc.(Silber et al, 2015; Vanderlaan et al, 2009;)

3.1 Foreign typical SRS

The emergence, development and maturation of the reporting system have been researched abroad first. Therefore, it is of great significance to study the foreign typical reporting system for the establishment of standardization and normalization of SRS in china.

3.1.1 AMVER

AMVER, established by USCG in 1958, is a global mutual aid system, providing assistance of search and rescue in waters around the world. (Shapiro, 2009; Wang, 2003)

The AMVER can analyze the sailing plan, position and other reports of ships to produce a SURPIC, which can be shown that in a certain ocean area, a vessel in distress and other vessels involved in AMVER are in relative position, (Figure 3.1) A RCC coordinator, based on the SURPIC provided by AMVER, can understand the detailed ship information on SURPIC, including whether there is a doctor onboard ship. The nearest vessel or shore rescue force is to be properly assigned to the scene according to the rescue requirements of the vessel in distress. (USCG, 2017)

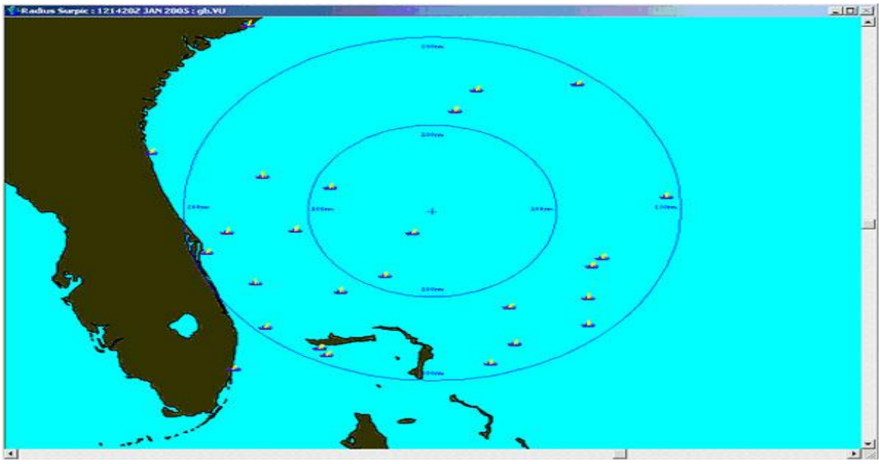

Figure 3.1 AMVER reporting system

Source: http://www.amver.com

It can be said, AMVER system is the originator of the world ship reporting system. Although a number of similar regional systems such as AUSREP and JASREP have been established; even today, AMVER is still the only global SRS.

3.1.2 REEFREP

In order to ensure navigation safety, to improve the efficiency of navigation and to protect marine environment of the Great Barrier Reef(a special sensitive waters)(Figure 3.2), AMSA and MSQ jointly set up a coastal type of the Great Barrier Reef and Torres Strait vessel traffic service system, which is composed of two parts: REEFREP and position monitoring system. REEFREP was adopted by MSC 52 (66), implemented in 1996 and later revised by MSC.161 (78) and MSC.315 (88). (Macdonald, 1996; Chen, 2006)

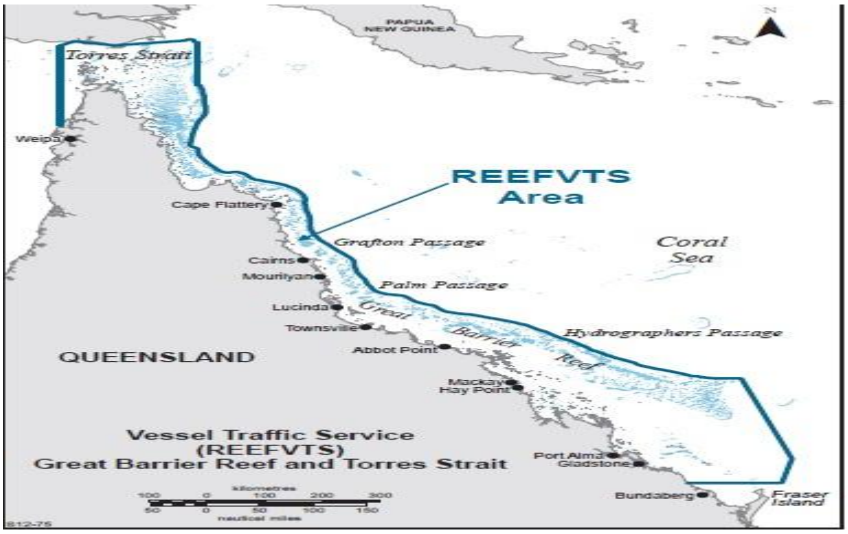

Figure 3.2 REEFREP Area
Source: https://www.amsa.gov.au/navigation/services/reefvts/

In spite the fact that the system combined with VTS, it can not only play the same functions as MASTREP, but also maintain the unity with MASTREP. When ships sail into REEFREP waters from MASTREP waters, AUSREP is converted to REEFREP immediately, and the similar thing would happen again when the ship finishes the final report. In this way, the problem of repeated reporting of the overlapping waters of the ship's report is well solved

3.1.3 STRAITREP

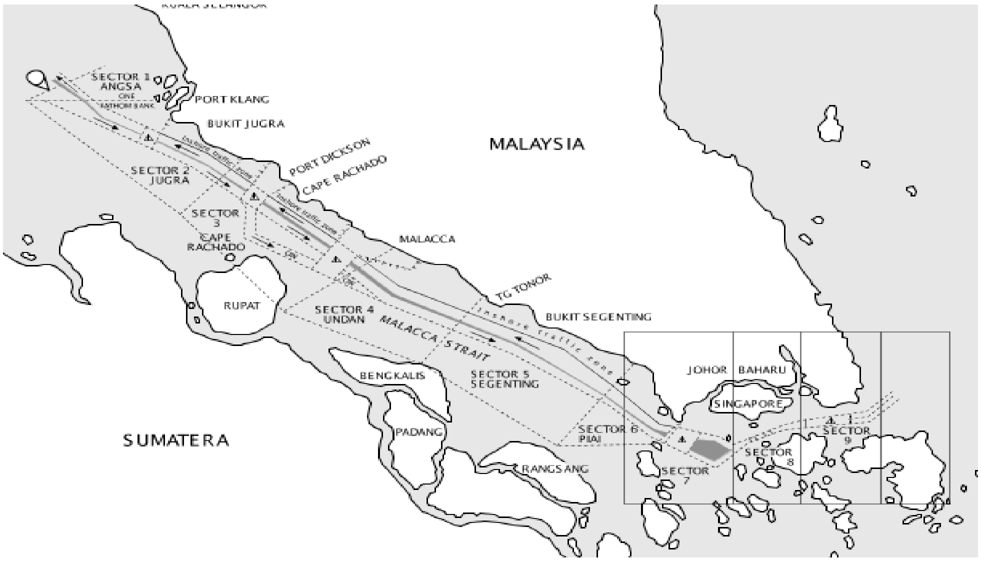

Figure 3.3 STRAITREP area

Source: MSC.73 (69)

This mandatory SRS was set up jointly by Singapore, Malaysia, and Indonesia on 1 December 1998, and effective operation of this system eventually replace the original Singapore ship reporting system. The entire reporting area is divided into nine districts from west to east. (Figure 3.3)

The implementation of the system enhances the ship navigation safety in Malacca and Singapore strait, effectively protects the Marine environment, greatly facilitates the channel of the ship passage, greatly improves emergency response speed of maritime search and rescue and oil pollution, for the maritime accidents were significantly reduced in the Straits. The Malacca Strait routeing, Singapore channel routing system were also built in the STRAITREP area at present.

The biggest highlight of the system is a multi-national co construction system, which provides a good reference for the implementation of VTS regional networking and sharing reporting data in all over the world.

3.1.4 Mandatory Ship Reporting System off Chengshan Jiao Promontory

Although the research on SRS started late in China, CMSA has always made the study of SRS as an important part of comprehensively improving the level of maritime service and regulatory effectiveness, gradually built a variety of SRS, matching ships' routeing and VTS, basically covering Chinese coastal waters which includes many important ports.

Mandatory ship reporting system off Chengshan Jiao promontory was adopted by MSC.93 (72) in September, entered into force on 12 January 2000. Officially, later amended by Resolution MSC389 (94). Therefore the newest requirements entered into force in June, 2015. (Fan, 2012) This is the only international SRS approved by IMO off waters China.

The reporting waters covered by the system are those with the VTS Centre (geographical position is 3723′.65N, 12242′.12E) as the center and 24 miles as the radius. (MSC 389(94)) as shown in Figure3.4.

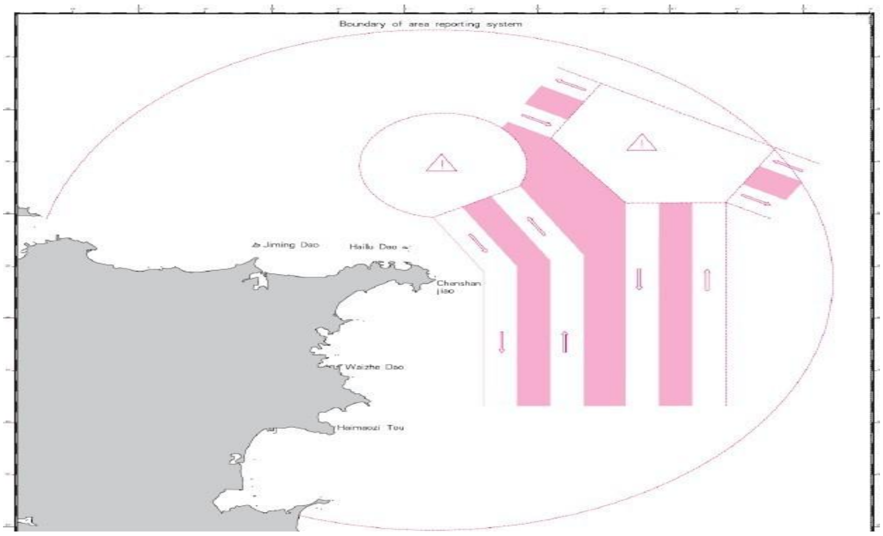

Figure 3.4 Reporting Area of Chengshan Jiao Promontory

Source: MSC.389(94)

Since the SRS has been carried out, the reporting rate has been increasing year by year, ship accident rate and violations have been significantly reduced, as shown in Figure 3.5.

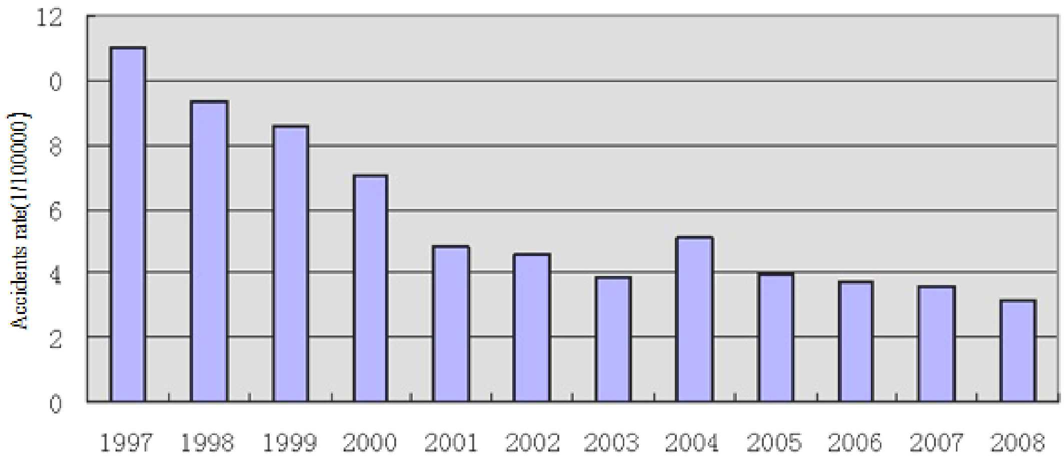

Figure 3.5 Ship Accident Rate

Source: Compiled by author based on China MSA

3.2 Characteristics of SRS

The ship reporting systems collect ship dynamic information and other static information, using the computer to store, track and analyze the necessary information for various purposes such as maritime management, environmental protection and human life rescue. The SRS has experienced three stages: generation, development and maturity, which is basically characterized by being voluntary to being compulsory, reporting area from small to large, reporting mode from complexity to simplicity and sharing information and even functional merger.

a. Applications widely

Although the establishment of SRS was designed to enable the timely detection of vessels in distress and the timely convening of other ships near the ship in distress to carry out rescue operations, it is found that the ship reported information can play a variety of roles to meet the different needs of the maritime sector, so different reporting systems for various purpose have been established. For instance, AMVER is to improve the efficiency of merchant ships' mutual assistance and maritime search and rescue; CALDOVREP which is to coordinate the effective implementation of ships' routeing;

b. development from a single technology to the jointly multi technology

SRS, with the continuous improvement and development, fully demonstrates the important role and strong vitality in maritime management and service support system. When it is in combination with other systems, they not only play their own advantages, but also improve the efficiency of other systems, and expand other functions of the system. (Zhu, 2015)

c. Making full use of modern science and technology to continuously improve the reporting system.

