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WORLD MARITIME UNIVERSITY

Dalian, China

**APPLICATION RESEARCH ON THE
INTEGRATED NAVIGATION GUARANTEE
INFORMATION SERVICE PLATFORM IN
NORTH CHINA SEA AREA**

By

LI Jian-ping

China

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

MASTER OF SCIENCE

(MARITIME SAFETY AND ENVIRONMENTAL MANAGEMENT)

2017

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: **Application Research on the Integrated Navigation
Guarantee Information Service Platform in North
China Sea Area**

Degree: **MSc**

Navigational guarantee information service, which is very important to ensure the safety of maritime activities and the protection of the marine environment, includes three aspects: aids-to-navigation, marine hydrography and maritime communication. In recent years, the emerging e-Navigation concept has been further studied and promoted, and has guided the development of navigation guarantee work in different countries. In China, the north China area is composed of the Bohai sea and northern Yellow Sea. With the advancement of China 13th Five-year Plan, the needs for navigation guarantee information services increased continuously around all types of water activities. Fascinated by the improvement of onboard navigation equipment, the needs of navigators onboard with timely, comprehensive and accurate information services are becoming more and more urgent, which also provide us with ample opportunity to develop a new e-Navigation integration information service platform to expand the navigation guarantee contents and modes.

In this paper, literature research method and comparative analysis method are exploited to summarize the advanced research results and work experience of domestic and international maritime information service; survey research method is used to study the current situation of information service, the user's type, characteristics and needs of the north China sea area. In detail, user types mainly include ship navigators, government administrative departments, port management and construction units, academic research institution, and other relevant units or individuals; user's needs are

primarily focused on the comprehensiveness, accuracy, timeliness, diversity and customizability of navigation guarantee service information.

Towards the e-Navigation initiative, the development idea of building integrated navigation guarantee information service platform is innovatively proposed in this paper, as well as the overall goals and main components of the platform construction. Specially, the integrated navigation guarantee information service platform is designed into two functional logic layers: the communication support service logic layer and the information guarantee service layer. Facing the communication support service logic layer, we discussed how to build high bandwidth land and water communication networks, which could meet the requirements of daily information services and emergency response activities. Notably, the information guarantee service layer is divided into three parts: information content, information form and information carrier. Meanwhile, the information content mainly includes four categories: aids-to-navigation, marine hydrography, communication service and comprehensive assistance; information forms mainly include text, image, graphics, audio, video, games and so on; information carriers mainly include Internet class, radio class and special equipment class.

Furthermore, the direction for the construction and development of the information service activities in the future is pointed out, through the research on the construction goal and main function of the integrated navigation guarantee information service.

KEY WORDS: e-Navigation, navigation guarantee, communication, information service, user needs

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LIST OF ABBREVIATIONS

AIS	Automatic Identification System
ASM	Application Specific Messages
CORS	Continuously Operating Reference Stations
DGPS	Differential Global Positioning System
ECDIS	Electronic Chart Display and Information System
GMDSS	Global Maritime Distress and Safety System
GPS	Global Positioning System
HF	High Frequency
IALA	The International Association of Marine Aids to Navigation and Lighthouse Authorities
IHO	International Hydrographic Organization
IMO	International Maritime Organization
MF	Medium Frequency
MMSI	Maritime Mobile Service Identify
MSA	Maritime Safety Administration
MSI	Maritime safety information
MSP	Maritime Service Portfolio
NBDP	Narrow-band Direct Printing

UAV	Unmanned Aerial Vehicle
VDES	VHF Data Exchange System
VHF	Very High Frequency
VoIP	Voice over Internet Protocol
VR	Virtual Reality
WiMAX	Worldwide Interoperability for Microwave Access

CHAPTER 1

Introduction

1.1 Research Background

In China, navigational guarantee information service, which is an important to ensure the safety of maritime activities and the protection of the marine environment, includes three aspects: Aids-to-Navigation, marine hydrography and maritime communication. In recent years, e-Navigation initiative has been further studied and promoted, and a series of research achievements have been achieved, which have guided the development of navigation guarantee work in different countries. A series of e-Navigation test projects have been carried out at home and abroad, such as Monalisa, EfficienSea, to improve the safety of navigation. These test projects have accumulated valuable experience for improving the information service level of marine navigation support (Axel & Andre & Martin & Sibylle & Jin, 2016, pp. 1-13). The promotion of GMDSS modernization has also laid the foundation for enhancing the capability of waterborne communication service and supporting the development of e-Navigation.

The north China area is composed of the Bohai sea and northern Yellow Sea. With

the advancement of China 13th Five-year Plan, the national strategies, such as Marine Power, 21 Century Maritime Silk Road, are actively implementing. Marine activities, such as water transportation, marine oil and gas development, marine project construction, fishery farming, tourism and recreational activities, are increasing rapidly in north China sea area. The demand for navigation guarantee information services will continue to increase in all types of water activities. With the marine traffic flow and scale increasing continuously, marine projects and maritime activities will be expanded from coastal waters to high seas. All of these need the guarantee of navigation information, and will put forward more and higher requirements for navigation guarantee work.

With the continuous improvement of onboard navigation equipment, the needs of ship navigators for timely, comprehensive and accurate information services are becoming more and more urgent. In order to meet the needs of digital information service of marine users, service providers need to constantly expand the content and means of service, and promote the construction of e-Navigation information service platform in the north China sea area.

1.2 Introduction of Development Strategy at Home and Abroad

1.2.1 Introduction of e-Navigation Development Concept

Faced with the increasingly complex marine transport environment, in 2006, the International Maritime Organization (IMO) proposed e-Navigation initiative on the basis of the need for coordinated navigation and shore services. e-Navigation is the harmonised collection, integration, exchange, presentation and analysis of maritime information onboard and ashore by electronic means to enhance berth to berth navigation and related services, for safety and security at sea and protection of the

marine environment. The purpose e-Navigation is to meet current and future needs of users through the coordination of maritime navigation system and shore service support.

Under the guidance of IMO, the concept of e-Navigation was studied deeply in the relevant international organizations such as IALA and other countries concerned. At present, IALA has completed the investigation and analysis of user demand gap, established the e-Navigation technology architecture, studied the MSP of shore service, and put forward the construction framework of new generation communication system, which was based on VDES technology. The IHO S-100 common hydrographic model data standard laid the foundation for the development of e-Navigation. S-100 series standard provided a framework for the development of a new generation of electronic chart products and related digital navigation products, which could facilitate the interaction of various digital hydrographic information and marine geographic information service.

Since 2010, foreign maritime developed countries have successfully established several e-Navigation test projects, such as EfficienSea, Monalisha, ACCSEAS and so on. These test projects validated the research results of e-Navigation, and improved the comprehensive navigation guarantee services in their water areas.

With the successful operation of Monalisa, EfficienSea and other test projects, e-Navigation development has gradually entered the implementation stage, and provided comprehensive support services for the ship and shore at all levels of users, so as to further strengthen the safety of navigation, improve transport efficiency and protect the sea environment.

1.2.2 Introduction of Marine Development Strategy in China

Since the 18th CPC National Congress, with the Marine Power, 21 Century Maritime Silk Road and other national strategies have been put forward, China has increasingly attached importance to the management and control of the ocean. 13th Five-Year Plan pointed out that China's economic development will enter a New Normal, which will have a profound impact on the total volume of China's foreign trade and the overall layout of the shipping industry. For a long time, China's coastal cargo and ship traffic will maintain steady development, and water traffic pattern will change profoundly. Marine economic activities will become more extensive, such as port channel layout adjustment, water construction, water tourism, yacht activities, oil and gas development, aquaculture and fishing, marine engineering, etc.

The Ministry of Transport proposed, in the future, to co-ordinate coastal navigation layout and management, improve the scientific level of navigation management, strengthen the digital navigation construction, promote the information management level of Aids-to-Navigation, study the establishment of comprehensive navigation guarantee service platform, and improve the comprehensive management level of navigation service capabilities

China MSA conducted a comprehensive study and deployment of navigation guarantee work. The future construction objective is that by 2020, a comprehensive marine guarantee system should be basically completed, which includes comprehensive coverage, efficient management, high quality service and timely guarantee.

1.3 Study Objective, Content and Significance

1.3.1 Study Objective

Based on the implementation of the e-Navigation framework, according to the data resources and user requirements of north China sea, the service provider determines the main content, form and carrier of information service of the navigation guarantee service platform, and study the construction of integrated water and land communication network, so as to point out the direction for carrying out specific construction work.

1.3.2 Main Contents of the Study

Under the guidance of e-Navigation concept of maritime development, the main contents of the study include:

- 1) Carry out user survey, collect the user's information service needs.
- 2) Study the integrated communication network which is based on air, space, sea and land station, determine the main construction contents and support functions of the communication infrastructure.
- 3) Study the main content, form and carrier of information service, and provide reference for the construction of one-stop navigation guarantee information service platform, which include wide service range, comprehensive service content, diversified service forms and carriers.

1.3.3 Study Significance

Carrying out the study of navigation guarantee service platform can help the researcher analyze the user's needs, and put forward suggestions for the development of the information service. The results of the study will help to clarify the development thought and content of the information service in north China sea areas, and to promote

the steady improvement of navigation guarantee information service based on e-Navigation concept.

1.4 Study Method

Based on this subject's characteristic and content, this paper used literature research method, survey research method and comparative analysis method. The comprehensive application of these methods ensures that the study result is more valuable based on actual data and user needs.

1.4.1 Literature Research Method

By collecting relevant documents and materials, this paper traces and arranges the latest achievements in the study of e-Navigation and information service capability both at home and abroad. On the basis of mastering the current research situation, the paper selected the topic and area of the study.

1.4.2 Survey Research Method

This paper analyzed the data resources of the north China sea area, and investigated the different types of users and needs. Through the questionnaire, the author collected the user's needs and the problems existing in the current service.

1.4.3 Comparative Analysis Method

This paper compares the international and domestic e-Navigation projects with the current situation of navigation guarantee information service in North China sea. And it analyzed the advanced experience of the e-Navigation test projects from the aspects of service content, data resources, and so on.

CHAPTER 2

Introduction of Research Achievements and Enlightenment of Test Projects

In recent years, with the development of science and implementation of e-Navigation concept, scholars at home and abroad have carried out a great deal of study on the aspect of improving maritime communication, expanding communication means and enriching service contents. The construction and operation of several e-Navigation test projects actively have served the safe navigation of the ships and the protected the marine environment. At the same time, abundant experience in navigation information service lays a solid foundation for future theoretical research and project implementation.

2.1 Theoretical Review

In order to promote navigation information service and meet the demand of different users, scholars have done a lot of research and discussed from different angles and aspects. These have put forward a great deal of constructive views on the development of e-Navigation.