Ship reporting system is a system based on information technology. SRSs keep pace with the rapid development of science and technology, and adjust the reporting system in a timely manner so as to mitigate the reporting burden onboard ships. E-navigation will make further efforts to implement single window declarations to simplify the current information reports on ships facing different requirements from various authorities. (E-navigation)

d. Obvious trend of expanding reporting waters, sharing resource, regional networking, functional mergers, multi-country joint construction.

The reporting system realizes the large capacity storage and exchange of ship data, so that the ship report data can be shared, and it also creates conditions for the networking of the reporting waters. For example, AMVER and JASREP, and AUSREP cooperate with each other; Singapore, Malaysia, and Indonesia are to establish STRAITREP system.

3.3 Impact of new technology development

3.3.1 Long-Range Identification and Tracking of Ships

As the AIS system is limited by the communication distance, only the inshore ship can be tracked, while the SRS can cover the whole world, but the message is artificially constructed, which may affect the tracking accuracy. In order to solve the problem of long-distance tracking of ships, some countries put forward the idea of establishing LRIT. MSC approved the amendments to the SOLAS 1974 in May, 2006, adding to the enforcement of LRIT system. LRIT system extracts IMO number, position and time through AIS, utilizing GMDSS, Inmarsat-C to send LRIT data at fixed time intervals, to achieve the remote identification and tracking.(Zhang & Bao, 2007)(Figure 3.6)

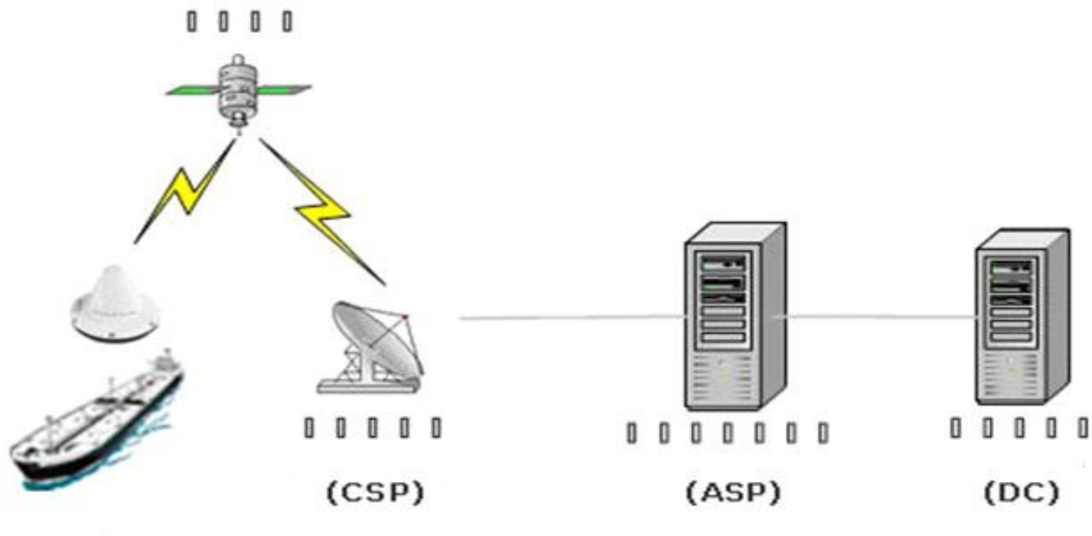

Figure 3.6 Transmission Process of LRIT Information

Source: www.lrit.com.cn/

The report of this system is automatic and without manual intervention at a certain time interval. It has advantages as a ship dynamic tracking, but the reported content is too simple and far from meeting the requirements of ship reporting system. Therefore, this system can be used as supplementary report of first report, and cannot be the main means of ship report.

3.3.2 BeiDou Navigation Satellite System

Beidou Navigation Satellite System (formerly known as COMPASS, hereinafter BDS) was an independent Global Navigation Satellite System (GNSS) developed by China. The BDS, whose first satellite was launched in 2000, has a three-phase development strategy namely, 2000-2007: experimental; 2007-2012 regional coverage; 2012-2020 global coverage (Kang and Quan, 2013). Current BDS (precision is about 10 meter) satellites are illustrated in Table 3.1.

Table 3.1 Summary of Beidou Satellites (AS OF 2015)

Block	Launch Period	Satellite launches			Currently in orbit
		Success	Failure	Planned	
1	2000–2007	4	0	0	0
2	2007-2012	16	0	0	14
3	From 2015	6	0	18	6
Total		26	0	18	20

Source: www.beidou.org.cn

BDS is an all-weather, high-precision satellite navigation and positioning system, which can achieve rapid navigation and positioning, two-way brief message communication and timing, 3 major functions. The outstanding advantage of BDS is interaction and openness that combines SMS service and navigation and adds communication function, and the system user terminal has two-way message communication function. (Wu et al, 2015; Zhou, 2014)BDS is developing, though it is not yet widely used, covering only the Asia-Pacific region.

3.3.3 E-navigation

As a result of the rapid development of navigation technology, VTS, GPS, ECDIS, AIS, GMDSS, LRIT, network and other electronic information technology are widely used, making the ship maritime navigation safer, convenient and environmentally friendly. However, these new technologies(i.e. navigational aids, communication) , on the one hand, provide a wealth of navigation and communication means for seafarers; (Costa, Lundh, & MacKinnon, 2018) on the other hand, these navigational systems are self-contained, which results in standards uniform and incompatibility between ship-borne equipment and shore infrastructure. The difficulty of sharing information and the complexity of operation greatly affect the initiative and actual use of the safety facilities and equipment by marine personnel and shore management personnel.

In order to maximize the use of the effective information, and to improve the convenience and accuracy of navigation, without increasing the workload of seafarers, IMO defines the concept of E-Navigation in MSC 81st session in 2005 for identifying its development strategy.

The core objectives of E-navigation include:

a. it is conducive to the safety and security of navigation vessels by taking into account of the hydrological, meteorological, navigational information and risks;

b. Conducive to the supervision and management of ship traffic;

c. Facilitate the exchange of data between ships-ships, ships-shore, and other customers;(Figure 2.8)

d. Support the effective operation of emergency response and search and rescue operations;

e. In terms of equipment, systems, operating procedures and so on, it is beneficial to global coverage, standard unification, compatibility and convenient operation.

Therefore, E navigation is a compatible and developing system, which plays an important role in the future development of technology and system.

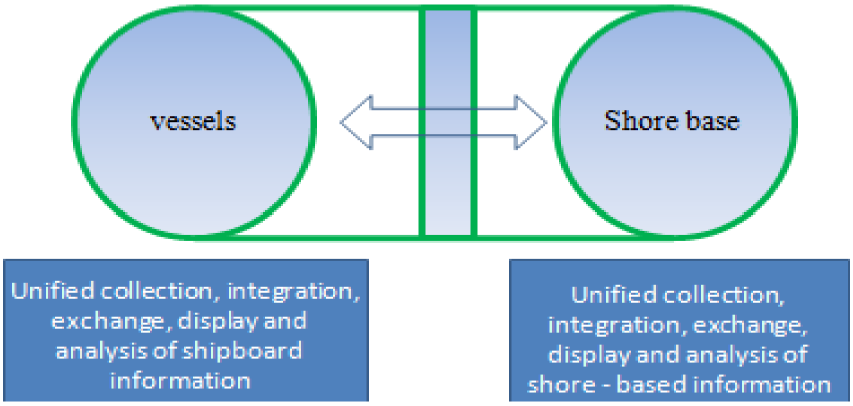

Figure 3.7 Simple E-navigation Overall Architecture

source: (Wang, Zhang, Huang, & Zhang, 2017)

In terms of the core elements of E-navigation, including high integrity electronic positioning, ECDIS, and communication infrastructure, E-navigation is obviously not a purely ship reporting means. However, the implementation of E-navigation will have an important impact on the changes in ship reporting. It is of great significance to promote the regional networking, information sharing of the reporting system and reducing the burden on mariners. (Weintrit, A., 2013)

3.3 Chapter summary

Currently, SRS, whether as a separate system, or integrated systems combined with ships' routeing and VTS or other related systems, has played a significant role in navigational services and support. As an advanced means of ship management, SRS is applied more extensively, and the trend of resource sharing, regional networking, functional integration, multi-national joint construction is obvious.

CHAPTER 4
APPLICATION ANALYSIS OF SHIP REPORTING SYSTEMS

4.1 Introduction

Various accidents caused casualties, property damage and environmental pollution has become even more shocking, especially seriously harm to the marine environment has aroused great attention from the international community. In order to reduce the risks mentioned above in the process of modern ship operation, the international community continuously improves ship design standards, manufacturing processes and configuration specifications to increase vessel safety factor; On the other hand, the management of ship traffic and the rapid response after accident are strengthened to reduce the probability of accidents and mitigate the harm of accidents. The SRS is one of the important means to be realized.

4.2 Functional analysis

Based on the SRS set up in various countries, there are two main types of SRS: 1) for the purpose of search and rescue, 2) for VTS waters and routeing.

4.2.1Reporting system set up for the purpose of search and rescue

The main functions of this type of reporting system are 1) to reduce the time interval between the loss of contact with the ship and the commencement of search and rescue operations when no distress signal is received; 2) A ship that is quickly identified as being able to be called in for assistance; 3) In the case of distress, the location of the ship is unknown or irregular, can be delineated within a certain range of search areas; 4) Providing emergency medical assistance or counseling.

The position and navigation of ships at sea are collected by dynamic periodic reports to dynamically monitor and manage ships. Database established by SRS is very important for the implementation of emergency search and rescue. When a ship is in distress, the search area can be narrowed down by querying the database and other ships nearby can be sent to rescue or aid as soon as possible so as to improve the efficiency of the rescue so as to minimize the loss. Many countries have designated the search and rescue areas in their coastal waters and have established a position reporting system. For example, JASREP, CHISREP etc..

4.2.2 SRS serving routeing and VTS

The meaning of the ships' routeing is the traffic separation scheme or traffic lane that the shore-based department uses to specify or recommend the form of the ship to be followed or used in certain waters. Ships' routeing is often the intended purpose through the SRS. Currently, SRSs have been established in many famous busy waterways, such as the Dover Strait, Malacca Singapore Straits, the Yangtze River estuary waters, the Pearl River estuary waters, Qiongzhou Strait.

Similarly, the reporting system has been widely established in the VTS service waters, which can make full use of VTS resources, to achieve the function of SRS.

（1）CALDOVREP

In 1967, IMO adopted the first ship routing system in the world - the Strait of Dover routeing, which replaced the original reporting system (MAREP / POSREP) in 1999. It can be seen from Figure4.1 that the management of the Dover Strait is a comprehensive system, including reporting system, VTS and traffic separation scheme.