Nie Qianzhen pointed out that the service provider should develop integrated navigation support service products based on user demand, and promote the

construction of intelligent integrated navigation support system (Nie, 2016, pp. 22-25). Wang Hexun put forward that the communication service of navigation guarantee should focus on four aspects: new field, new technology, new service and new way. Through the opening of public platforms and collaborative application development, the establishment of one-stop navigation information service platform could provide special data services, such as fisheries, marine resources and so on (Wang, 2016, pp. 10-11). Li Shubing pointed out that in order to carry out e-Navigation construction, service provider should research the needs of users, analyze the demand gap, and propose solutions (Li, 2015, pp. 21-26). Yang Liang summarized the technologies used in water communication in China, introduced the advantages and disadvantages of existing communication methods, and looked forward to the new generation of communication technologies and application fields (Yang, 2012, pp. 49-52). Zhang Tiejun carried on the discussion on the development idea of the electronic chart under the e-Navigation concept, and proposed that service providers should strengthen the information fusion and the standardization construction (Zhang & Zhu, 2012, pp. 46-49). Xu Yan introduced the IHO S-100 standard system, and proposed to establish MSP to improve the service level of navigation guarantee service (Xu, 2017, pp. 55-57). Cui Kuntao introduced the main functions of the Beidou navigation satellite, and proposed that the Beidou satellite was an important choice for expanding the means of maritime information service (Cui & Sun & Xia, 2015, pp. 15-17). Zhang Xinggu discussed the function, structure and key technology of integrated navigation aid information service system, and proposed the construction thinking and methods (Zhang & Zhou, 2013, pp. 15-18). Min Shiquan elaborated the object, thinking, plan and function of the space-ground integration network, and provided the reference for the construction of land and water communication network (Min, 2016, pp. 27-37). Wang Wenge analyzed the characteristics of radio and satellite communication technology, and proposed that the service provider can make full use of the existing

satellite technology to improve the level of maritime communication (Wang, 2016, pp. 47-52). By analyzing the problems of the current GMDSS MSI service and the features and functions of NAVDAT system, Cui Kuntao pointed out that NAVDAT is an important supplement to enhance development of e-Navigation (Cui & Sun & Xia, 2015, pp. 52-53). Yang Yi proposed to make full use of existing physical Aids-to-Navigation resources to promote the construction of sea-based communication platform, and expand the way of building maritime communication link (Yang, 2016, pp. 46-48). Zhang Guiqing considered that the Beidou navigation satellite system, which could achieve positioning of the ship in distress rapidly, could effectively improve the efficiency of distress search and rescue (Zhang & Li, 2016, pp. 49-50). Gong Haifang analyzed the limitation of current AIS, introduced the technical features of VDES and ASM, and put forward integrated function of AIS+ASM data stream, which provided reference experience for solving the problem of maritime navigation communication (Gong, 2016, pp. 53-55). Wang Yulin proposed the establishment of MSP list, studied the MSP product specification, and then defined the MSP system development roadmap and implementation methods (Wang, 2014, pp. 54-56).

2.2 Introduction of test projects and relevant enlightenment

2.2.1 Introduction of e-Navigation test projects

2.2.1.1 MONALISA test project

MONALISA 1.0¹ mainly provided users with four aspect services: dynamic and proactive route planning, electronic verification of officer's certificates, ensuring the quality of hydrographic data on shipping routes and areas, and global sharing of

¹IALA web site gives further information on courses:
<http://www.iala-aism.org/products-projects/e-navigation/test-bedsprojects/monalisa-1/>

maritime data. MONALISA 2.0² used Standard Operating Procedures (SOP) and standard protocol to support Sea Traffic Management, which promoted the construction of STM and information management. The implementation of the MONALISA 2.0 project has improved the level of management, coordination and interoperability between onshore and offshore safety management. At the same time, MONALISA 2.0 has helped streamline administrative procedures, reduce crew workload, and improved the operational safety of ship navigation.

2.2.1.2 EfficienSea³ Test Project

EfficienSea test project developed a prototype application system, which can provide users with marine safety information (MSI) display, hydrological and meteorological information display on the route, route data exchange and suggestion. The system can display the received MSI directly on the electronic chart to avoid missing important information, thereby reducing the crew burden and work pressure. The system only showed the hydrological and meteorological information of the concerned area of the crew, thus avoiding the overload of information. When finding out the problem of the intended route of the ship, the system can provide the suggestion route for the ship, and enhance the safety of the ship navigation.

2.2.1.3 ACCSEAS⁴ Test Project

ACCSEAS mainly studied the demand of ship traffic in the North Sea Region, and analyzed the density of ships and the degree of traffic congestion. ACCSEAS system

² IALA web site gives further information on courses:
<http://www.iala-aism.org/products-projects/e-navigation/test-bedsprojects/monalisa-2-0/>

³ IALA web site gives further information on courses:
<http://www.iala-aism.org/products-projects/e-navigation/test-bedsprojects/efficiensea/>

⁴ IALA web site gives further information on courses:
<http://www.iala-aism.org/products-projects/e-navigation/test-bedsprojects/accseas/>

can provide multi-source positioning, intended route sharing, MSI and NM services, dynamic No-Go Area services, SAR tools and VTS data exchange services. Multi-source positioning means that when the satellite positioning system data is unreliable, the location data from other positioning sources can be selected to meet the positioning requirements. Intended route sharing means that in the busy water areas, the ship's navigator can grasp the intended route of other ships to avoid collision. MSI and NM services are provided in a variety of ways to ship users. The SAR tool can provide search and rescue information, calculate search areas and specify search methods automatically. The VTS data exchange service expands the scope of surveillance by the maritime authority.

2.2.1.4 The Maritime Cloud⁵

The Maritime Cloud project has powerful data processing and user management functions, which could provide identity registration, service registration, maritime messaging services and other functional support. The Maritime Cloud is an important part of the EfficienSea2 projects, which is backed by the European Union. For secure and reliable identity information, the Maritime Cloud provides a single login to all services. It can be used for registering, discovering and using all relevant e-Navigation and e-Maritime services. Through the Maritime Cloud, users could intelligently exchange information between communication systems connected to the cloud.

2.2.1.5 Yangshan Port Test Project

Yangshan Port test project can provide high precision differential location service for

⁵ Maritime Cloud web site gives further information on courses:
<http://maritimecloud.net/>

users, and provide information service on Aids-to-Navigation, hydrological monitoring and nautical chart effectively. The command and scheduling platform can display various kinds of ship's information by accessing the AIS. The project's cloud data maintenance center visits the marine meteorological service system in the East China Sea, and shows the real-time weather information of the existing meteorological stations. Using the pilot dispatching data of Shanghai pilot station, the visual display of ship pilotage scheduling is realized (Wang, 2016, pp. 82-84).

2.2.2 The Inspiration of e-Navigation Test Projects

Through the analysis of e-Navigation test projects, their characteristics and advantages can bring a lot of inspiration to the construction of navigation guarantee information service in the north China sea area.

2.2.2.1 Communication Link Unobstructed

MONALISA provided a good communication link for the electronic verification of officer's certificates. ACCSEAS provided users with multi-source position signals to achieve multiple coverage of the signal.

2.2.2.2 The Types of Data Resource are Various

ACCSEAS and Yangshan Port projects have achieved real-time acquisition of multiple types of data, which covered marine navigation and related sea areas. Maritime Cloud has provided support services for computing, storage and data processing for several e- navigation test projects, such as ACCSEAS and EfficienSea.

2.2.2.3 High Degree of Data Sharing

MONALISA, Yangshan Port and other projects have achieved a variety of integration of marine data resources. Relying on the Maritime Cloud, MONALISA, ACCSEAS and other projects have achieved the data resources sharing of ship intended route.

2.2.2.4 Precision of Information Service

EfficienSea combined the MSI with the electronic chart system and displayed the information visually. At the same time, in order to avoid information overload, EfficienSea only showed regional hydrological and meteorological information concerned by crew members, and effectively reduced the burden on the crew.

2.2.2.5 Wide Range of Service Objects

Yangshan Port and other projects provided information services to a variety of users, such as pilotage station, harbor bureau, fishing boat and ocean bureau.

2.2.2.6 Abundant Auxiliary Decision-making Function

The SAR tool of the ACCSEAS project can provide fast and reliable search and rescue information, calculate search area, assign tasks and specify search methods, so as to improve the efficiency of search and rescue. EfficienSea can provide users with suggestion ship route and safety decision-making.

CHAPTER 3

Present Situation of Marine Guarantee Information Service in North China Sea Area

3.1 Introduction of the North China Sea Area

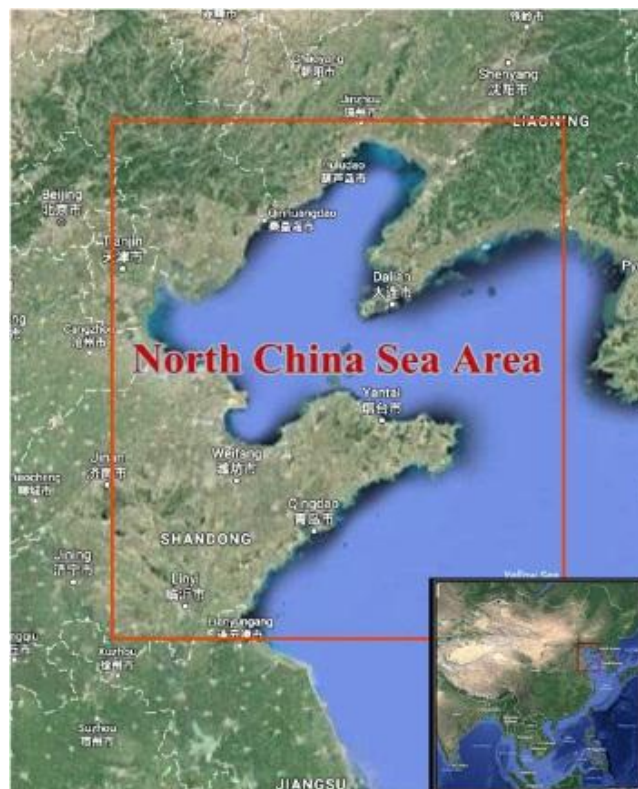


Figure 1- Location Map of North China Sea Area

Source: Compiled by the author.

As shown in the Figure 1, the north China area is composed of the Bohai sea and northern Yellow Sea, which is from Yalu River Estuary, Liaoning Province, to Lanshan, Shandong Province. The coastline is 5967 kilometers. There are many islands, reefs and shoals in the water area, and the hydrology and meteorology are complex and changeable.

The tides along the Bohai sea coast are mostly irregular semidiurnal tides. The tides along the northern coast of the Yellow Sea belong to regular semidiurnal tides. In winter, the coastal areas of northern and western Bohai sea have severe ice conditions, while most coastal waters have less ice. The ice period was mostly from November to March of next year, and the ice thickness was generally 10cm- 40cm. In 2010, the Bohai sea and northern Yellow Sea suffered the worst ice storm in 30 years. Maximum floe ice edge of Liaodong Bay reached more than 70 miles.

3.2 Overview of Major Ports and Waterways

The north China sea area locates in the economic circle around the Bohai sea. There are many ports in this area. There are 9 large ports and 4 important regional ports. By the end of 2016, the number of ports with annual throughput of more than 100 million tons was 9, including Tianjin, Tangshan, Qingdao, Dalian, Rizhao, Yingkou, Huanghua and Qinhuangdao Port. In addition to Qinhuangdao port, other ports showed a growth status. Details are shown in Table 1.

Table 1- List of Port Throughput in China in 2016

Ranking	Port name	Throughput in 2016 (million tons)	Rise rate	North China Sea Area
1	Zhoushan Port	917.77	3.30%	
2	Shanghai Port	700.05	-2.40%	

Ranking	Port name	Throughput in 2016 (million tons)	Rise rate	North China Sea Area
3	Suzhou Port	573.76	6.30%	
4	Tianjin Port	550.00	1.80%	√
5	Guangzhou Port	521.81	4.30%	
6	Tangshan Port	515.80	4.70%	√
7	Qingdao Port	500.83	3.40%	√
8	Dalian Port	428.73	3.40%	√
9	Rizhao Port	350.62	4.00%	√
10	Yingkou Port	347.02	2.50%	√
11	Yantai Port	265.36	5.50%	√
12	Zhanjiang Port	255.17	15.80%	
13	Huanghua Port	245.11	47.10%	√
14	Nantong Port	223.30	2.30%	
15	Nanjing Port	216.92	1.10%	
16	Shenzhen Port	214.17	-1.30%	
17	Xiamen Port	209.04	-0.60%	
18	Beibuwan Port	204.19	-0.30%	
19	Lianyungang Port	202.08	2.30%	
20	Qinhuangdao Port	186.03	-26.50%	√

Source: <https://sanwen8.cn/p/7cetZIK.html>

Owing to the existence of many large ports, the ship volume is very large and the navigation environment is very complicated in this area. In Figure 1, it can be seen that a number of major waterways cross and merge.

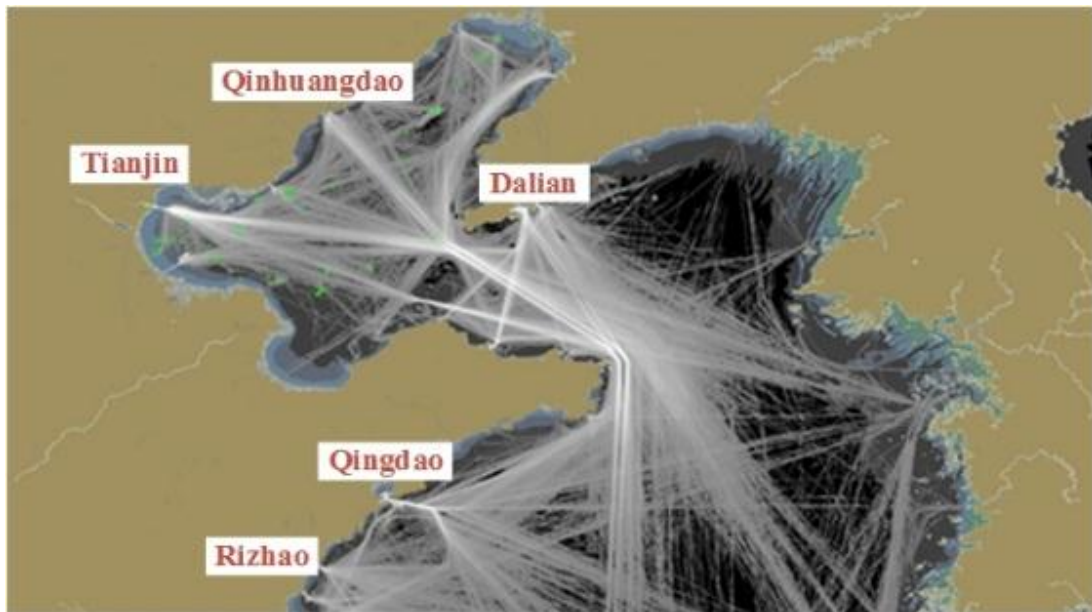


Figure 2 - Trajectory of Ship Sailing in North China Sea Area

Source: Compiled by the author.

3.3 Status of Marine Guarantee Service

In recent years, the maritime administration and navigation guarantee departments in the north China sea areas have actively strengthened the integrated information service, further enriched the marine support service products, and expanded service means and channels. The navigation guarantee department has officially developed information service website to provide navigational guarantee information, which included navigation warning, notice to mariners, chart correction, weather forecast, cloud chart, etc. In order to provide users with efficient information service and expand the types of information service, the service provider has launched the Tianjin Aids-to-Navigation and Tianjin Radio public account, Beihai Voice broadcast and AIS base system to carry out maritime information service, through the methods of WeChat, micro-blog, VHF and Beidou satellites.

3.3.1 Construction of Information Service Communication Network

In the field of terrestrial cable communication network, the maritime security department set up a comprehensive information network, including 42 maritime service information network links, 37 Internet links and 58 private network links. These communication links assume the task of transmitting land information. The details are shown in Table 2.

Table 2 - Navigation Guarantee Land Communication Link Statistics

Unit: PCS

Link class		Optical fiber	100M bandwidth Link	10M bandwidth Link	4M bandwidth Link	2M bandwidth Link
Maritime network	First level	3	0	1	6	0
	Second level	2	0	0	9	21
Private network	AIS	0	0	0	0	43
	Others	0	0	0	1	14
Internet		0	3	22	5	7
Total		5	3	23	21	85

Source: Compiled by the author.

In the maritime wireless communication network, in north China sea area, 4 intermediate frequency coast station achieved the basic coverage of coastal waters 150 nautical miles, 2 high frequency coast station realized the communication coverage of all the coastal waters and most of the world's waters.

3.3.2 Current Service System

The maritime administration and navigation guarantee departments actively promoted the construction and application of information service systems, and all kinds of systems have played a significant role in navigation information services. The main application systems are shown in Table 3.

Table 3 - Main Software System of Navigation Guarantee Service

No.	System name
1	Basic database system of coastal Aids-to-Navigation in China
2	Comprehensive information management platform for Aids-to-Navigation in north China sea area
3	Telemetry and telecontrol system for Aids-to-Navigation
4	Automatic Identification System
5	Port environment monitoring system
6	AIS base station automation service on duty and management service system
7	Comprehensive management system of Qingdao navigation aids
8	Aids-to-Navigation patrol information management system
9	Hydrological information collection and management system
10	Chart public management system
11	Dynamic management system of survey ship
12	Display platform of electronic chart service in north China sea area
13	Maritime communication management information system
14	Automatic transfer reporting system
15	Digital selective calling system
16	Tianjin port meteorological information service platform
17	Beidou satellites emergency command broadcast system
18	Navigation guarantee center website in north China sea area

Source: Compiled by the author.

3.3.3 Navigation Guarantee Cloud Data Center and Data Resources

At present, Navigation Guarantee Cloud data center is under construction, and already has a certain amount of data storage and processing capabilities. Navigation Guarantee Cloud contains three-layer service: IaaS, PaaS and SaaS. Relying on the strong ability of cloud computing, storage and data processing, Navigation Guarantee Cloud can meet the needs of data cleaning, data exchange and so on. It provides a powerful support for the construction of navigation guarantee information service capability. At present, there are 8 main types of marine navigation data resources. These data are provided to users through a variety of means, such as web sites, WeChat, AIS, and so on. The specific circumstances of marine protection data resources are shown in Table 4:

Table 4 - Navigation Guarantee Data Resource Statistics

No.	Category	Content	Electronic data quantity	Current service method
1	Aids-to-navigation	Basic information of Aids-to-navigation	5.75G	Website, paper publics
2		Dynamic information of Aids-to-navigation	18.9G	Internal data sharing
3	Hydrology	Speed	8G	Data resource service
4		Direction		Data resource service
5		Temperature		Data resource service
6		Water level		Data resource service
7	Meteorology	Temperature	1.2G	Website, WeChat, radio broadcast
8		Humidity		Website, WeChat, radio broadcast
9		Wind speed		Website, WeChat, radio broadcast
10		Wind direction		Website, WeChat, radio broadcast
11		Visibility		Website, WeChat, radio broadcast

12	Ship	Basic information of ship	4T	AIS
13		Dynamic information of ship	4T	AIS
14	MSI	Meteorological information	9G	Website, WeChat, radio broadcast
15		Navigational warning		Website, WeChat, radio broadcast
16		Ice condition information		Website, WeChat, radio broadcast
17		Distress information		Radio broadcast
18	CCTV	Video data	45G	Resource sharing
19	Tide	Tide prediction	1.2G	Resource sharing
20	Electronic chart	Electronic chart data	308G	Resource sharing

Source: Compiled by the author.

CHAPTER 4

Service Need Investigation and Gap Analysis

Clearing the object, demand and existing problems of navigation guarantee information service is the premise of carrying out information service construction. With the implementation of China's Marine Power and Shipping Power strategy, the production activities at sea have increased. The former navigation guarantee information service has been unable to meet the needs of different users and activities. The investigation of the users' field, characteristics and needs should be carried out so as to find out the service problems and gaps, and determine the concrete direction and focus for the next step to carry out the construction of marine support information service.

4.1 Service Objects

The service objects are the administrative counterparts of navigation guarantee information service, and the final beneficiaries and users of navigation guarantee information. The purpose of navigation guarantee is to meet the needs of users in different fields and levels to carry out their management and production other activities, and effectively ensure the safety and orderly development of various marine activities (Daniel & Jennifer & Lisa, 2016, pp. 25-30). Meeting the needs of all kinds of

service objects is the starting point and end point of navigation guarantee information service. Only when the field, category and work characteristics of the service object are defined, the information service work can be carried out more targeted. The main service objects in north China sea include the following categories:

4.1.1 Ship Navigators

Ship navigators are the primary object of navigation guarantee information service. The degree of information acquisition by ship navigators is directly related to the safety of ship navigation. According to the accurate and real-time information, ship navigators determine the ship navigation schedule, such as speed, direction and route (Kwang, 2016, pp. 15-20). Such users mainly include merchant, passenger, fishing and tourist ships' navigator.

4.1.2 Government Administrative Departments

With the aid of navigation guarantee information, the government departments are mainly engaged in vessel traffic service, emergency search and rescue, accident investigation, marine exploration, marine environment protection, policy planning activities and so on. The relevant government departments include the China Maritime Safety Administration, China Rescue and Salvage, Maritime Court, State Ocean Administration, the Fishery Bureau, the Customs, Exit and Entry Inspection Station, Port Police Station, local traffic management administration and Bureau of Urban Planning.

4.1.3 Port Management and Construction Units

Port management and construction units mainly carry out the construction of ports and waterways, promote the development of port infrastructure, and enhance the level of

port construction, so as to meet the needs of the ship's safe navigation. The port management and construction units mainly include pilotage stations, dock construction units, waterway construction and maintenance units, and water construction units.

4.1.4 Academic Research Institution

The academic research institutes mainly use the service information of navigation guarantee to carry out research and teaching work on the aspect of port construction, water channel design, economic development, scientific investigation, marine environmental protection and technical application. Such institutions mainly include Maritime Universities, Waterborne Transport Research Institutes, Marine Resource and Environment Research Institutes, maritime colleges and universities, and culture heritage research units.

4.1.5 Other Relevant Units or Individuals

Navigation guarantee information service can help these users to master the dynamics of ships, crews and goods timely. The information demand of these users is scattered, and most of them do not need to carry out deep processing. Such users mainly include the crew's family members, banks, insurance companies, cargo agents, cargo owners, ship owners, shipping agents, commodity trading centers, etc.