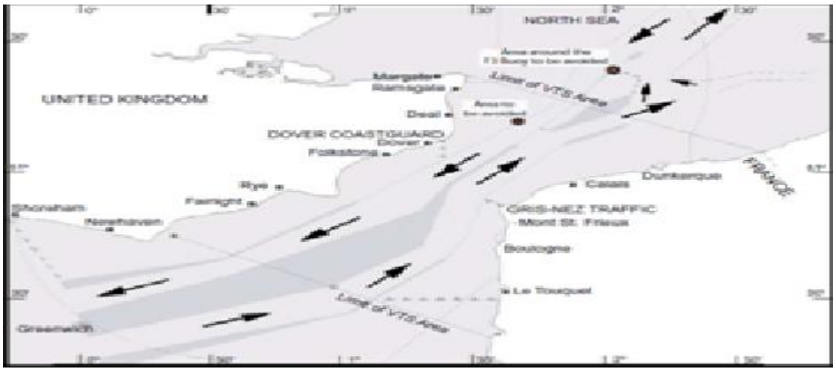

Figure 4.1 CALDOVREP waters
Source: https://www.gov.uk/government/organisations/maritime-and-coastguard-agency

（2）Hong Kong Ship Reporting System

Hong Kong SRS is a part of an integrated system, which is mandatory and divided into three regions: the eastern part of Hong Kong, the western part of Hong Kong, and Hong Kong port area, where ships must continuously remain on the corresponding VHF channel on duty. Table 4.1 Provide more details about the reporting.

Table4.1 VHF Channels required by Hongkong Reporting system

Purpose	Channel	Call Sign
Eastern approaches Vessel Traffic Services	12	MARDEP, Hong Kong
Western approaches Vessel Traffic Services	67	MARDEP, Hong Kong
Harbour-Vessel Traffic Services	14	MARDEP, Hong Kong
Navigation warnings	20	
Berthing Kwai Chung Container Terminals,	74	Kwai Chung Control
Berthing China Ferry Terminal	68	China Terminal
Berthing Macau Ferry Terminal	71	Macau Terminal
Pilot	11	Hong Kong Pilots
Tugs	09	
Intership	06	

Source:compiled by author

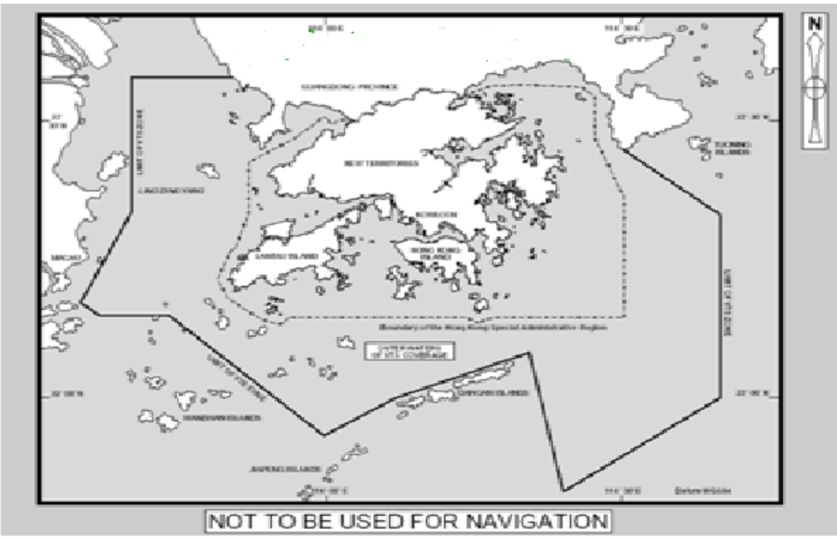

Figure 4.2 Sketch map of Hongkong reporting system
Source: http://www.mardep.gov.hk/en/home.html

4.3 Application, establishment and operation analysis of ship reporting system

After the implementation of the ship reporting system, remarkable results have been achieved, 1) There have been a fundamental improvement in the water safe situation and navigational order; 2) The implementation of the ship reporting system has brought significant economic benefits. e.g. the reduction of ship sailing time and loss.

4.3.1 Establishment process of reporting system

Usually, the reporting system is established in the following steps

a. Set up a compilation team to investigate the actual situation of the reporting system waters, grasp the actual situation of hydrological, navigable environment, traffic flow, and port user' requirements and opinions, conduct feasibility study, form a feasibility study report and apply for review and project;

b. The scope of application, communication requirements, reporting format, content and requirements, reporting institutions, relevant party responsibilities, obligations and effective time are specified in the reporting system, and a complete reporting system is formulated;

c. To solicit opinions from all parties, and to assess and further improve the amendment,

d. The Ministry of transportation (MOT) issues a notice of trial operation after approved;

e. Formal operation.(China MSA, 2017)

4.3.2 Operation of ship reporting systems

In order to make the reporting system be better implemented, the necessary measures should be taken in the process of operation. 1) reporting system of propaganda; 2) strengthen supervision after implementation; 3) maintenance of the operation center including Software and hardware. (China MSA, 2017)

The following example of implementation of SRS in China:

（1）Ningbo port reporting system running situation

After the operating SRS in Ningbo port waters, the navigational order and efficiency have been greatly improved; meanwhile, accidents and dangerous situations declined significantly. The annual dangerous situation of ships in the Ningbo VTS management area has been basically maintained at 320-330, and the accidents have declined dramatically from 2007 to 2012, the Table 4.2, and Figure 4.3 provide more details.

Table 4.2 Accident Annual Statistics

year	Dangerous situation	accidents
2007	325	7
2008	323	5
2009	327	10
2010	328	5
2011	324	2
2012	421	1

Source: Compiled by author based on China MSA

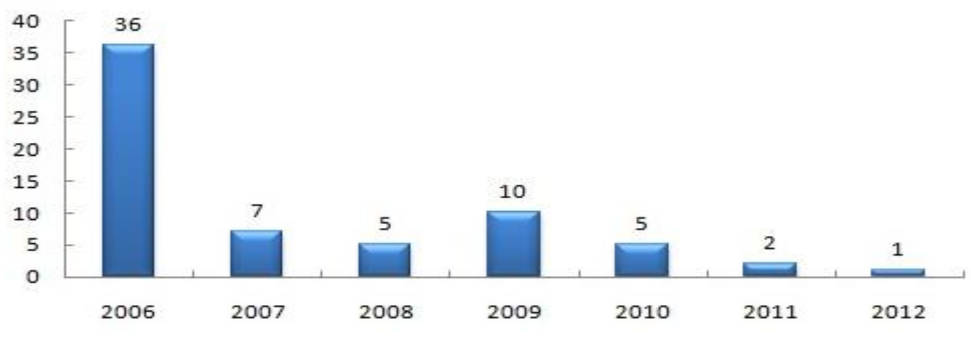

Figure 4.3 Accident Annual Statistics
Source:　Compiled by author based on China MSA

4.4 Chapter summary

4.4.1 Application and operation of reporting system

There are two types of ship reporting systems that are currently established and operated internationally: ship reporting systems established for search and rescue purposes and ship reporting systems serving in regional and VTS regional services;

It is not difficult to see from APPENDIX B that each reporting system is basically the same in its overall form, but the reporting requirements have their own characteristics.

4.4.2 Existing problems

(1) There is no uniform standard for the establishment process and procedure of the ship reporting system. The level of the competent authorities is different, and the standards for planning and establishment are not clear and should be unified.

(2) The functions, requirements, contents and procedures of the reporting system are not the same. The setting of the reporting point is lack of basis, and the corresponding standards should be standardized and unified;

(3) The internal management and operation of the reporting system lacks uniform standards, the management requirements and allocation standards need to be further improved, and there is a lack of scientific working mechanism in information processing and management;

(4) According to demands and feedback of users, the report content is complex, and communication channel resources are few, resulting in seriously mutual interference;

(5) In the adjacent reporting area, coordination is not taken into consideration, and the workload of ship reporting is too heavy, and the reporting requirements and contents are not uniform, and resource utilization is low;

(6) There is no evaluation of SRS, lack of evaluation and improvement of the operation and effectiveness of the reporting system.

4.4.3 Countermeasures

Taking into full account of the Guidelines and Standards and the Mandatory Provisions of SOLAS 1974 on ship reporting systems, through the practical application of establishment and operation analysis, measures for improvement are put forward in the following aspects:

(1) Providing unified procedures and standards for the establishment of reporting system, and to promote the standardization of the establishment and operation of reporting system;

(2) Clarifying the specific requirements of the reporting system to avoid confusion in the different reporting systems;

(3) Actions should be taken when the vessels have not implemented SRS;

(4) Giving consideration to the factors that should be considered in reporting lines and reporting points;

(5) Establishing the information sharing mechanism of ship report, strengthening the coordination among regions, simplifying the reporting procedure, contents and requirements of ships;

CHAPTER 5
EVALUATION THEORY AND MODEL

The SRS is constructed according to the guidelines, whether or not it can be effectively operated, whether or not the running process is defective, how can the defects be corrected quickly and effectively, which will directly affect the function of the reporting system itself. Therefore, effectiveness evaluation system is needed, in order to identify the value of the reporting system in maritime management, and to find out the defects in the system and correct it in time so as to ensure efficient and orderly operation of the system.

5.1 Theoretical basis of effectiveness evaluation

Effectiveness evaluation refers to the quantitative calculation or conclusion evaluation of effective indicators such as quality, function, and status of a certain task or system, which is widely used in military, scientific research and manufacturing industries.

5.1.1 Overview of evaluation methods

The commonly used methods of effectiveness evaluation includes Analytic Hierarchy Process (AHP), fuzzy comprehensive evaluation method, TOPSIS method, Principal Component Analysis (PCA) method, factor analysis method, a coefficient method, and entropy method etc..(Cao, 2015)

5.1.2 Functions of evaluation

（1）Guiding functions

The guiding function of the evaluation is determined by the directivity of the evaluation criteria. The essence of evaluation is that the assessor guides and constrains the development direction of the evaluated object according to the security, quality and economic concept of a certain society. In order to give full play to the guiding function of evaluation, it is necessary to determine the correct target, and to formulate appropriate evaluation content and standards according to the target, so as to comprehensively measure and evaluate the effectiveness of systems.

（2）Identification functions

The identification function of the evaluation is accompanied by the occurrence of the evaluation activity and is still the main function of the evaluation, which are reflected in the following aspects: 1) Assessment of SRS is assessed through the evaluation of the hardware and software support reliability, supervision and management effectiveness, service efficiency, social recognition and response in the evaluation system. 2) Making an approved assessment of the ship reporting system at the operational stage.

（3）Incentive improving functions

The incentive and improvement functions of evaluation are an important breakthrough in concept with the development of evaluation. Modern evaluation is not only to analyze the object of evaluation, but also to motivate the improvement of objects. The purpose of evaluating the effectiveness of SRS is to identify the potential problems, deficiencies and shortcomings in the operation of the system, so as to make reasonable proposals for improvement.

5.1.3 Structure of evaluation system

According to the evaluation function described above, it is very important to establish the effectiveness evaluation model of ship reporting system and to study its structure. The specific system consists of four parts:

(1) Fundamental Datasets

It is the basis of quantitative analyzing and evaluating index, including original data.

(2) Evaluating index set.

It is the main component of the evaluation system which is composed of a series of internal, representative and comprehensive evaluation systems, and it should be able to respond comprehensively to various factors affecting system effectiveness.

(3) Evaluation criteria.

The evaluation criteria are the rules of judgment for each specific indicator, which is an important basis for measuring the score of each index.

(4) Evaluation model.