4.2 User Needs Research

Navigation guarantee information service should be guided by user needs. To understand the needs of users, comprehensive and detailed research is needed. Through interviews, surveys and questionnaires, the author has obtained the actual needs of relevant units and staff in the sea related areas. The survey has interviewed

73 users in different fields, issued questionnaires through the Internet 148 copies, and recovered 112 valid questionnaires. The questionnaire format is shown in Appendix A. The content of user needs, from interviews, surveys and questionnaires, are summarized in Table 5:

Table 5 - User needs statistics

Service category	User needs	Existing problems	User expectations
ECDIS	Large and medium scale ECDIS should meet the requirements of ship navigation in north China sea area.	ECDIS updating is delayed for about 2 weeks. Different ECDIS, produced by different manufacturers, have different data standards, display formats and using ways, which brings inconvenience to the crew.	Rich ECDIS of different scales. ECDIS update uses a variety of convenient means.
Paper nautical charts and publications	Convenient to purchase all kinds of nautical charts and publications.	The paper nautical charts and publications not convenient to purchase.	Provide web online order for paper nautical charts and publications. Provide digital nautical products.
Chart correction	Receiving Correction Notice in time.	The Correction Notices are issued in less ways and has poor timeliness.	Enrich methods to release Correction Notice and improve real-time performance. The updating of paper chart can be printed and pasted directly, and the workload of crew can be reduced.
Navigation plan	Timely obtain all kinds of information and materials, to meet the needs of navigation plans.	The timeliness of the data is poor. Many kinds of information such as Aids-to-Navigation, hydrology, tides and weather, cannot be supplied at one time.	The means of information service are further enriched, and the timeliness of information is further improved. Provide a one-stop, packaged route planning information service for ships.

Service category	User needs	Existing problems	User expectations
Pilotage plan	Timely obtain all kinds of information and materials, to meet the needs of pilotage plans.	The timeliness of the data is poor. Many kinds of information such as Aids-to-Navigation, hydrology, tides and weather, cannot be supplied at one time.	Enhance the real-time performance of notice to mariners.
Navigation safety	Perceiving the traffic situation of the surrounding area in real time.	The acquisition methods of vessel traffic situation information are less. Lack of real-time information about weather, hydrology and tides.	Provide comprehensive and real-time information services. Increasing more form and means of information services.
MSI Service	Provide comprehensive MSI for marine users.	The scope of service is not large. MSI real-time information needs to be improved. There is not much service means.	Expanding the scope and means of MSI service. Improving the real-time of information service.
Aids-to-Navigation information service	Acquire all kinds of navigation information in real time, including high-precision position, AIS, Aids-to-Navigation and virtual Aids-to-Navigation information.	There are not many means to acquire Aids-to-Navigation information.	Increase the means of information service. Set up Aids-to-Navigation scientifically to improve navigation efficiency.
Notices to mariners	Timely obtain notice to mariners, navigation warning, etc.	The broadcast frequency of notice to mariners is low.	Provide more real-time and abundant information service of notice to mariners.
Integrated navigation information broadcasting	Obtain news, regulations, entertainment, information, etc.	Beihai Voice service frequency is less, the program time is short, and the broadcast coverage is low.	Increase the frequency of integrated navigation information broadcasting. Provide a comprehensive range of coverage, higher timeliness, more comprehensive marine broadcasting.

Service category	User needs	Existing problems	User expectations
Scientific research	The marine research agency needs detailed submarine sweeping data of a certain water area. Meteorological and hydrological research users need relevant hydrological and meteorological historical data.	Incomplete data type. Incomplete data coverage.	Provide comprehensive and detailed historical data. Data format is standardized.
Data resource exchange	Some marine related departments need data resources of navigation guarantee.	Data format is not uniform. Incomplete data resources.	Uniform data standard. Data coverage is wider.
Ship-shore communications	The ship terminal can exchange data with the shore side through digital or voice communication.	The means of communication are limited. The communication link bandwidth is low.	Increase communication means Increase link bandwidth and coverage.
Operation training	Launch electronic chart operation training. Carry out simulation training.	Few training and limited means. The actual data of the simulation equipment is limited.	Provide more convenient training through the Internet and new technologies. Increase the actual data of some ports for crew simulation training.

Source: Compiled by the author.

4.3 Analysis of the Gap of Navigation Guarantee Information Service

According to the analysis and review on the research results, it shows that many aspects of navigation guarantee information service, including coverage, timeliness, display forms, service means and data standard, cannot fully meet the user's expectations. At present, the problems and gaps existing in the navigation guarantee information service in north China sea areas are mainly reflected in the following

aspects:

4.3.1 The Bandwidth of the Maritime Communication Link is Not High

At present, the means of maritime information service are mainly based on MF/HF/VHF of coastal radio station. The bandwidth, coverage and signal stability of the link are difficult to fully meet the increasing demand of marine users. The broadband, high-speed, safe, stable and wide covering communication links, which can carry pictures, videos and other multimedia files, become the demand of the users. Navigation guarantee service departments need to actively use new technologies such as NAVDAT, VDES, and new equipment, such as VSAT and new generation maritime satellite, to enhance the communication link bandwidth, coverage and stability. Finally, space-ground integrated broadband communication networks are built to support the growing demand for information services and other maritime communications.

4.3.2 The Forms of Information Service are Less

Current users prefer the simple and intuitive ways of information display, which can reduce the search, query, analysis and understanding of the work process, and can enhance work efficiency and accuracy. The current online information services in north China sea mainly focus on text format, as well as a small amount of picture and audio information services, and lack of visual, attractive display forms such as video, animation, games and so on. At the same time, the service forms of a kind of navigation guarantee information are less, and lacks of various forms of classification and display to meet the needs of different users and different needs.

4.3.3 The Scope of the Service Object is Relatively Single

In recent years, more attention has been paid to the maritime support information service in the northern sea areas. In recent years, the information service of navigation guarantee in the north China sea area has been mainly focused on merchant ship users. Due to the lack of attention to users in other areas, such as offshore resources development, drilling platforms and submarine cables, navigation information services are difficult to meet the needs of diversity maritime activities. Next, navigation guarantee information services need to expand the scope of services and increase the means of service.

4.3.4 Real-Time Data Services are Less

At present, the real-time data of the information service, including navigation aids, hydrology, tide, meteorology, etc., is limited and the means of service are few. There is a large gap between the user expectation and the real information service. In order to improve the service level of real-time information, the service provider should support the data service by relying on the data exchange, convergence and switching capabilities of the Navigation Guarantee Cloud data center.

4.3.5 Lack of Personalized and Customized Information Services

The current information service mainly provides universality and broadcast services, which push all kinds of navigational guarantee information to all users through related means. After receiving the information, users need to analyze and use it by themselves. Different users expect to get customized service information according to different levels and action requirements, so that the analysis process can be avoided, and the work efficiency and accuracy can be improved. Information service providers should use big data and cloud computing technology to carry out the data mining for the user needs, such as information analysis, decision making, risk warning

and crisis forecast.

CHAPTER 5

Construction Way of Integrated Navigation Guarantee Information Service Platform

Navigation guarantee information service platform is a logical layer between data resource layer and user layer. As shown in Figure 3, on the one hand, the service platform is supported by Navigation Guarantee Cloud in the aspect of cloud computing, storage and processing of data resources; on the other hand, various forms and carrier service platform through the user has to provide the needed information content. The service platform provides information to users through many kinds of forms and carriers. Therefore, the navigation guarantee information service platform should strengthen the research of construction idea and concrete function to point out the direction for the future work. Finally, the purpose of improving service quality, reducing user work intensity, ensuring ship navigation safety and protecting marine environment is realized.

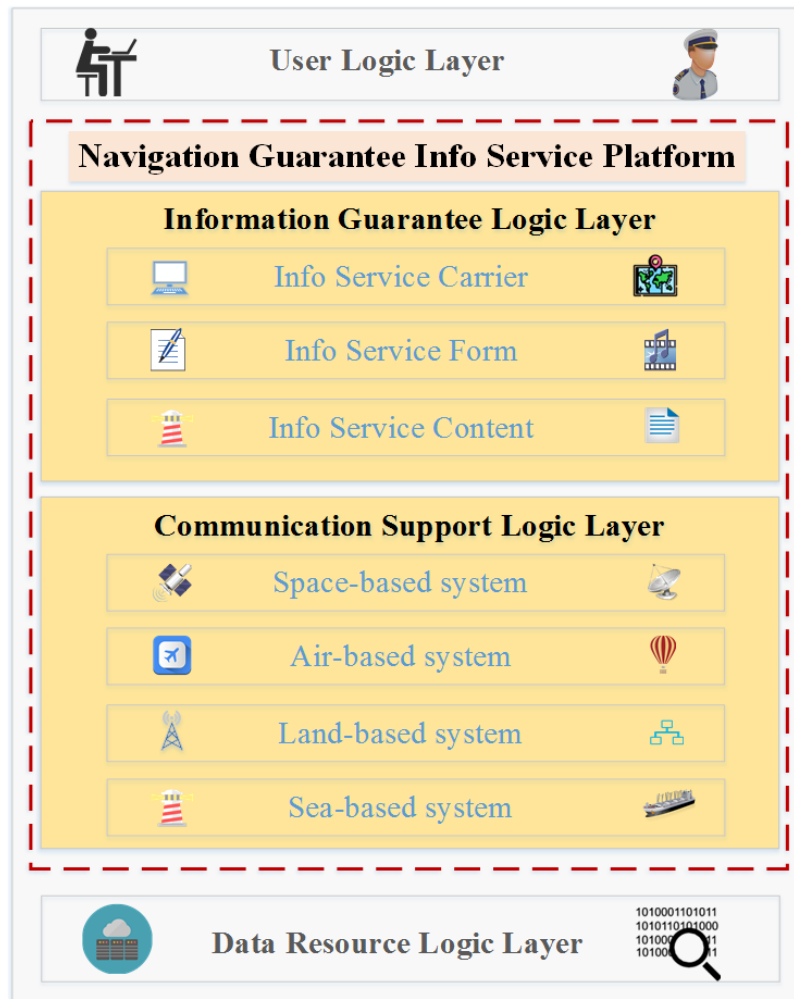


Figure 3 - Logical Structure Chart of Integrated Navigation Guarantee Information Service Platform

Source: Compiled by the author.

5.1 Construction Goal and Main Function of Service Platform

5.1.1 Construction Goal of Service Platform

The overall goal of navigation guarantee information service platform in north China sea area is that with user's demand as the guide, relying on the Navigation Guarantee

Cloud function support, by 2020, the navigation guarantee information service contents are comprehensive and accurate, the service forms are visual and diverse, and the service carriers are diversified and convenient. As shown in Figure 4, the platform can meet the multi-level, differentiated, one-stop information service needs of the user, and realize the benign interaction between service providers and users, so as to ensure the safety of ship navigation and protect the marine environment.