The evaluation model is a quantitative model. The object of analysis is the evaluation index set, and the mathematical model is used to describe the relationship between the main elements of the system. The quantitative results are given by some calculation methods. (Li, 2011) The structure of evaluation system of ship reporting system can be expressed in Figure 5.1

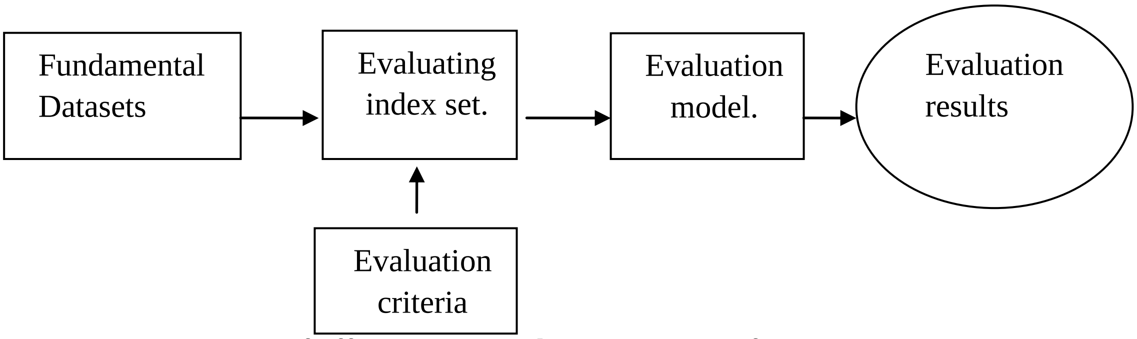

Figure 5.1 Structure of effectiveness evaluation system of SRS

Source: Compiled by author based on (Li, 2011)

5.2 Construction of evaluation index system

5.2.1 Principles of evaluation index system construction

The selection of evaluation indicators should be consistent with certain principles, so that it could be scientific, rational and objective, in order to fully and systematically reflect the performance of the ship reporting system level.

(1) Systematic principles

The selection of individual index of evaluation should base on the importance of each index to achieve the goal of evaluation, taking into account of the reasonable composition of the indicators in the evaluation index system and the logical correlation between the indicators. Through the reasonable selection of indexes and the setting of index weights, the evaluation indexes can not only focus on the key points, but also keep the relative balance and unity and realize the optimization of the system. (Yang, 2010)

(2) Practical principles.

The purpose of the evaluation of SRS is to analyze the operation of SRS, to implement the scientific management and improve the quality of operation. Therefore, the evaluation index system should be clear, and can accurately and comprehensively reflect the actual situation of emergency response capabilities.

(3) Principle of independence.

In order to get the comprehensive evaluation results of ship reporting system, it is necessary to weightedly sum up the scores of each index. If factors with repeated content are selected to participate in the evaluation, indexes do not filter out the information, which cause a big gap between evaluation results and the actual situation.

5.2.2 Establishing process of evaluation index system

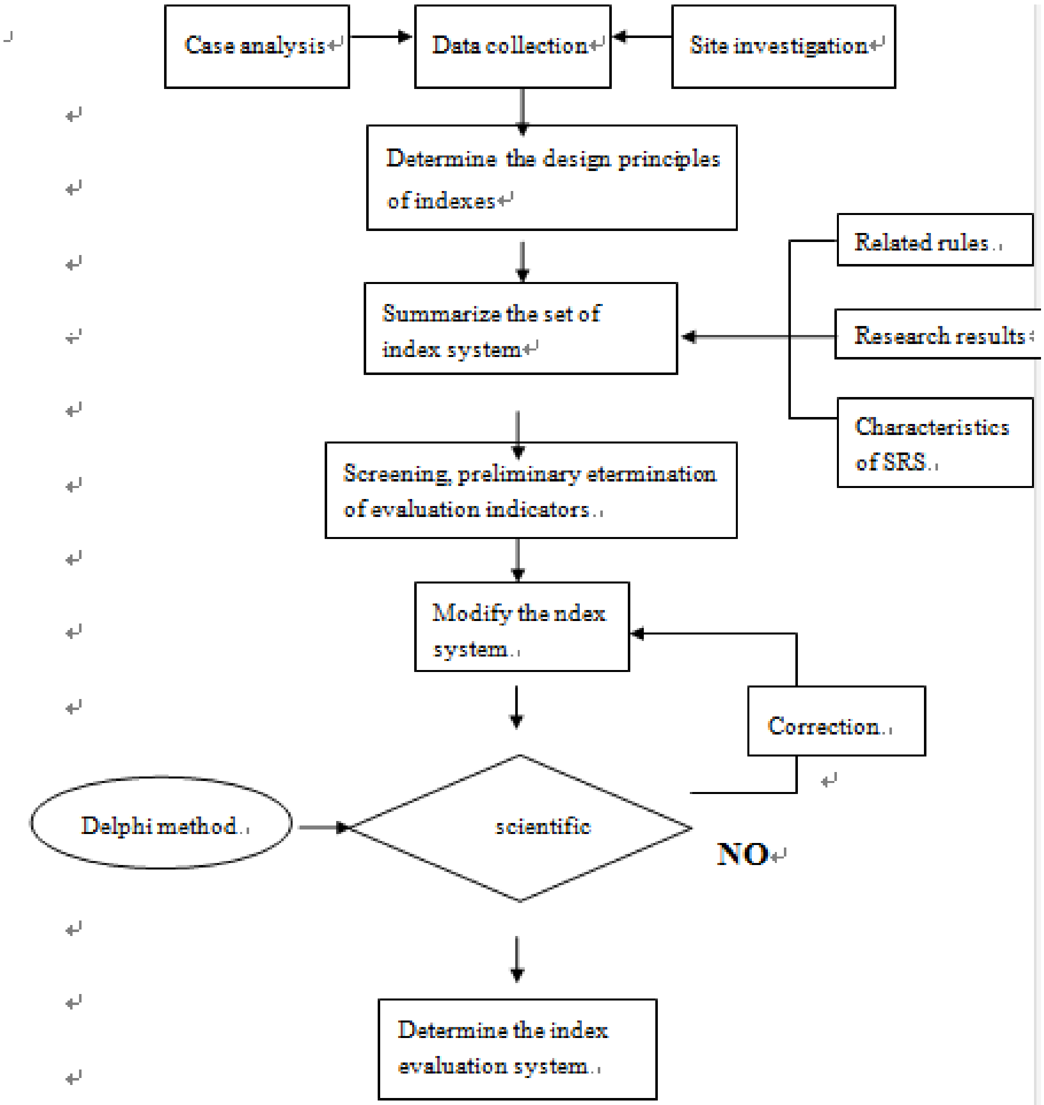

Figure 5.2 Process of Evaluation Index System

Source: (Xin, 2008)

To carry out scientific and rational evaluation, a complete evaluation index system should first be constructed that should follow certain procedures which shows in the Figure 5.2.

5.2.3 Selection of construction methods

Delphi Method is that investigators drew up questionnaires to consult the members of the panel in the form of correspondence, in accordance with established procedures, and the members of the panel submitted an opinion in an anonymous manner (letter). After several repeated inquiries and feedback, the views of the members of the group gradually tend to focus on the final access to a very high accuracy of the collective judgment results.

Delphi method is essentially a kind of anonymous feedback inquiry method which has three distinctly differentiated characteristics from other expert predictive methods, i.e. anonymity, multiple feedback, and group statistical responses.

5.3 Determination of weight coefficient

In the process of evaluation, the evaluation factor weight coefficient is very important, which can directly affect the comprehensive evaluation of the results. In order to reflect the objective reality of evaluation factors, this paper uses the Analytic Hierarchy Process (AHP) method to determine the weight coefficients of each evaluation factor. In the questionnaire survey, Pairwise comparison method is used to inquire maritime experts about the relative importance of each evaluation to the effectiveness of the ship reporting system and the relative importance of each aspect to each aspect. (Lee et al, 2006) Despite the lack of statistical data on the importance of the various evaluation factors that affect the target, and expert opinions are subjective, but the expert's opinion is a summary of its rich practical experience, is a reflection of objective facts, and a large number of investigations can reduce, avoid and eliminate the influence of subjectivity, so as to objectively reflect the importance of each factor.

5.3.1 Analytic Hierarchy Process

The analytic hierarchy process (AHP) is proposed by American scholar T.L.Saaty in 70s. It is a simple and practical multi criteria decision making method, which quantifies subjective judgments objectively with a certain scale and makes quantitative analysis of qualitative problems. (Lv, 2002)

The AHP method usually has four implementation steps, **1)** system is decomposed into different elements through the analysis of the factors contained in complex systems and their relationship, so that the multi-level analysis of the structural model is formed objectively. **2)**The relative importance of the scale, which is obtained by pairwise comparing each element from each level with its previous level and element, is used to establish the judgment matrix.(Figure5.1). **3)** By calculating the maximum eigenvalue of the matrix and its corresponding eigenvectors, the importance order of each layer factor to the upper layer is obtained, and the relative weight vector is established. **4)** Finally, from top to bottom, the combination weights of each element are used as weights. (Deng, 2012) The relative weight vectors of each element of the hierarchy are weighted summed to obtain the combination weights of all levels of factors about the overall goal of the system

Table 5.1 Judgment Matrix

B	B_1	B_2	…	B_m
B_1	b_{i1}	b_{12}	…	b_{1m}
B_2	b_{21}	b_{22}	…	b_{2m}
…	…	…	…	…
B_m	b_{m1}	b_{m2}	…	b_{mm}

Source: (Lv, 2002)

5.4 Effectiveness evaluation model of ship reporting system

The ship reporting system cannot be treated in isolation, so it must be studied from the point of view of system theory. Since systematic engineering has been widely used in many fields, the evaluation methods are various.

For the factors affecting the system operation efficiency are numerous and complex and many of them are fuzzy, the original data obtained from the evaluation are also fuzzy. Furthermore, when using fuzzy evaluation method to establish system risk evaluation index system, the fuzziness of indicators should be taken full account, we cannot blindly pursue accurate quantitative indicators, and ignore the qualitative indicators.

5.4.1 Fuzzy evaluation method

The fuzzy theory was presented by Professor LA.zadeh, an expert in automatic control in 1956, which has been widely used in various research fields. Fuzzy comprehensive evaluation method is a comprehensive risk assessment method applied in a wide range. In terms of system risk assessment, it is more suitable for the case where no data is determined. (Liu et al, 1998)

Fuzzy comprehensive evaluation is a method to evaluate a given object by considering a variety of fuzzy factors which is also to make a comprehensive assessment of these attributes or factors that belongs to some systems or things. The basic idea of evaluation is shown in Figure 5.4 below,

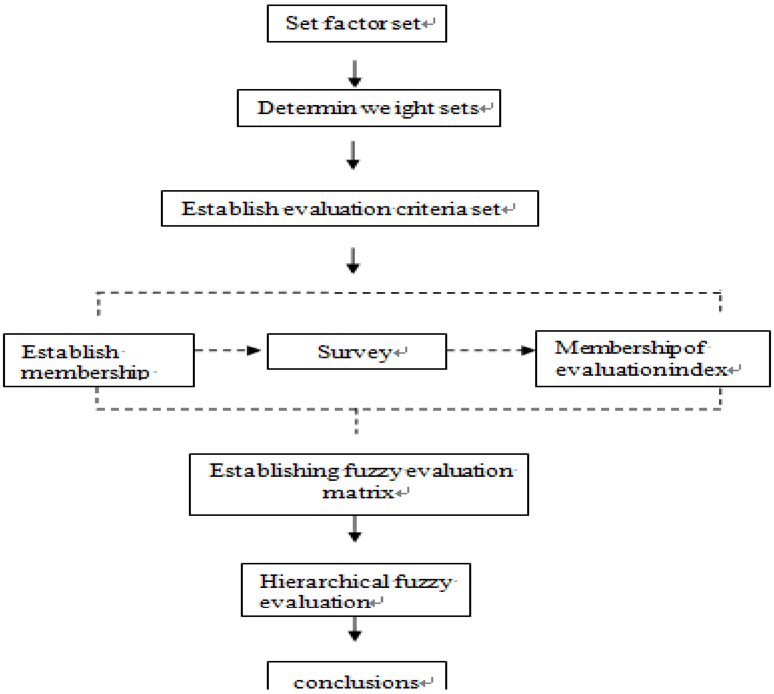

Figure 5.3 Process Of Fuzzy Comprehensive Evaluation

Source: (Liu et al, 1998)

5.5 Chapter summary

According to the characteristics of ship reporting system, this paper introduces the theory of application efficiency evaluation, selects the fuzzy comprehensive evaluation method to evaluate the operational effectiveness of SRS, emphasizes the basic theory of the effectiveness evaluation, including the establishment principle, process and method of evaluation index system, and the method of determining weight value; Finally, a fuzzy comprehensive evaluation model of the effectiveness of ship reporting system is introduced, which provides theoretical and technical support for the following concrete evaluation work.