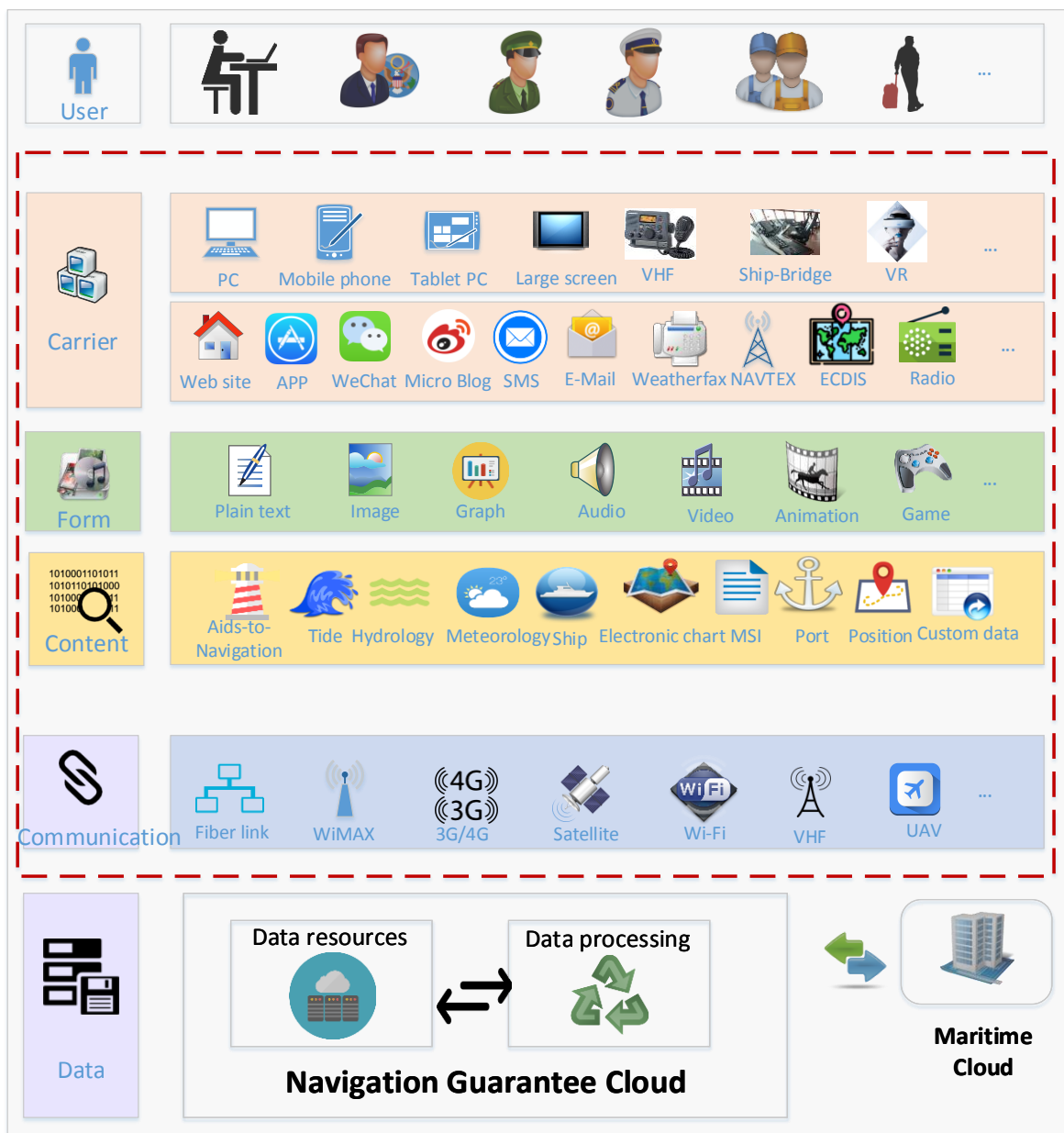


Figure 4 - Function Structure Chart of Integrated Navigation Guarantee Information Service Platform

Source: Compiled by the author.

5.1.2 Main Function of Service Platform

The main function of service platform is to provide abundant navigation support information to users in different areas and different levels. Service platform is a collection of navigation support information, various transmission channels, different display forms and application carriers. According to the user's individual needs, the platform's service content can be flexibly assembled and packaged.

The service platform consists of two parts: communication support service and information support service.

- 1) The communication support service mainly refers to the construction of integrated land water broadband communication link, which provides the necessary technical support and guarantee for various types of information services.
- 2) Information security services mainly refer to the specific content and data provided for users, including service content, service form and service carrier.

The information service platform should have the following characteristics:

- 1) Service information should be accurate and reliable to avoid the accidents which caused by wrong or inaccuracies service information.
- 2) Service information should be real-time, so as to ensure the safety of ship

navigation.

- 3) The content of the service should be comprehensive, including variety areas information and historical data, to meet the diverse needs of users.
- 4) Service content should be flexible, which could follow the changes of user needs, and improve service content timely.
- 5) The format of service information should be standardized and unified, so as to ensure the rigor of information service.
- 6) According to the characteristics of different requirements, various forms, such as text, picture and video, are used to provide information services to users.
- 7) The information service should be user-friendly and ensure that the data is visually displayed and easy to use.
- 8) Service carrier should be diversified, with various advanced technologies and software and hardware platform to meet the needs of users to obtain information services.
- 9) Service carriers should be safe and reliable to prevent data from being disturbed or artificially destroyed during transmission.
- 10) The platform can provide one-stop services.

5.2 Communication Support Services

The communication support service logic layer is between the data resource logic layer and the information assurance service layer. As shown in Figure 5, this layer is the

bridge and link between the data resource and the user, which undertakes the construction of communication link and the transmission of service data. With the help of electronic information means, various kinds of navigation service windows have extended the service information and data resources to the user side, and have shortened the distance between the service provider and the user. At the same time, users also use the communication link to realize the convenient and fast feedback of demand and suggestion, so as to prompt the service provider to adjust the content and form of service in time.



Figure 5- Logical Structure Chart of Communication Support Services

Source: Compiled by the author.

At present, land communication network technology is mature. The wire links, such as cyber, and wireless network, such as 3G,4G and Wi-Fi, are abundant in resources and have strong data transmission capacity, which can meet the needs of navigation support to provide various types of data transmission and information services, e.g. text, picture, video. However, the development of water communication links is relatively slow. Many problems and deficiencies, such as relatively backward technology, poor hardware and software resources, have become the bottleneck which restricted the development of high quality and level services on the water. It is imperative to promote the construction of water communication link network (Yang, 2017, pp. 13-14).

5.2.1 Construction Way of Communication Support Service System

The service provider should make full use of GMDSS and other modern communication technology and the means to achieve the smooth communication of various heterogeneous networks and to achieve multiple coverage and seamless connection in different sea areas. Finally, high bandwidth land and water communication networks are being built to meet the needs of daily information services and emergency response activities. The framework is shown in Figure 6.

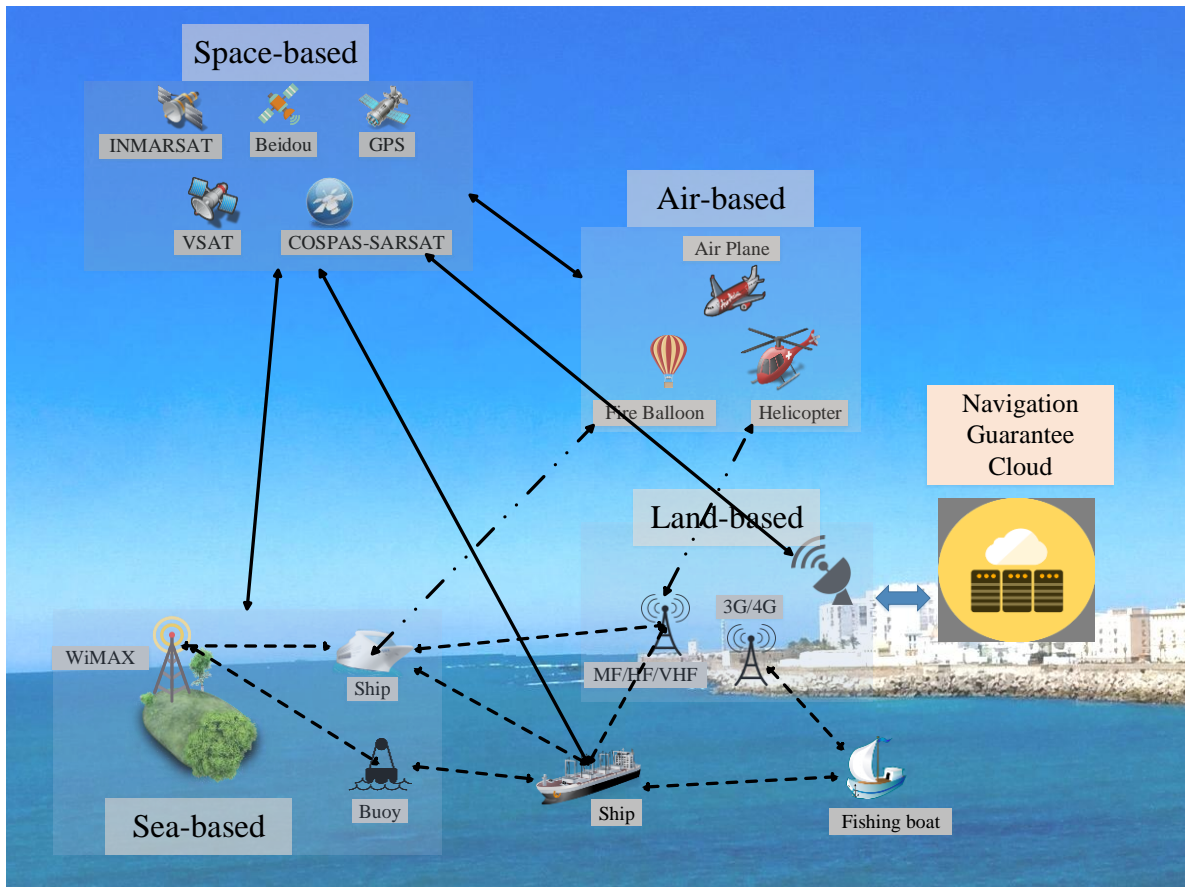


Figure 6 - Integrated Communication Structure Chart

Source: Compiled by the author.

5.2.2 Components of a Communication Support Service

Communication network mainly includes four parts: space-based, air-based, land-based and sea-based. Through the interconnection of four parts, the data can be transmitted safely and conveniently between heterogeneous networks.

5.2.2.1 Space-based System

The space-based system is composed of different types of communication satellites, and has the characteristics of wide coverage, high bandwidth, safety and stability.

This system can provide broadband communication services for high seas and solve the bottleneck coverage of land-based wireless systems.

At present, the available satellites include Inmarsat-C/B/F, COSPAS-SARSAT, Iridium, IPSTAR, VSAT, and Beidou navigation satellites. All satellites can cover the north China sea area (Zeng & Zhang & Wang & Luo, 2016, pp. 15-17). Except the Beidou navigation satellite only has the short message transceiver function, other satellites can meet the transmission needs of multimedia files (Qian & Li & Zhao & Yang, 2015, pp. 23-27).

In the near future, with the completion of GlobalXpress, Inmarsat-5 System will be able to provide higher bandwidth data services (Chen & Shao & Chen & Liu & Li, 2015, pp. 8-10).

5.2.2.2 Air-based System

The space-based system mainly uses the relay base stations, carried by unmanned aerial vehicle (UAV), drones, helicopters, airships or hot air balloons, to provide a convenient broadband link service for some water areas (Michael, & Sun-Bae, 2016, pp. 8-12). At present, due to the power supply system and construction costs, the air-based system mainly serves temporary special actions or large-scale search and rescue emergency tasks, not as a daily application.

In the future, Google Loon can be used to provide more convenient and inexpensive air base station services to meet the needs of daily services (Ji, 2013, pp. 5-7).

5.2.2.3 Land-based System

Land-based systems mainly include ground based radio base stations(MF/HF/VHF) in

GMDSS and 3G, 4G, Wi-Fi, WiMAX and other communication means (Zhang, 2016, pp. 20-28). Except MF and HF, other communication means have relatively short transmission distances and can only meet the coverage needs in harbor or certain areas. However, the communication means, including 3G, 4G, Wi-Fi and WiMAX, have the advantages of high bandwidth and convenient access. Emergency communication vehicles can quickly set up regional communication networks to meet the needs of emergency and special activities, and can be used as backup means for daily links (Ding & Feng & Jiang, 2017, pp. 57-61).

Next, with the maturity and application of new technologies such as NAVDAT, VDES and 5G, the service providers can further enrich the network means and enhance the link bandwidth (Xiong, 2016, pp. 35-40).