CHAPTER 6

COMPREHENSIVE ASSESSMENT OF SHIP REPORTING SYSTEM

6.1 Introduction of comprehensive assessment of ship reporting system

Assessment is a very sophisticated process, in essence, is a process of judgments. Bloom, an American literary theorist, has taken evaluation as the most basic factors in the hierarchy of human thoughts and cognitive processes. Based on his model, evaluation and thinking are the two most complicated activities in the human cognitive processing model. He thought: "the assessment is of certain ideas, methods, and materials to make the process of value judgment. It is a process of assessing the accuracy, effectiveness, economy, and satisfaction of things using standards."

Considering a wide range of factors, the comprehensive assessment of the ship reporting system means that quantitative and non-quantitative measurement processes are carried out by evaluators on various aspects of the ship reporting system by evaluation criteria, and ultimately a reliable and logical conclusion is drawn.

This paper will focus on the self-condition and operations of the ship reporting system to comprehensive assess, in order to meet the relevant requirements (Figure 6.1). In addition, the purpose of evaluating the operations is to search problems existing in the running process of SRS and shortcomings in it.

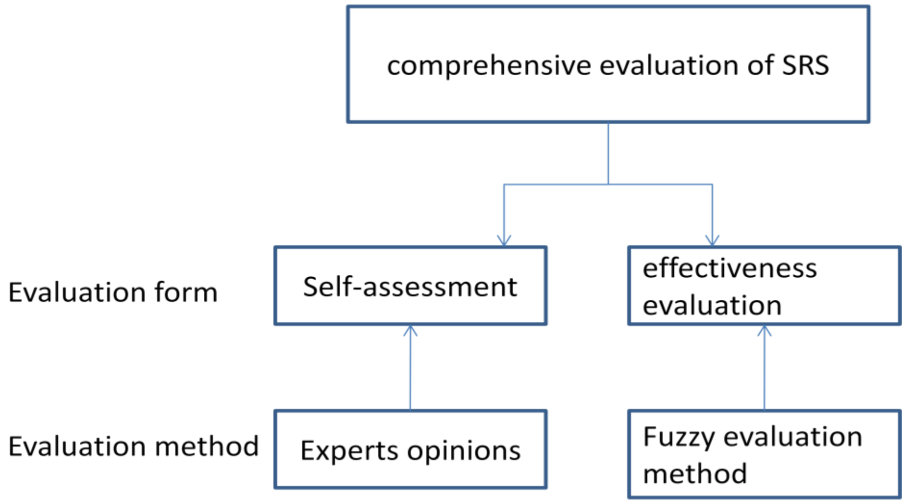

Figure 6.1Comprehensive evaluation flow chart of ship reporting system

Source: author

6.1.1 Self-assessment of SRS

First of all, the initial draft of SRS is completed by the guideline of compilation, based on the marine environment, traffic flow, ship type and channel terminals in this area, and then assessed in four aspects (legitimacy, economy, integrity, normative). The specific methods are as follows:

a. the initial drafts are distributed to some experts (i.e. managers in the shipping company, experienced captains, experts and professors in the maritime universities, maritime management personnel, senior pilots and heads of terminal management department), to collect opinions and shortcomings of this SRS;

b. holding a professional seminar to emphatically discuss reflected issues.

c. forming the manuscript

6.1.2 Effectiveness assessment of SRS

The Effectiveness assessment of SRS refers to the evaluation of the efficiency index of the performance of SRS conducted by the operational center, such as quality, effects and status etc..

The specific method is Fuzzy Comprehensive Evaluation method (FCE), which is to determine the weight coefficient and to construct the fuzzy matrix through establish the index system, and finally to use the semi - quantitative form of the fuzzy mathematics theory to evaluate.

6.2 Construction of index system

6.2.1 Index system structure

According to the Delphi method, first of all, investigation questionnaires would be distributed to the maritime experts including experienced captains, experts and professors in the maritime universities, maritime management personnel in the form of letters and mail for consultation. It is because it is necessary to consider the objective and principle of the SRS and experiences the effectiveness evaluation; furthermore, the research results from other fields should be appropriately used the evaluation index system with high accuracy would be obtained after several times consultations and feedback. The Table 6.1 illustrates the whole factors of the SRS.

The effectiveness evaluation system of SRS is the basis and core of the process of the assessment. The objective of evaluation is determined by whether or not single index is scientific, rational and practicable. Therefore, questionnaires were objectively and cautiously sent to MSAs, large shipping companies and pilot stations in the form of mail to ensure that it meets its requirements of the evaluation.

A total of 35 administrations and enterprises were surveyed, including 13 MSA, 10 large shipping companies and 10 pilot centers. The questionnaires were recovered well, with a total of 486 copies. Recovered questionnaires were collated and analyzed, in the form of a percentage of the importance of the index through the mathematical statistics. See Table 6.1 for details.

Table 6.1 Summary of Questionnaire Survey on the Importance of Indexes

Contents	**First stage index layer**	**Second stage index layer**	**Third stage index layer**	**Degree of importance**				
				extremely	**relatively**	**common**	**some**	**little**
Summary of questionnaire survey on the importance of indexes	reliability of support B1	reliability of equipment B11	Equipment operation	94.3/	6.7/	0	0	0
			plant maintenance	90.3/	6.7/	3/	0	0
		personnel reliability B12	manning	91.3/	8.7/	0	0	0
			personnel management	85.3/	10.7/	4/	0	0
		mechanism reliable B13	organizational normative	89.3/	9.7/	2/	0	0
			Completeness of institutional system	91.3/	6.7/	0	0	0
			incentive of performance management	89.9/	6.7/	0	0	0
	supervision effectiveness B2	response to report B21	response to Ship's dynamic information	94.3/	6.7/	0	0	0
			response to dangerous goods information	90.3/	6.7/	0	0	0

		response to the navigation safety information	91.3/	6.7/	0	0	0
	order control B22	order in the channel	88.3/	6.7/	0	0	0
		order in anchorage	87.3/	6.7/	0	0	0
		traffic control	91.3/	6.7/	0	0	0
	punishment of violations B23	investigation of ships' violations	94.3/	6.7/	0	0	0
		situation of reducing ship violations	90.3/	6.7/	0	0	0
highly efficient service B3	accuracy of information B31	accuracy of vessel-shore information	91.3/	6.7/	0	0	0
		accuracy of safety information	90.8/	6.7/	0	0	0
		Accuracy of maritime internal information	94.1/	6.7/	0	0	0
	timely warning B32	severe weather warning	94.2/	6.7/	0	0	0
		marine traffic environment warning	94.3/	6.7/	0	0	0
		dangerous warning	94.4/	6.7/	0	0	0
	highly efficient emergencies B33	efficient emergency response	94.5/	6.7/	0	0	0
		search and rescue information	94.6/	6.7/	0	0	0
		efficient obstacle wreck handling	94.7/	6.7/	0	0	0

	social recognition B4	navigation safety B41	Reducing the loss of traffic	94.8/	6.7/	0	0	0
			ensuring the safety of rescue	95/	6.7/	0	0	0
		navigation efficiency B42	the increase in traffic flow	91.3/	6.7/	0	0	0
			increase of utilizing anchorage	82.9/	6.1/	0	0	0
		social satisfaction B43	users' satisfaction	90.3/	6.7/	0	0	0
			reduction of oil pollution accidents from ships	88.3/	6.7/	0	0	0
			the decrease of oil spillage	87.6/	6.7/	0	0	0

Source: compiled by author

6.2.2 Connotation of evaluation index

The context of assessment should be considered about the actual situation of waters covered by SRS, It is due to the fact that there is in favor of improving the condition of operation of SRS, improving the supervision level of the SRS, enhancing the service capability of the maritime managers, protecting the marine environment and strengthening maritime navigation safety.

To ensure the high quality of the evaluation and reflecting the actually operational situation of the SRS, the context of the assessment would be divided into three index levels. In the next part, each index is explained in detail to provide the theoretical support for the analysis.

6.2.2.1 Reliability of support

The reliability of the operational system is the basis of SRS running normally and steadily, which includes equipment, personnel and mechanism.

(1) Reliability of equipment

The reliability of equipment involves in the hardware equipment, mainly consisting of CPU and operating terminal equipment, radar, VHF communication (VHF) devices, communication equipment (i.e., microwave), meteorological monitoring equipments, AIS equipment, CCTV monitoring equipment, diesel generator, voltage stabilizer and UPS. Obviously, the normal operating rate of the equipment is a very crucial index.

(2) Human reliability

Personnel reliability refers to whether operators on duty are dependable or not, including manning and the regulations they followed.

Those who are included in the assessment should contain running central management personnel, operators, equipment management and maintenance personnel. In this process, the staffing and management assessment can be carried out in accordance with the manning and management standards of VTS.

（3）mechanism Reliability

Operating mechanism and regime of the SRS are key points of the MR, which includes the standardization of reporting center, completeness of the institutional system and the incentive of performance management. This is because an effective management mechanism can urge that the operational center runs scientifically, reasonably, and can improve the ability and level of operational center

6.2.2.2 Supervision effectiveness

（1）response to report

The effectiveness of response to report means that the information transferred between ships and centers are responsed effectively. Three factors should be considered, such as ships'dynamic information, dangerous goods information and navigational environment, and they could be evaluated by processing flow, record files and information transfer.

（2）order control

Those orders mainly consist of orders in channel and anchorage, or under the traffic control. It also can be assessed by many elements (i.e. monitoring and control images, navigational warning, information broadcasting)

（3）punishment of violations

The effectiveness of punishing violations specifically means that the monitoring and punishing the violations are enforced to prevent the violation from happening again. And the whole evaluation can be judged from many aspects, such as the procedures of investigating violations, kinds and change of violations etc..

6.2.2.3 High efficient service

In this part, the accuracy of information, timely warning and the highly efficient emergencies related to the reporting system were used to assess system.

(1) Accuracy of information

Precise information is a guarantee of good communication between the operation center and ships, which includes the safety information service and the maritime internal information. In the meanwhile, it should be noted that the accuracy of information is established on the effective communication, delivery and records of information. That can be assessed by oral English ability, information acquisition, correspondence files and relevant records.

(2) Timely warning

In the shipping industry, early warning has taken many forms, mainly includes warning of the severe weather, marine traffic environment, ships and dangerous goods etc..

The work of evaluating this aspect can focus on the efficiency of collecting, transferring and processing information; feedback is also a very important part.

（3）Highly efficient emergencies

It is clearly expressed in Chapter V Article11 of SOLAS convention and SAR convention that one of main purposes of the ship reporting system is beneficial to the safety of life at sea; therefore, efficient emergency is a powerful support for reducing the loss of human life and protecting the marine environment. The emergency response to marine traffic accidents and the search and rescue information service are the main aspects of the assessment. For instance, the effective evaluation of search and rescue information service could be carried out by means of emergency accident express and information of emergency situations.

6.2.2.4 Social Recognition

It is mainly embodied in safety of human life, navigation safety and efficiency and marine environment protection in the reporting waters, in terms of social satisfaction.

(1) Navigation safety

The purpose of ensuring the navigation safety is to reduce the traffic accidents, to avoid close-quarters situation, and to protect the property and lives; therefore, the process of assessment can be carried out by comparing the annual accident rate before and after the enforcement of the ships reporting system, by comparing the loss of each accident, especially the loss of the rescue forces suffered.

(2) Navigation Efficiency

Navigable efficiency refers to the effect of the reporting system on the increase of the traffic flow, mainly including increasing the passage of the channel and improving the utilization rate of the anchorage which can be assessed by means of the increase of traffic ships flow including the passage of the channel and the rate of utilizing anchorage.

(3) Social Satisfaction

It has to note that users' satisfaction with the reporting system and the recognition of protecting marine environment are main indicators of SC.