5.2.2.4 Sea-based System

Sea-based systems mainly use fixed or mobile communication facilities at sea to build communication network coverage surrounding waters. Sea-based communication stations connect with submarine cable or satellite, and use 3G, 4G, Wi-Fi, WiMAX and other technologies to provide link service. At the same time, ships can use Mesh and other technical means to build ad hoc networks, and further expand the coverage of the water networks.

5.2.3 Network Coverage and Communication Capability

Through the construction and improvement of each base station, the service provider could build a multi-covered water communication link network. Based on the data processing and the network core exchange function of Navigation Guarantee Cloud, the interconnection and interworking of different base stations and heterogeneous

networks can be realized. Finally, connected with the high-speed broadband network of land, an integrated land and water communication network is constructed, and the "last mile" problem of data transmission can be effectively solved. The network coverage and transmission capability are as follows:

- 1) Using 3G, 4G and Wi-Fi networks to provide multimedia data communication services for land, docks and coastal waters (within 5 km).
- 2) Using VHF links to provide data communication services for offshore areas (within 30 nautical miles).
- 3) Using MF links to provide information services for offshore 200 nautical miles.
- 4) Using HF links to provide information services for offshore 1000 kilometers.
- 5) Using satellite base station to provide multimedia data communication service for the whole sea area.
- 6) Using WiMAX network to build offshore hotspots based on offshore platforms, lighthouses and large buoys, so as to achieve regional broadband network coverage.
- 7) Using the multi hop structure of wireless Mesh technology to realize the self-assembling network among ships, and expand the coverage area of the network at sea.
- 8) Using the aircraft, UAVs, airships, hot air balloons, mobile base stations on the vehicle to build an emergency communication network to meet the needs of

emergency or special operations.

5.3 Information Guarantee Services

The information guarantee service layer is a user oriented logic layer. According to the different requirements of users, data resources, which are transmitted by communication support logic layer, are presented in different categories, forms and carriers, so as to meet the needs of users to obtain information, assist work and decision-making. As shown in Figure 7, the logic layer of navigation guarantee information service mainly includes three parts: service content, service form and service carrier.

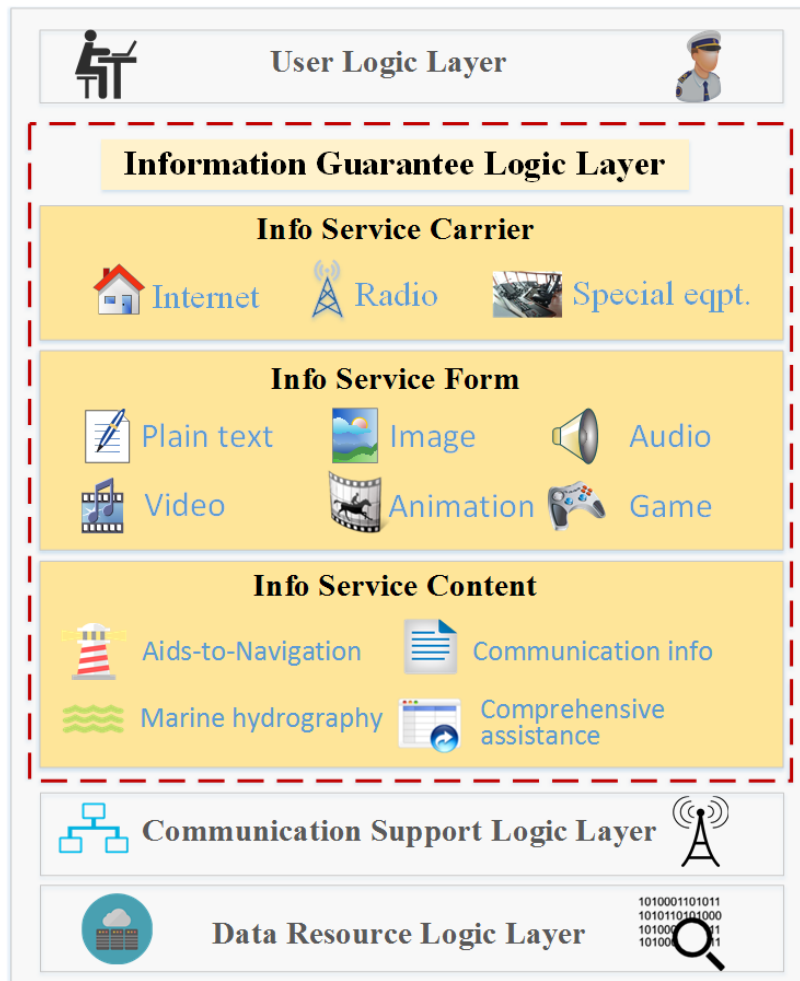


Figure 7 - Logical Structure Chart of Information Guarantee Services
 Source: Compiled by the author.

5.3.1 Information Service Content

The contents of navigation information service mainly refer to the specific data and information which are displayed or provided directly to the users. For example, the position coordinates of a navigation aid, the real-time temperature of a certain water area, and so on. The scope of information services is determined by the responsibility of information service providers and the needs of users. According to the characteristics and requirements of different users, the information service provider

sorts, classifies and refines the navigation support data, and determines the content of the information service. As shown in Figure 8, the information service contents mainly include four categories: Aids-to-Navigation, marine hydrography, communication service and comprehensive assistance.

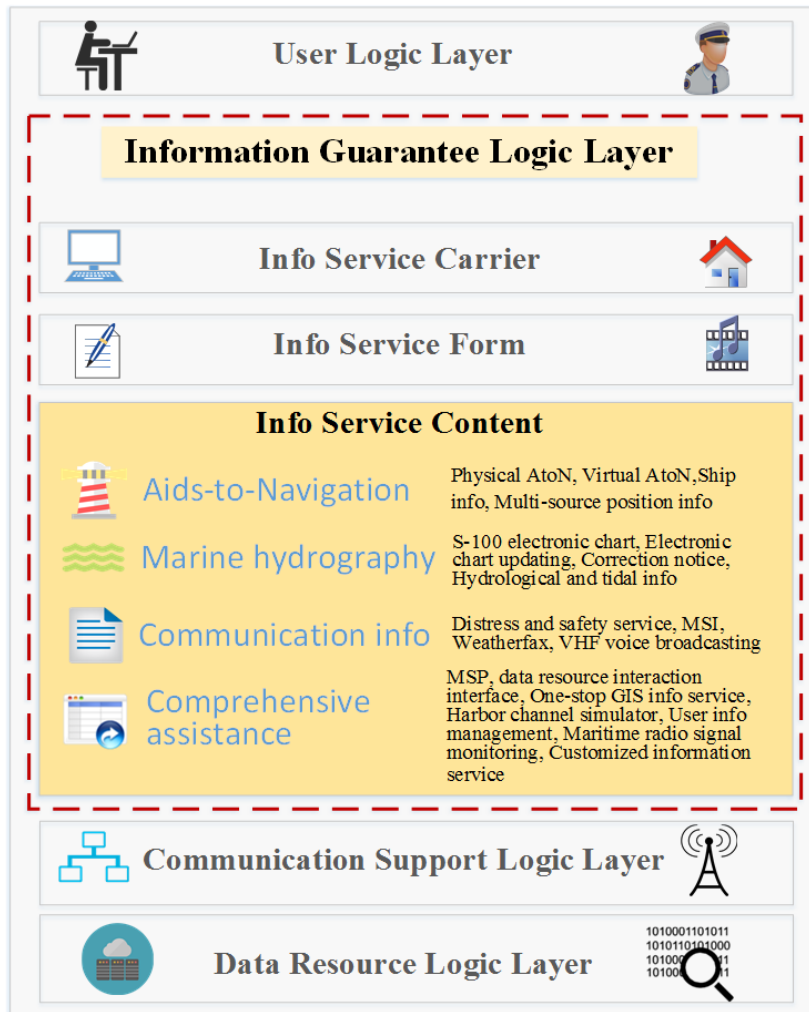


Figure 8 - Logical Structure Chart of Information Service Content

Source: Compiled by the author.

5.3.1.1 Aids-to-Navigation

The navigation aids information service mainly includes navigation mark information, ship information, differential location service information, and so on. The purpose of this service is to provide precise positioning and navigation services for ship users, and to provide ship's real-time data, such as position, speed or heading, for government administration, enterprises and institutions. This is an important means for the ship to determine its position, clear the channel and direction of travel, control the traffic situation of surrounding vessels and prevent collisions.

1. Aids-to-Navigation Information

1) Physical Aids-to-Navigation Information

The traditional physical navigation aids include lighthouse, light beacon, pile, buoy, and so on. The location and classification information of navigation aids are important reference to help ship navigators to locate their positions and clear navigate direction (Zhu & Axel & Yuan & Wen, 2016, pp. 103-108). According to the e-navigation initiative, users, such as ship navigator, can obtain relevant navigation aids information conveniently through modern electronic techniques and means. For example, through stand-alone version or web version, electronic chart, or application software inquiries.

2) Virtual Aids-to-Navigation Information

Compared with the traditional physical Aids-to-Navigation, the virtual Aids-to-Navigation based on AIS has the characteristics of easy setting, cancellation, low cost, and so on. Virtual Aids-to-Navigation has significant advantages in emergency response actions and special areas, where it is not easy to set physical Aids-to-Navigation, such as sea reef, coastal shoal or tourist island route. Using virtual Aids-

to-Navigation as an important auxiliary means of traditional counterparts fully conforms to the e- navigation initiative (Wang, 2017, pp. 11-12). With the port traffic becomes more and more intensive, promoting the virtual Aids-to-Navigation scientific and reasonable setting can more easily cause the navigator's vigilance in the ECDIS, and effectively reduce the incidence of navigation accidents (Ryszard & Tadeusz, 2010, pp.58-63).

2.Ship Information

1) Ship Static Information

Ship static information includes the ship name, MMSI, flag, type, length, and so on. AIS provides convenient search function to facilitate the shipping and traffic management departments to access relevant information. Relying on the Internet and other electronic information technology, service providers should aim at different areas and levels of users to develop more various means of service.

2) Ship Dynamic Information

The ship dynamic information refers to the ship's real-time position, speed, destination port, and so on. It can provide information reference for ship navigators and vessel traffic service departments to carry out ship navigation and water traffic management. AIS can help ship navigators to learn about the surrounding conditions, especially in harsh or poor visibility weather situation, to enhance the safety of ship navigation and avoid the occurrence of ship collision and grounding accidents. At the same time, it provides clear and accurate information service to the traffic administration to for vessel traffic management (Michele & Andrea & Domenico, 2016, pp. 45-60).

3.Multi-source Position Information

Accurate location information is the necessary data for ship navigation, Aids-to-Navigation setting, water and underwater construction, etc. The high-precision location information service covering the whole sea area has gradually become the new demand for maritime activities. The coverage of multiple radio position signals, such as DGPS, DBD and Beidou CORS, can further ensure the safety of water activities in the key water areas and important navigation points. In the north China sea, service providers should ensure that users can receive the DGPS, DBD and Beidou CORS broadcast signals from the nearest base station, e.g. Dalian, Yingkou, Qinhuangdao, Tianjin, Yantai and Qingdao, to determine their position.