On the one hand, based on the ture feelings of users, the performance, advantages and weaknesses, and even some problems of the service can be reflected in this index. Obviously, from the perspective of users to identify deficiencies through questionnaires and interviews, they can urge the operational center to improve its demand-oriented service. On the other hand, the effect of protecting marine environment would be indicated by the reduction of oil pollution accidents from ships and the oil spillage.

6.3 Determination of weight coefficient

6.3.1 Calculating weights

(1) Establish a hierarchical structure

A hierarchical structure would be built based on operational effectiveness evaluation index system of the established ship reporting system;

Target layer: performance evaluation system of SRS (B)

First stage index layer: reliability of support B1, supervision effectiveness B_2, highly efficient service B_3, social recognition B_4,

Second stage index layer: reliability of equipment B11, personnel reliability B12, mechanism reliable B13, response to report B21, order control B22, punishment of violations B23, the accuracy of information B31, timely warning B32, highly efficient emergencies B33, navigation safety B41, navigation efficiency B42, social satisfaction B43.

Third stage index layer: Equipment operation, plant maintenance; manning, personnel management etc.; Table 6.2 provides details.

(2) Constructing the judgment matrix of the first level index layer to the target layer

Since the determination of the index weight is critical to the accuracy of the evaluation results, according to the AHP method, 10 maritime and port experts, who have rich experience in maritime or port management, were invited to evaluate the index weights of three layers which mentioned above. Using expert surveys, the data, collected from questionnaires distributed to experts are analyzed for preliminary statistics on the evaluating the importance of index, The obtained data are processed by the geometric mean method, where,

it is assumed that there are m experts, so

$$a_{ij} = \sqrt[m]{\prod_{k=1}^{m} a_{ij}^{(k)}}$$

Applied to the calculation of weight and membership

The evaluation index weight processed are compared pairwise, to establish judging matrix B;

after that weight was calculated by the judging matrix- ω;

And , calculating the maximum eigenvalues of the matrix λ_{max} ;

Calculating the consistency test indicator CI.

(3) Constructing another judging matrix of second stage layer(the process of calculation is similar to the upper step)

(4) Constructing another judging matrix of third stage layer(the process of calculation is similar to the upper step) Judging matrix (B_{ij}, i=1,2,…,4; j=1,2,3); the weights ω_3, the maximum eigenvalues λ_{max}, and CI are calculated in the same method which is stated in the step2.

(5) Calculating the weights of the evaluating index system

Firstly, the judging matrix is stated by geometric mean method, based on the experts' evaluated data.

B	B1	B2	B3	B4
B1	1	5.56	2	7
B2	0.17	1	0.2	0.8
B3	0.5	5	1	3
B4	0.14	1.25	0.33	1

The method of maximum eigenvalues and eigenvector simplification algorithms is applied in the judging matrix to get the weights;

$$W = (0.2051, 0.2312, 0.3081, 0.2556)$$

maximum eigenvalues λ_{max}:

$$\lambda_{max} = \sum_{i=1}^{n} \frac{(A \cdot W)_i}{nW_i} = 4.1175$$

CR=CI/RI ：

$$CI = \frac{\lambda_{max} - n}{n-1} = \frac{4.1175-4}{4-1} = 0.0392$$

$RI = 0.9$, $CR = CI/RI = 0.0436 < 0.1$

The results proved that meet the consistency test

Therefore, the weights of the judging matrixes B_1-B_4 can be easily concluded in the similar way:

W_1 = (0.2013, 0.3373, 0.4614), *CR* = 0.0039;

W_2 = (0.4253, 0.3512, 0.2235), *CR* = 0.0043;

W_3 = (0.3518, 0.3272, 0.3210), *CR* = 0.0036;

W_4 = (0.4742, 0.3195, 0.2063), *CR* = 0.0037;

similarly, weights of the third index layer are calculated:

ω3 = (0.0248, 0.0165, 0.0311…0.0163) ，

Table 6.2 illustrates each weight of whole evaluating index system of SRS.

Table 6.2 weights of each layer in the effectiveness evaluation system

Target layer	First stage index layer	Weight ω1	Second stage index layer	weight ω2	Third stage index layer	Weight ω3	Consistency test
Operational effectiveness of SRS	reliability of support B1	0.2051	reliability of equipment B11	0.2013	Equipment operation	0.0248	Meet the requirements
					plant maintenance	0.0165	
			personnel reliability B12	0.3373	manning	0.0311	
					personnel management	0.0380	
			mechanism reliable B13	0.4614	organizational normative	0.0294	
					completeness of institutional system	0.0251	
					incentive of performance management	0.0401	
	supervision effectiveness B2	0.2312	response to report B21	0.4253	response to Ship's dynamic information	0.0474	Meet the requirements
					response to dangerous goods information	0.0206	

					response to the navigation safety information	0.0303	
			order control B22	0.3512	order in the channel	0.0365	
					order in anchorage	0.0244	
					traffic control	0.0202	
			punishment of violations B23	0.2235	investigation of ships' violations	0.0315	
					situation of reducing ship violations	0.0202	
	highly efficient service B3	0.3081	accuracy of information B31	0.3518	accuracy of vessel-shore information	0.0379	Meet the requirements
					accuracy of safety information	0.0379	
					accuracy of maritime internal information	0.0325	
			timely warning B32	0.3272	severe weather warning	0.0403	
					,marine traffic environment warning	0.0353	
					dangerous warning	0.0252	

			highly efficient emergencies B33	0.3210	efficient emergency response	0.0396	
					search and rescue information service	0.0297	
					efficient obstacle wreck handling	0.0297	
	social recognition B4	0.2556	navigation safety B41	0.4742	reducing the loss of traffic accidents	0.0727	Meet the requirements
					ensuring the safety of rescue	0.0485	
			navigation efficiency B42	0.3195	the increase in traffic \ flow	0.0489	
					the increase of utilizing anchorage	0.0327	
			social satisfaction B43	0.2063	users' satisfaction	0.0206	
					reduction of oil pollution accidents from ships	0.0158	
					the decrease of oil spillage	0.0163	

Source: Compiled by author

(6) Weights analysis

Firstly, in the Table6.2, the efficiency of service is an important factor in efficient operation of the ship reporting system, because efficient service accounts for over 30% of the total. The accuracy of ships' basic information and sailing plan from the reporting ships can guarantee that operators or officers provide ship dynamic surveillance to achieve safe, smooth and rapid transit through complex waters, to give a warning in bad weather or colliding risk. More importantly, it also can provide useful information in search and rescue operations for minimizing the loss (i.e. human life, property) and damage to the marine environment.

Secondly, social recognition is the most immediate response to the circumstance of the SRS. To be specific, if the rate of accidents decreases, mariners and managers can easily feel out.

Thirdly, efficient regulation is an important guarantee for the effective implementation of ship reporting systems. On the one hand, establishing communication with ships, entering the regulatory waters, is a prerequisite to achieve function of SRS, but also to achieve the real-time monitoring, traffic organization, information services, early warning alerts, search and rescue etc.. On the other hand, proper punishing the illegal activities is the need to ensure the dignity of the law and continuous operation of SRS, but education is obviously more effective than punishment.

At last, the software and hardware environment that supports the SRS accounts for a low proportion. With the development of technology and training, the ability of operators has been improved and the equipment of surveillance has also been innovated. On the other hand, the ability of users (officers on board ship) of the SRS, with the Large-scale, high-speed and automation of ships has been integrally improved, especially in the international ports. High-quality navigational equipment and high quality of the officer on watch also ensure the effective implementation of the SRS. Therefore, the proportion of the indicators is not very high. In addition, considering the importance of managing factors, the reliability of the mechanism accounts for the highest proportion, which is to ensure that “personnel is reliable”.

6.4 Determination of remark set

Based on the characteristics of the ship reporting system, 4 levels are recommended to indicate each index of layer, including excellent, good, medium, and poor level.

$$V = \{V_1, V_2, V_3, V_4\}$$

6.5 Determination of the fuzzy evaluation matrix

In the fuzzy evaluation, how to determine the various factors corresponding to the degree of membership of each rating level is the key to whether or not the entire evaluation can be carried out. In order to better determine the membership function of each factor, each index is comprehensively assessed through the formation of expert evaluation teams and the way to issue comment forms. (four scales: excellent, good, medium and poor) Finally, the fuzzy judgment matrix is formed by normalization. Table 6.3 illustrates the rating of evaluation indexes.

Table 6.3 Rating Form of evaluation index

Target layer	**First stage index layer**	**Second stage index layer**	**Third stage index layer**	**Rating**			
				excellent	good	medium	poor
Effectiveness Evaluation of SRS	reliability of support B1	reliability of equipmentB11	Equipment operation				
			plant maintenance				
		personnel reliability B12	manning				
			personnel management				
		mechanism reliable B13	organizational normative				
			completeness of institutional system				
			incentive of performance management				
	supervision effectivenes s B2	response to report B21	response to Ship's dynamic information				
			response to dangerous goods information				
			response to the navigation safety information				
		order control B22	order in the channel				
			order in anchorage				
			traffic control				
		punishment of violations B23	investigation of ships' violations				
			situation of reducing ship violations				

	highly efficient service B3	accuracy of information B31	accuracy of vessel-shore information				
			accuracy of safety information				
			accuracy of maritime internal information				
		timely warning B32	severe weather warning				
			marine traffic environment warning				
			dangerous warning				
		highly efficient emergencies B33	efficient emergency response				
			search and rescue information service				
			efficient obstacle wreck handling				
	social recognition B4	navigation safety B41	Reducing the loss of traffic accidents				
			ensuring the safety of rescue				
		navigation efficiency B42	the increase in traffic \ flow				
			the increase of utilizing anchorage				
		social satisfaction B43	users’ satisfaction				
			reduction of oil pollution accidents from ships				
			the decrease of oil spillage				

Source: compiled by author

Considering the complication of calculating the matrix, to simplify the process of calculation, the calculation in the weight and evaluation matrixes should be eliminated, and operational effectiveness of evaluation should be increased. Therefore, each factor is needed to be de-fuzzled.

6.6 Defuzzification

The result of fuzzy comprehensive evaluation is the fuzzy vector, which is the subordinate degree vector belonging to each judge. When determining the level of the object, it is necessary to make the fuzzy vector anti-fuzzification, also known as clarification.

In this paper, the center of gravity is used to anti-fuzzify, which is essentially a weighted average method.

$$M = \frac{\sum_{i=1}^{n} b(u_i)\ x\ u_i}{\sum_{i=1}^{n} b(u_i)}$$

In the upper formula, u_i is the corresponding value of each factor for remark set.

In order to obtain a precise evaluating result, the range of each remark set is listed in Table 6.4, and if you calculate the median of each group, that is. Finally, a synthetic evaluation value M is obtained, and according to this value, the final evaluation results is the reflected by grade remark, which is corresponding to M. (Refer to Table 6.4)

Table 6.4 Range of Each Remark Set

Evaluation grade	Evaluation value	Median
Excellent	100~90	95
Good	89~75	82
Medium	74~60	67
Poor	59~0	30

Source: Compiled by author

6.7 Assessment implementation

The first few sections of this chapter focus on the construction of a scientific and rational evaluation method for ship reporting system, while in the next part, specific steps of how to assess would be presented.

6.7.1 Preparation

Before organizing a panel of experts, it should be noted that the team consists of various domain experts, including people who work in MSA, MU, shipping companies, ships and port corporations. (i.e. captains, shipping managers,)

6.7.2 Assessment method

The operational effectiveness evaluation of SRS.

The subsets of the evaluation enumerated in the evaluation system (Figure6.2), are given the "excellent, good, medium, poor" ratings or remarks based on a variety of approaches, and then fill the Table 6.3

The specific evaluation method is

1. Review the relevant information, including file and audio records.

2. Inquiring about the personnel concerned

It is necessary to ask the personnel on duty, the maintenance personnel, users and supervisors for further collecting information.

3. Questionnaire

Related questionnaires are distributed to consult operational advice and requirements, and measures of improvement.

4. Holding an appraisal meeting
a. The assessed object self-reports.
b. The evaluation team internally discusses and exchange views about it .

5. Data Processing

The questionnaires were recovered for filling in Table 6.3, and the corresponding evaluation was weighted average calculated. For example, there are 11 experts in a group, who give 4 excellent, 5 good, and 2 medium comments to one factor; therefore, this factor's distribution of membership degree is [4,5,2,0]. Finally, the comprehensive evaluation of this factor is good. Ratings of 31 indexes can be obtained in this way.

The target of following step is to search the rating of the objective layer, which obtained by calculated weighting to each index.

6. Comprehensive Assessment

（1）assessment results

Based on the final assessment results, it has to raise deficiencies (i.e. improving the accuracy of information) and some suggestions for the evaluation results of target layer directly reflect the overall situation of the SRS. **In addition**, the evaluation results of large weighted index should also be noted for they may not be reflected in the final ratings.

Due to the limitation of the evaluation system, it has only 31 factors after three times analysis, which cannot cover the whole process and contents of SRS. Hence, the other evaluation methods (i.e. document consultation, questionnaires) should be utilized.

（2）Evaluation Report

At the end of the assessment, the evaluation report should be written and submitted, conforming to the prescribed format.

The report should reflect the overall operation of SRS, and point out the flaws and shortcomings in the process of reporting system. On the basis of analyzing its main causes, scientific and feasible amendments and rectification program would be proposed.

6.8 Chapter summary

This chapter begins with the meaning of comprehensive evaluation of SRS, focuses on the effectiveness evaluation of SRS. Based on the theoretical foundation and mathematical model of the chapter5, Index System was established by application of AHP. Scientific and rationality of indexes are demonstrated through questionnaire study; furthermore, the meanings of indexes are analyzed deeply.

The weight of each index was analyzed and determined by three steps (expert consultation - data processing - judgment matrix). Taking full account of the operability of the comprehensive evaluation, the evaluation results are subjected to anti-fuzzification, and a large number of mathematical calculations are reduced without affecting the evaluation results. Finally, some specific assessment procedures were presented to support the actual assessment work.

Although we do our best to make the evaluation method more scientific, more responsive to authenticity, due to the restriction of various factors, there are some limitations inevitably. Therefore, when making the conclusion of evaluation, we should pay more attention to the combination of other evaluation methods, to form a comprehensive fuzzy evaluation method, assisted with other evaluation methods.

CHAPTER 7
CONCLUSIONS AND EXPECTATION

7.1 Conclusions

This paper mainly focuses on two aspects of research about comparison and assessment of SRS. **At the beginning,** by comparing and analyzing the domestic and foreign SRSs, this paper probes into the application of the reporting system in China. In accordance with international conventions and relevant laws and regulations, the establishment and operation of the reporting system are further standardized through combining with practical working experience, which provide theoretical basis and technical support for the research of reporting system. **Additionally,** in order to find out and solve the problems existing in the establishment and operation of the reporting system, and to promote efficient and orderly operation of the reporting system, a comprehensive evaluation method of quantitative and qualitative analysis is used to assess the operational effectiveness of the reporting system. **Subsequently,** the establishment of the evaluation system is based on expert advice and questionnaire survey, index weights are determined by the method of AHP. **Finally,** through the anti-fuzzification process to simplify a large number of mathematical calculation work, which makes the evaluation results can reflect the operation realistically.

7.2 Limitations

On the one hand, due to the limitations of time and accessible resources, in the course of the survey, experts who received the questionnaires are Chinese, without international investigation, which could lead to limitations in analysis and evaluation.

On the other hand, as the factors affecting the reporting system are relatively broad, and the limited knowledge and ability of the author, there are inevitably some limitations about indexes or factors; Therefore, the comprehensiveness of indicators needs to be further improved, so as to achieve more satisfactory evaluation results.

7.3 Expectation

In the development trend of the new reporting system, the application of new platform would be reflected in the preparation and evaluation of the reporting system. Under the existing information platform and system, the networking and sharing functions of reporting system should be actively promoted; even the brand-new revolutionary application platform, paves the way for the improvement of the future reporting system, and provides an interface for the new application and unification.

REFERENCES

Bi, B. (2012). *Challenges Posed By the Large Scale of Container Ships*. Logistics Engineering and Management, 34, (1) 138-140.

Bo, H. U. (2014). *Three Power Objectives of China's Maritime Power*. Pacific Journal, 3, 009

Cai, X.M. (2011a). Application and development of AIS. *Mechanical and Electrical Equipment*, 1, 28-31.

Cao, G.D. (2015). The evaluation of ships' routeing system and reporting system on ship navigation environment. *Pearl River Water Transport* (10), 50-52.

Chen, J.F. & Yang, F.M. (2006). Introduction of Australian ship position reporting system AUSREP and the Great Barrier Reef ship position reporting system REEFREP. *Tianjin Navigation*, 2, 3-5

Costa, N. A., Lundh, M., & MacKinnon, S. N. (2018). Identifying Gaps, Opportunities and User Needs for Future E-navigation Technology and Information Exchange. In N. A. Stanton (Ed.), *Advances in Human Aspects of Transportation: Proceedings of the AHFE 2017 International Conference on Human Factors in Transportation, July 17−21, 2017, The Westin Bonaventure Hotel, Los Angeles, California, USA* (pp. 157-169). Cham: Springer International Publishing.

Wang, C., Zhang, X., Huang, W., & Zhang, H. (2017). E-navigation and its data standard analysis. *World Shipping*(01), 22-24.

Deng, X. & Li, J.M. et al (2012). Analysis of weight calculation method of analytic hierarchy process and its application. Mathematics in Practice and Theory. *42*(7), 93-100

Du, Z.P. (2010). China Long Range Identification and Tracking System. *Digital communication world,* 6, 44-47.

Fan, Z. Z., Zhao, Z. L., & Zhang, C. (2012). Research on the vessels' routeing system and ship reporting system off Cheng Shanjiao. *Advanced Materials Research,* *542-543*, 749-755.

Howard, B. (2004). The amver program: matching distress calls with the vessel(s) best suited to respond. *Coast Guard Journal of Safety at Sea Proceedings of the Marine Safety & Security Council, 61*.

IMO (2008) MSC 85/26/Add.1, Annex 20. *Strategy for The Development and Implementation of E-Navigation.* International Maritime Organization, London

IMO. (1994), *Guidelines and criteria for ship reporting systems* (MSC 43(64)). London: Author

IMO. (1997), General principles for ship reporting systems and ship reporting requirements, including guidelines for reporting incidents involving dangerous goods, harmful substances and/or marine pollutants(A.851(20)). London: Author

IMO. (1997). *Guidelines for Vessel Traffic Services* (A. 857(20)). London: Author.

IMO. (2000). *Adoption of Amendments to the International Convention for the Safety of Life at Sea, 1974,* as Amended (MSC.73). London: Author.

IMO. (2006). Adoption of Amendments to the International Convention for the Safety of Life at Sea, 1974, as Amended (MSC.202(81)). London: Author.

IMO. (2008b). *Revised Performance Standards and Functional Requirements for the Long-Range Identification and Tracking of Ships* (MSC.263(84)). London:Author.

IMO.(2008a). *Establishment of the International LRIT Data Exchange on a Interim Basis* (MSC.264(84)). London: Author.

Jacobsen, T. (2003). *A potential of reducing the risk of ship casualties by 50%. In:* Marine technology V.

Kang, D.B., & Quan, H.F. (2013). The feasibility analysis of IMO recognized Beidou Navigation system. *Satellite and network*, 12, 72-75.

Kim Tae-eun, Gausdal Anne Haugen. (2017). Leading for safety: A weighted safety leadership model in shipping. *Reliability Engineering and System Safety*. 165: 458-466

Lee, B., Choi, C. H., Choi, N. S., Kim, K. M., Kim, Y. H., & Choi, S. K., et al. (2006). *Distribution System Evaluation Algorithm Using Analytic Hierarchy Process*. *Advances in Applied Artificial Intelligence*. Springer Berlin Heidelberg.

Li, S.B. & Xiong, Q. Q. (2011). The structure of program evaluation system: model and analysis. *Studies in Dialectics of Nature*.

Li, Y, S, (2011), The impact of large container ships on ports. *Logistics Engineering and Management.* 33. (3) 23-24

Liu, P.Y. & Wu, M.D. (1998) Fuzzy theory and its application. University of defense science and technology press

Lv, Y.J. (2002). The sorting of fuzzy analytic hierarchy process based on fuzzy uniform matrix. Fuzzy systems and mathematics. *16*(2), 79-85

Ma, L., & College, T. M. (2013). Ship reporting system automation based on the gmdss communication technology. *Computer & Telecommunication*.

Macdonald, J. C. (1996). The australian reefrep system: a coastal vessel traffic information service and ship reporting system for the torres strait region and the inner route of the great barrier reef. *Journal of Navigation,49*(3), 299-308.

Nakazawa, T. (2016). *Impact of Maritime Innovation and Technology*. Unpublished lecture handout, World Maritime University, Dalian, China.

Nicole A. Costa, Monica Lundh, & Scott N. MacKinnon. (2017). Identifying gaps, opportunities and user needs for future e-navigation technology and information exchange.

Nie, X.L.& Dai, R. et al. (2013) Based on the fuzzy comprehensive evaluation, the study of the environmental hazard of the waterway.. *Journal of Dalian Maritime University,* 01, 27-30

Qiu, D. P., & Cui, Z. F. (2009). Study on ship reporting system. *Journal of Dalian Maritime University*.

Rahman, N. A. (2014). Multilateralism in the straits of Malacca and Singapore. *Marine Policy, 44*(1), 232-238.

Shapiro, A. J. (2009). Annual presentation of the amver awards. *Physica Status Solidi, 123*(2), 479-483.

China MSA. (2017). Report of China MSA Vessel-Traffic-Service Reorganization (Unpublished Report)

China MSA. (2012). Report of Chengshan Jiao Promontory Vessel-Traffic-Service (Unpublished Report)

China MSA. (2017). Procedures of establishing Ship reporting system (Unpublished Report)

Ship 's Large - scale Process. *Transportation Research Part D, 3 (2014):37–1*

Silber, G. K., Adams, J. D., Asaro, M. J., Cole, T. V., Moore, K. S., & Ward-Geiger, L. I., et al. (2015). The right whale mandatory ship reporting system: a retrospective. *Peerj, 3*(43), e866.

Stopford, M. (2009). *Maritime economics, 3rd edition.* London: Routledge.

International Convention on Maritime Search and Rescue, IMO, (1979).

International Convention for the Safety of Life At Sea, 1974, and its protocol of 1988, IMO, (2009).

Theologitis, D. (2009) *Deployment of e-Maritime systems, maritime transport and ports policy; maritime security. In: Joint Meeting at Short Sea Shipping and Motorways of the Sea*, Brussels, 8 July 2009

Trbojevic, V. M. (2006). Risk criteria for the shipping industry. *Quality & Reliability Engineering International*, *22*(1), 31–40.

UNCTAD. (2016). *Review of Maritime Transport.* New York and Geneva

USCG (2008)., AMVER partners rescue solo oceankite sailor.*Washington Letter of Oceanography*.

USCG. (2017). *Amver Ship Reporting SystemManual*. Retrieved June 6, 2017 from: http://www.amver.com/Content/Docs/Manuals/UscgCgMixAmverShipReportingManualEnglish.pdf

USCG. (2017). *History of the Amver System*. Retrieved June 6, 2017 from: http://www.amver.com/Home/AmverHistory

Vanderlaan, A. S. M., Corbett, J. J., Green, S. L., Callahan, J. A., Wang, C., & Kenney, R. D., et al. (2009). Probability and mitigation of vessel encounters with north atlantic right whales. *Endangered Species Research*, *6*(6), 273-285.

Wang, J. J. (2002). Observe the ship reporting system and consummate the safety management system. *World Shipping*. Vol.25

Wang, S., & Shi, L. (2003). American automated mutual-assistance vessel rescue system (amver). *World Shipping*. *26*(4), 11-12.

Weintrit, A. (2013) Prioritized main potential solutions for the e-Navigation concept. *TransNav Int. J. Mar. Navig. Saf. Sea Transp*. **7**(1), 27–38

Wu,H.L., & GAO, L.F. et al (2015) Development and application of beidou satellite navigation system. Navigation and positioning journal, *3*(2), 1-6.