5.3.1.2 Marine Hydrography

Based on e-navigation framework, the marine hydrography services mainly include electronic charts, correction notices, hydrography and tide information services and other navigational materials. Marine hydrography information, which is the auxiliary guide for marine navigation safety, can provide several kinds of geographic and navigation information to users, such as coastal topography, submarine topography, hydrology, Aids-to-Navigation and navigational obstructions. The details are as follows:

1.S-100 Electronic Chart Product

The electronic chart product based on S-100 series standards is the development trend in the future. S-100 general electronic chart platform, as well as the specific waters of large scale electronic chart, can meet the requirements of marine oil and gas development, submarine cables and marine construction activities.

2.Electronic Chart Updating Service

Because of the changing of navigation elements, such as the coastline, harbor channel, water depth, Aids-to-Navigation and navigation obstacle, and the electronic chart data of the ship can be updated in time to ensure the safety of the ship's navigation (Oliver & Martin & Dennis & Holger & Axel, 2016, pp. 116-119). The timely updating of the ship's electronic chart data can guarantee the safety of navigation. With the development of satellite, radio and other communication technologies, it has become an urgent demand for ship users to promote the update frequency of electronic chart data. It is an important task of navigation information service to realize real-time data of electronic chart (Li, 2014, pp. 8-9).

3. Correction Notice Online Service

Notification information, including notice to mariners and correction notice, can be released via multiple electronic communications means. Marine users can obtain and query relevant information and historical data in a timely manner, and understand the surrounding environment to enhance the safety of ship navigation (Chen & Shiotani & Sasa, 2015, pp. 257-260).

4. Hydrological and Tidal Information Service

1) Hydrological Information Service

Service providers use various means to provide online hydrological forecasts and real-time hydrological information, which could provide convenient information services for marine users. At the same time, the service enables users to subscribe to hydrological information of a small water area, which could reduce redundant information and users' workload.

2) Tidal Information Service

Online tide forecasts and real-time tide information, which are provided by various means, can help marine users scientifically establish navigational plans and reduce the probability of accidents.

5. Convenient Service of Nautical Chart and Publication

New service mode based on Internet and mobile platforms, such as web online bookstores, can satisfy the user convenient order of nautical chart and publication needs. A well functional service system can produce personalized nautical chart and publication according to user's requirements. At the same time, digital nautical products can provide more convenient service for marine users.

5.3.1.3 Communication Information

The MF, HF and VHF links built in the ground wireless system of GMDSS take on the service of maritime information service, including distress security duty, distress follow-up communication and maritime safety information. The traditional navigation guarantee communication service mainly relies on the GMDSS and provides maritime safety information to the ships, including navigational warning, weather warning, weather forecast, and so on. At present, relying on the development of AIS, Beidou satellite and ECDIS, the means of maritime safety information broadcasting become more diverse. Next, with the development of new technologies and equipment, such as VDES, NAVDAT and fifth generation maritime satellites, the means of service will be further expanded, and the quality of service will also be significantly improved.

1. Distress and Safety Service

Distress and safety communications mainly include distress and security duty and

follow-up communications. Marine users can obtain information about ship distress warning and ship position by means of coast station, INMARSAT, COSPAS-SARSAT, and mobile communications, Beidou navigation satellite and AIS. Ships in distress can communicate conveniently with the search and rescue departments.

2. Maritime Safety Information Service

It is one of the most important functions of GMDSS to ensure the safety of navigation through the timely and effective provision of maritime safety information from the shore to the ship (Axel, 2014, pp. 18-21). Maritime safety information (MSI) includes navigational warnings, weather warnings, weather forecasts, etc. Using AIS, Beidou satellite and VSAT, the service side can provide better quality MSI services. At the same time, through the integration with the electronic chart system, a variety of marine information can be displayed more intuitively and completely, so as to improve service quality and reduce the crew workload.

3. Weatherfax Service

Weatherfax is a necessary information to ensure the safe navigation of ships, such as weather forecast, wave forecast, ocean current and satellite cloud photograph information. The ship user can receive and print automatically through the ship weatherfax machine. The weatherfax service, with various means and abundant contents, can provide better information service for the ship users, so that they can make more accurate and reasonable navigation plans.

4. VHF Voice Broadcasting Service

Beihai Voice is a marine voice broadcast service provided by Tianjin coast station in north China sea, which covers a wide range of information, such as navigation

knowledge, conventions and regulations, news reports, and so on. In view of the crew's needs, in future, the service providers further enrich information content and increase broadcast means, so as to provide more convenience for ships.

5.3.1.4 Comprehensive Assistance

With the increasing frequency of maritime activities, information services will face more fields and types of maritime users. Relying on the data processing function of Navigation Guarantee Cloud, the service side will carry out innovative applications based on big data services, including simulation, model prediction, management optimization, comprehensive planning and auxiliary decision-making. The information service platform can provide more comprehensive, professional, deep and standard services, and form a package of personalized and customized service products. These products could provide users with one-stop services to reduce their working intensity for querying information and analyzing data.

1. Research and Establishment of Maritime Service Portfolio (MSP)

With the shore-based e-navigation architecture, according to the demand of maritime users and the current situation of navigation guarantee service, service providers study the development and construction methods of MSP, which could lay the foundation for the construction of information service in the north China sea area. The construction of MSP application system can promote the shipborne equipment to support MSP information service, realize the MSP information interaction between ship and shore, and build a comprehensive intelligent information service environment for the users.

2. Construction of Data Resource Interaction Interface

According to the S-100 data standard of IHO, a multi-channel, open and standardized

data publishing method and exchange interface are set up to meet the requirements of multi-mode information sharing and interoperation. According to the customized data processing method, the navigation support data resource management and sharing service platform is built, and the data resource flow service is provided.

3. One-stop GIS Information Service Software Platform

Relying on the existing service website, the GIS online service platform is built to further enrich AIS, hydrological and meteorological information. The content of information service mainly includes ship dynamic and static information, electronic chart correction data, hydrological and meteorological information, Notices to Mariners, ship traffic organization information, navigation environment situation, etc. At the same time, according to the different needs of users, the service platform can use customized frequency, form and content to broadcast and push information (Serrão & Rodrigues & Buf, 2014, pp. 28-37).

4. Harbor Channel Simulator in North China Sea

The service provider can use the maritime data of the main ports in north China sea area, including harbor environment, hydrology, meteorology and waterway transportation information, to develop the navigation simulation systems. Based on VR, front-projected holographic display or ship bridge simulation equipment, these systems can be widely used in traffic monitoring, crew training, teaching and emergency rescue activities.

5. User Information Management and Requirement Analysis

Through the establishment of user information database, the user characteristics and requirements of different fields and levels can be analyzed comprehensively. The

result of data analysis is helpful to improve the quality of information service. By means of convenient ways such as web page, WeChat and micro-blog, the demand of navigation service information service is continuously and extensively investigated, and the feedback information and relevant suggestions of users are obtained in time. The establishment of customer satisfaction evaluation system, which could fully analyze the needs and satisfaction of all users, can promote the timely adjustment of the form and content of services, and enhance the level and quality of information services.

6. Maritime Radio Signal Monitoring Service

The accuracy of positioning information is essential to ship navigation safety and marine construction operation. Integrity monitoring of DGPS, DBD and Beidou satellite systems, and timely broadcasting of status information are important to ensure accuracy of position information. At the same time, detecting the maritime communication frequency in north China sea can guarantee the communication order and environment.

7. Research and Develop Customized Information Service Products

According to the characteristics of ship plan routes, traffic supervision, maritime search and rescue, accident investigation, drilling exploration, water construction and other activities, navigation support data can be processed encapsulated and provided to the users (Jaeyong & Sekil & Oh-Seok, 2016, pp. 21-31). The information can satisfy the demand of maritime activities, such as navigation track research and the best route work, reduce the workload of users inquiring and obtaining information, and enhance the safety of maritime operation (Richard, 2015, pp. 17-25).

5.3.2 Information Service Form

The forms of service are the specific combination and presentation of various data resources. The forms of navigation guarantee information service which are based on electronic technology mainly include text, image, graphics, audio, video, games and so on.

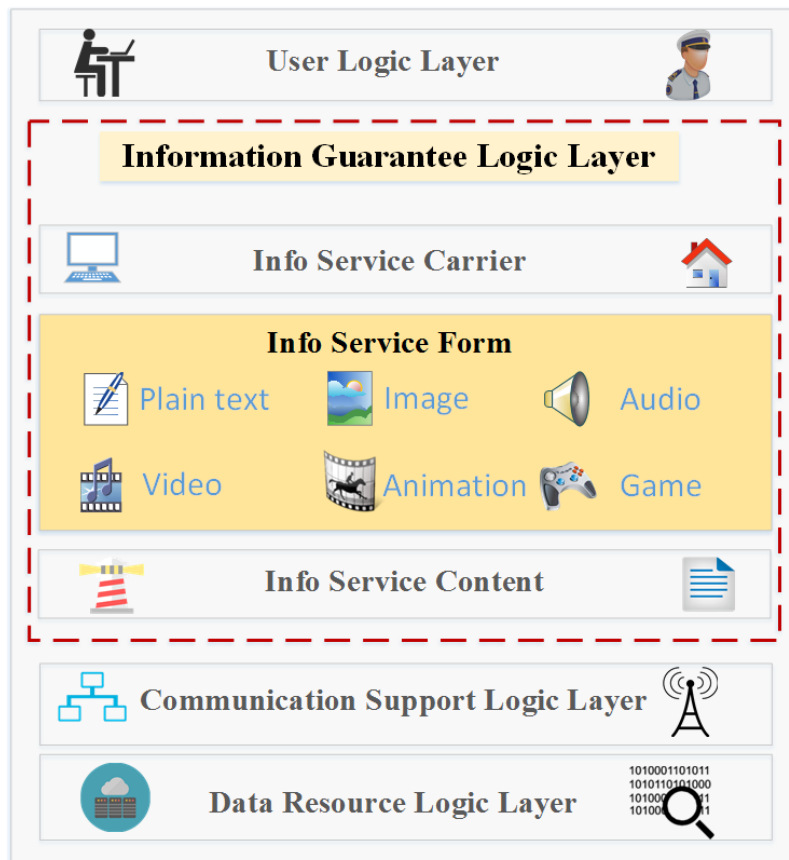


Figure 9 - Logical Structure Chart of Information Service Form

Source: Compiled by the author.

5.2.2.1 Plain Text Form

Plain text is the most common form of information display. This form occupies low

communication bandwidth, and is especially suitable for narrowband communication links over water. At the same time, plain text is simple in structure, small in storage space and large in information content. The information in the form of plain text can be used both for operating users and for specific devices.

5.2.2.2 Image and Graphic Form

Based on the user's point of view, the information in the form of images and graphics can be presented to the user more intuitively. This form can improve the efficiency of information transmission, break through the language and cultural barriers, and reduce the logical analysis workload of the service information.

5.2.2.3 Audio Form

The audio form of information service has the characteristics of low production cost, easy broadcasting and flexibility. As an important part of maritime information service, the audio form information can be easily received by onboard equipment.

5.2.2.4 Video Form

The form of video service is intuitive and has the advantages of image and graphics. The display of video form information is intuitive and has the same advantages as image and graphics. Rich content can fully display the process of development. And video form information is suitable for education and training.

5.2.2.5 Electronic Game Format

The information service of electronic game form can be close to reality by creating a particular scene and process. This form can help users deepen their understanding of

knowledge and information, and be suitable for the simulation training of users.