Xiang, J. & Jin, Y.L. (2014). Analysis on the Factors and Restrictive Factors of

XIN, Y.H. (2008). *Performance evaluation of ships' routeing in Laotieshan watercours*e. Unpublished master's thesis, Dalian Maritime University, Dalian, China.

Yang, C. Z., Liu, H. Y., Zhan, X. C., & Zheng, H. P. (2010). Construction of Ship Safety Management Performance Evaluation System. *International Conference on Management and Service Science*, Vol.28, pp.1-7.

Yin, H.X. (2015). *Research on the influence of large-scale vessels put on carbon emiision of shipping industry.* Unpublished master's thesis, Shanghai Jiaotong University, Shanghai, China. pp.39-60

Zhang, S. & Bao, J.Z.(2007). Progress of Long-Range Identification and Tracking of Ships. China maritime, (2), 55-59

Zhu, L. (2014) Ship monitoring application and prospect of beidou satellite navigation system. China Water Transport *14*(7), 82-83.

Zhu, Y.Z. & Xue, R.Y. et al (2015). *Comparative study of ship reporting system and* *development strategy of ship reporting system in China*. China Maritime Safety, 8, 42-45

APPENDIX: A Ship Report Message Item List

Telegraphy	Telephone (alternative)	Function	Information required
Name of system (e.g. AMVER/ AUSREP/MAREP/ ECAREG/JASREP)	Name of system (e.g.AMVER/AUSREP/ MAREP/ECAREG/ JASREP)	System identifier	Ship reporting system or nearest appropriate coast radio station
	State in full	Type of report	Type of report:
SP			Sailing plan
PR			Position report
DR			Deviation report
FR			Final report
DG			Dangerous goods report
HS			Harmful substances report
MP			Marine pollutants report
Give in full			Any other report

A	Ship (alpha)	Ship	Name, call sign or ship station identity, and flag
B	Time (bravo)	Date and time of event	A 6-digit group giving day of month (first two digits), hours and minutes (last four digits). If other than UTC, state time zone used
C	Position (charlie)	Position	A 4-digit group giving latitude in degrees and minutes suffixed with N (north) or S (south) and a 5-digit group giving longitude in degrees and minutes suffixed with E (east) or W (west); or
D	Position (delta)	Position	True bearing (first 3 digits) and distance (state distance) in nautical miles from a clearly identified landmark (state landmark)
E	Course (echo)	True course	A 3-digit group
F	Speed (foxtrot)	Speed in knots and tenths of knots	A 3-digit group
G	Departed	Port of departure	Name of last port of call

	(golf)		
H	Entry (hotel)	Date, time and point of entry into system	Entry time expressed as in (B) and entry position expressed as in (C) or (D)
I	Destination and ETA (india)	Destination and expected time of arrival	Name of port and date and time group expressed as in (B)
J	Pilot (juliet)	Pilot	State whether a deep-sea or local pilot is on board
K	Exit (kilo)	Date, time and point of exit from system or arrival at the ship's destination	Exit time expressed as in (B) and exit position expressed as in (C) or (D)
L	Route (lima)	Route information	Intended track
M	Radiocommunications (mike)	Radiocommunications	State in full names of stations/frequencies guarded
N	Next report (november)	Time of next report	Date and time group expressed as in B
O	Draught (oscar)	Maximum present static draught in metres	4-digit group giving metres and centimetres
P	Cargo (papa)	Cargo on board	Cargo and brief details of any dangerous cargoes as well as

			harmful substances and gases that could endanger persons or the environment (See detailed reporting requirements)
Q	Defect, damage, deficiency, limitations (quebec)	Defects/damage/deficiencies/other limitations	Brief details of defects, damage, deficiencies or other limitations (See detailed reporting requirements)
R	Pollution/dangerous goods lost overboard (romeo)	Description of pollution or dangerous goods lost overboard	Brief details of type of pollution (oil, chemicals, etc.) or dangerous goods lost overboard; position expressed as in (C) or (D) (See detailed reporting requirements)
S	Weather (sierra)	Weather	Brief details of weather conditions and sea conditions prevailing
T	Agent (tango)	Ship's representative and/or owner	Details of name and particulars of ship's representative or owner or both for provision of information (See detailed reporting requirements)
U	Size and type (uniform)	Ship size and type	Details of length, breadth, tonnage, and type, etc., as required

V	Medic (victor)	Medical personnel	Doctor, physician's assistant, nurse, personnel without medical training
W	Persons (whiskey)	Total number of persons on board	State number
X	Remarks (x-ray)	Miscellaneous	Any other information - including, as appropriate, brief details of incident and of other ships involved either in incident, assistance or salvage (See detailed reporting requirements)
Y	Relay (yankee)	Request to relay report to another system e.g. AMVER, AUSREP, JASREP, MAREP, etc.	Content of report
Z	End of report (zulu)	End of report	No further information required

APPENDIX: B Requirements of Typical Reporting Systems

name	Participating ships	Reporting time, position, or requirements	Mode, channel	Accept the reporting agency	Reporting content	others
Dover Strait	300 gross tonnage and above	sailing Northeast bound abeam buoy Bassurelle	VHF13 It can also be reported through AIS	Gris Nez Traffic	The ship's name, call sign, A: IMO (MMSI) B:date and time, C or D: position or orientation distance, EFGI: heading, speed, port of departure, destination and ETA, O: draft, P: goods (dangerous goods quantity and category), R or Q: damage the defects, T:detailed information of dangerous goods, W: Number of Personnel on board, X :others(fuel quantity);	Crossing the channel report
		Sailing Southwest bound before passing the North Foreland Light line with the border of Belgian and French	VHF11 It can also be reported through AIS	Dover Coastguard		
Singapore Malacca Strait	300 total tonnage and above (including combination	Between the longitude of 100-40E and 104-23E in the Singapore Malacca	VHF channel 10.14.61.73.88	VTS centers in each partition	A: IMO (MMSI) B:date and time, C or D: position or orientation distance, E\F heading / speed, P goods	

	of towing and pushing), LOA 50 meters and above (including towing and pushing combination), carrying dangerous goods ships, all passenger ships;	Strait waters, the reporting area is divided into 9 zones			(dangerous goods should be quantity and category), Q or R defects, damage; Deviation report	
San Francisco	LOA 40 meters and above, vessels carrying more than 50 passengers, vessels engaged in commercial towage over 8 meters and above;	It is divided into 2 areas: 1 districts and 2 districts; The replacement of the VHF channel or the end of the VHF is subject to the consent of the VTS Center	Zone 1 VHF CH12 Zone 2 VHF CH 14	SAN FRANCISCO TRAFFIC	。 Report Type: 1) Pre-arrival report (24 hours in advance), 2) 15 minutes before entering VTS waters (A / C or D / H / I / L / P / Q / X, 3) Report point report: 15 4) Deviation report A / I / X, 5) End Report: A / C or D; 6) Additional Information Report: Vessel Defects, Maritime Accidents,	Ship-owners, carriers, charterers, captains and officers must be responsible for the operation of the vessel in this area at any time

					Pollution Accidents, Vulnerability, Any harm to the situation of navigation, adverse weather.	
HONG KONG	300 gross tonnage or over, entering Hong Kong waters must obtain permission VTS.	three areas: the eastern part of Hong Kong arrived, the Hong Kong West arrived in Hong Kong, Hong Kong port area	East Arrival Area VHF CH12 West arrival area VHF CH67 Port Area VHF CH14	MARDEP HONGKONG	1) Pre-arrival notification: 24 hours before entering, via TELEX, E-MAIL, FAX, webpage, report contents A / B / G / H / J / O / P / Q / T / U / W / X / Including purpose, clearance height, security information); 2) initial report: when entering the boundary line, report A/C/ via VHF12 or channel 67, and provide information if changes are made in the arrival notice 3) Report Point (CIP) Report: Report A / D and Report Point Name via Corresponding VHF	

					Channel 4) Report of the situation affecting the safety of navigation: the corresponding channel report A / X 5) Tanker Arrival Notice: 24 hours in advance by TELEX \ FAX \ EMAIL \ WEBSITE Report A / B / O / P / U / X (including keel placement date and projected berth) 6) arrival report: when anchoring or mooring, report A/B/D via the appropriate VHF channel 7) departure report VHF: prior to departure, the forecast will be reported by A/X underway report A/X, and the transfer report shall be completed by	

					A/B/D 8) pilotage: Pilot board must be reported 9) providing services: navigational warning and meteorological information broadcasting, 10) ships sailing through mawan fairway should also provide draft water, clearance height, ETA Tsing Ma Bridge (northbound), /Ha Pang (Nan Xiang); plans to ship alongside the KCCT pier should be provided: draft, headroom, ETA (KCCT)	
Yangtze River estuary	Passenger ships; other ships of 300 gross tonnage and above; ships of 300 gross tonnage	Reporting requirements: a) vessels reporting entry waters should be reported, leaving, not required to report.	Call channel and language: VHF, CH8, Mandarin or English Duty requirement:	The competent authority: Shanghai MSA. Received the reporting authority for Wusong ship	1)A:name,calling sign or MMSI, C or D: position, E: heading, F:speed, G&I: last and next port, Q: defects and restrictions (towing should report the length	

	voluntarily acceded to this reporting system	b) a ship equipped with the device and entered correctly AIS A, I and U type of information item and ship reporting is not required. C) An anchorage in the Yangtze River estuary should be reported 15 minutes in advance.	the ship should keep listening at VHF CH8.	traffic management center.	of towing and the name of towed object), U:LOA and GT 2) When a water traffic accident or pollution accident occurs in the reporting waters, the ship shall immediately report the type, time, place, damage or pollution of the accident and whether it is in need of assistance, in accordance with the requirements of the Administration, provide the other information.	
Chengshan Jiao Promontory	a)passenger ships; (b) all oil tankers 150 gross tonnage and above, all ships carrying hazardous cargo; (c) ships of	the VTS Centre (geographical position is 3723′.65N, 12242′.12E) as the center and 24 miles as the radius。 Language: Chinese or English. Reporting mode:	Work Channel: Ch 8 or Ch 9; Standby Channel: Channel: Channel 65; Call Channel: Channel 16 Chengshan	SHANGDONG MSA	A / C or D, position / E heading / F speed / G, port of departure / I port of destination (optional) / Q, defects and restrictions (towing should report the length of towing and the name of towed object) / U, LOA & GT	Measures to be taken by ships that fail to comply with reporting systems: appropriate measures consistent with international

	LOA more than 200m or draft more than 12m; (d) ships engaged in towing or pushing another ship, regardless of gross tonnage; and	Telegraphy and radiotelephony communications. high frequency (single sideband), telex (fax), e-mail or mobile phone.	VTS Center to maintain a 7-24hours duty.			law are adopted to ensure the implementation of reporting systems
Pearl River Estuary	Fishing ships: LOA 24 meters and above, cargo ships of 500 gross tonnage and above and passenger ships as amended by SOLAS 1974	North reporting line is 22 ° 20'00 "N / 113 °40'00" E with 22 °20'00 "N / 113 ° 52'08.8" E two-point connection; West reporting line is 22 ° 20'00 "N / 113 °40'00" E and 22 °00'16 "N / 113 ° 40'00" E two-point connection; Southeast reporting	Call Channel: VHF09 Working channels: VHF21, VHF01 Alternate channel: VHF64 Guangzhou ship traffic control center to maintain 7-24 hours duty.	GUANGDONG MSA。	A ship name, call sign and IMO number (if applicable) C or D position (latitude and longitude or position relative to landmark) E Direction F Speed G Port of Port I Destination Port Q defects and restrictions (tugboats should report their towing length and the name of the towed)	Measures to be taken by ships that fail to comply with reporting systems: appropriate measures consistent with international law are adopted to ensure the implementation of reporting

		line is the arc line taking Guishan pilot anchorage as center point (22 ° 07'54 "N / 113 ° 46'50" E) and with a radius 10 n miles			U total length and gross tonnage	systems