5.3.3 Information Service Carrier

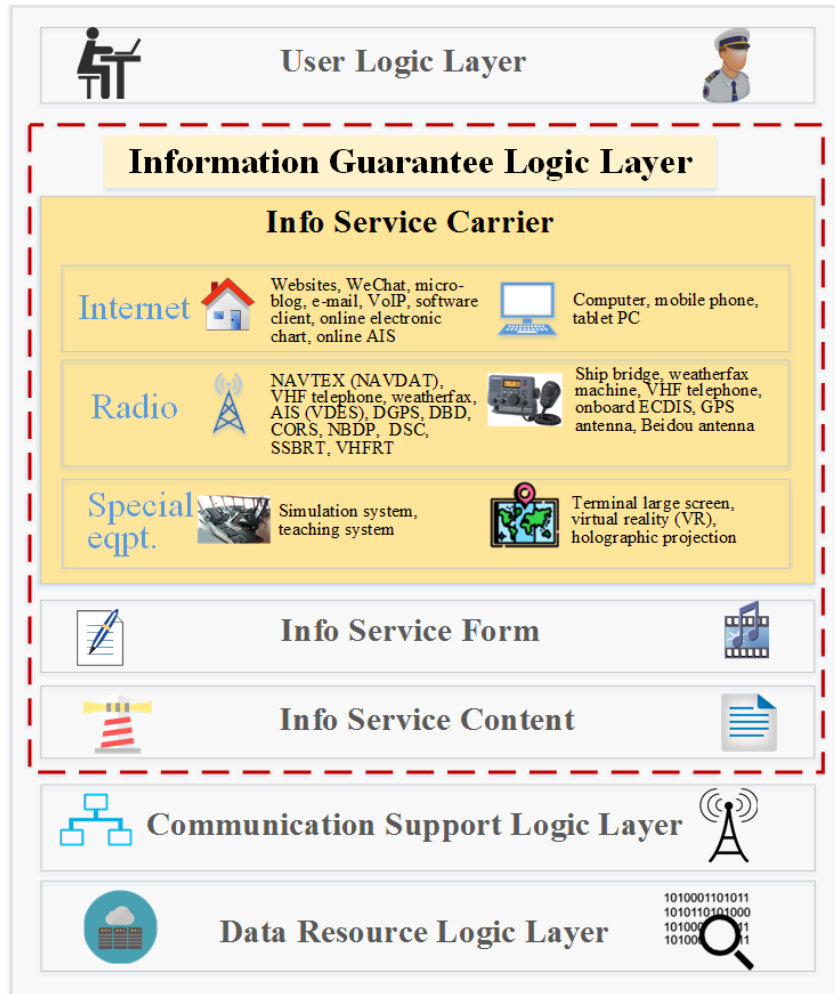


Figure 10 - Logical Structure Chart of Information Service Carriers

Source: Compiled by the author.

The information service carriers are software or hardware tools for users to acquire information services, which provide all kinds of information services. The carriers of information service based on e- navigation concept mainly includes Internet class,

radio class and special equipment class. The details are as follows:

5.2.3.1 Internet Class

The software carrier of Internet class mainly includes websites, WeChat, micro-blog, e-mail, VoIP, software client, online electronic chart, online AIS, and so on. They can carry text, pictures, audio, video, electronic games and other forms of information services. The related hardware equipment of Internet class includes computer, mobile phone, tablet PC and other intelligent operating system equipment.

5.2.3.2 Radio Class

The software carrier of radio class mainly includes NAVTEX (NAVDAT), VHF telephone, weatherfax, AIS (VDES), DGPS, DBD, CORS, NBDP, MF/HF/VHF, DSC, SSBRT, VHFRT, electronic chart, and so on (Wang & Peng & Zhang, 2015, pp. 24-27). They can undertake information services in the form of text, pictures and audio. The related hardware equipment of radio class includes ship bridge, weatherfax machine, VHF telephone, onboard ECDIS, GPS antenna, Beidou antenna, etc.

5.2.3.3 Special Equipment Class

The special equipment information service carrier includes simulation system, teaching system, terminal large screen, virtual reality (VR), holographic projection, and so on. This class requires the development of professional software and hardware devices to meet the user's personalized and customized needs (Liu & Song Li & Zou, 2013, pp. 1851-1855).

CHAPTER 6

Conclusion

With the development of economy and the increase of maritime activities, navigation guarantee service needs to face more different types of maritime users and information service requirements. Combining with the previous research achievements and the successful experiences of global e-Navigation test projects, in this monograph, we have investigated the user's type and needs; analyzed the problems and gaps of current information service; and proposed to develop and construct the integrated navigation guarantee information service platform in the north China sea area. The main content of this paper is shown as follows:

1. Through the analysis of investigation and questionnaire results, we considered that the maritime user mainly included ship navigators, government administrative departments, port management and construction units, academic research institution, and other relevant units or individuals. User's needs mainly focused on the comprehensiveness, accuracy, timeliness, diversity and customizability of navigation guarantee service information.
2. We have investigated the previous works related to navigation guarantee service and summarized the current problems and gaps, for example, the

bandwidth of the maritime communication link is not high, the forms of information service are less, and so on.

3. According to the results of our research, integrated navigation guarantee information service platform was a logical layer between data resource layer and user layer, which could provide comprehensive and diverse information to users through many kinds of forms and carriers. We have studied the construction goal of the service platform and shed light on that relying on the Navigation Guarantee Cloud function support, by 2020, the navigation guarantee information service contents would be comprehensive and accurate, the service forms would be visual and diverse, and the service carriers would be diversified and convenient. Finally, the integrated service platform could meet the multi-level, differentiated, one-stop information service needs of the user, so as to ensure the safety of ship navigation and protect the marine environment. The service platform contained two parts: communication support service logic layer and information support service logic layer.

1) The communication support service logic layer was the bridge and link between the data resource and the user, which undertook the construction of communication link and the transmission of service data. We have addressed the information transmission issue in terms of using the advanced electronic information means, such as space-based system, air-based system and land-based system. As a result, high bandwidth land and water communication networks could be built, and various kinds of information service windows could be extended to the user side. At the same time, users also could use the communication link to realize the convenient and fast feedback of demand and suggestion.

2) The information guarantee service layer was a user oriented logic layer, which could provide navigation guarantee information in different categories, forms and carriers. The logic layer mainly included three parts: service content, service form and service carrier. Information service contents mainly included four categories: Aids-to-Navigation, marine hydrography, communication service and comprehensive assistance. The service forms mainly included text, image, graphics, audio, video, games and so on. And the service carriers mainly included Internet class, radio class and special equipment class.

We believe this is just the tentative beginning of integrated navigation guarantee information service research. With the development and application of marine communication and data processing technology, such as the big data and cloud computing technology, we will face many new challenging research issues. We close this monograph with some additional thoughts on future research directions in this field. In the future, the main direction would be the aspect of intelligent decision analysis, virtual reality simulation, accurate information alarm via wearable devices, and so on.

REFERENCE

- Axel, H. (2014, December). Test Bed for Safety Assessment of New e-Navigation Systems. *International Journal of e-Navigation and Maritime Economy*, 1, 14-28.
- Axel, H. & Andre, B. & Martin, F. & Sibylle, F. & Jin, H. P. (2016, December). Requirements for e-Navigation Architectures. *International Journal of e-Navigation and Maritime Economy*, 5, 1-20.
- Chen, C. & Shiotani, S. & Sasa, K. (2015, October). Study on a Numerical Navigation System in the East China Sea. *Applied Ocean Research*, 53, 257-266.
- Chen, R. & Shao, Z. Z. & Chen, K. & Liu, X. Y. & Li, Z. (2015). The Research of architecture and network topology in Inmarsat-5 System. *Information & Communications*, 8, 8-10.
- Cui, K. T. & Sun, W. Q. & Xia, G. Z. (2015). Enhancement of NAVDAT's modernization of GMDSS Maritime Safety Information Service. *China Water Transport*, 2, 52-53.
- Cui, K. T. & Sun, W. Q. & Xia, G. Z. (2015). Maritime Safety and communication system based on Beidou Technology. *China Water Transport*, 12, 15-17.
- Daniel, B. & Jennifer, B. & Lisa, V. (2016, June). Improving Canada's Marine Navigation System through e-Navigation. *International Journal of e-Navigation and Maritime Economy*, 4, 23-30.
- Ding, S. S. & Feng, T. N. & Jiang, C. H. (2017). Research progress of fishermen's maritime emergency communication mode in China. *Chinese Journal of Hygiene Rescue (Electronic Edition)*, 2, 57-61.
- Gong, H. F. (2016). Discussion on VHF data exchange system. *China Maritime Safety*, 3, 53-55.
- Jaeyong, O. & Sekil, P. & Oh-Seok, K. (2016, December). Advanced Navigation Aids System based on Augmented Reality. *International Journal of e-Navigation and Maritime Economy*, 5, 21-31
- Ji, A. (2013). Google balloon. *Software Engineering*, 9, 5-7.

- Kwang, A. (2016, June). E-navigation Services for Non-SOLAS Ships. *International Journal of e-Navigation and Maritime Economy*, 4, 13-22.
- Li, A. G. (2014). Study on effective application of ECDIS in ship pilotage. *China Water Transport*, 14, 8-9.
- Li, S. B. (2015). Coastal port e-Navigation top design. *Journal of Dalian Maritime University (Social Sciences Edition)*, 2, 21-26
- Liu, X. Z. & Song, Y. & Li, C. X. & Zou, W. Y. (2013). Study of Real-time Augmented Environment for Ship Handling Based on AIS Data. *Journal of System Simulation*, 25(8), 1851-1855.
- Michael, B. & Sun-Bae, H. (2016, June). Improving and Assessing the Impact of e-Navigation applications. *International Journal of e-Navigation and Maritime Economy*, 4, 1-12.
- Michele, F. & Andrea, C. & Domenico, D. (2016, December). AIS Data Visualization for Maritime Spatial Planning (MSP). *International Journal of e-Navigation and Maritime Economy*, 5, 45-60.
- Min, S. Q. (2016). Conception of integrated information network between heaven and earth in China. *Satellite Application*, 1, 27-37.
- Nie, Q. Z. (2016). Research on the comprehensive navigation safeguarding system on the base of E-navigation philosophy. *China Maritime Safety*, 12, 22-25.
- Oliver, K. & Martin, K. & Dennis, G. & Holger, K. & Axel, H. (2016). From Nautical Path Planning in ECDIS to Their Realisation Applied for Fully Actuated Ships. *IFAC-PapersOnLine*, 49(23), 115-120.
- Qian, C. & Li, G. X. & Zhao, L. W. & Yang, H. Z. (2015). Application of Beidou mid earth satellite in maritime search and rescue. *Satellite Application*, 5, 23-27.
- Richard, L. S. (2015, April). Teasing out the detail: How our understanding of marine AIS data can better inform industries, developments, and planning. *Marine Policy*, 54, 17-25.
- Ryszard, W. & Tadeusz, S. (2010). The possibility of use of the AIS data transmissions for safety and security monitoring in the Polish maritime areas.

IFAC Proceedings Volumes,43(23), 58-63.

Serrão, M. & Rodrigues, J.M.F. & Buf, J.M.H. (2014). Navigation Framework Using Visual Landmarks and a GIS. *Procedia Computer Science*,27, 28-37.

Wang, C. L. & Peng, G. J. & Zhang, X. J. (2015). Research on NAVDAT information content of new marine digital communication system. *Port Economy*, 5, 24-27.

Wang, H. X. (2016). Development and application of marine guarantee technology. *China Water Transport*, 12, 10-11.

Wang, W. G. (2016). Options of marine communication. *China Maritime Safety*, 8, 47-52.

Wang, X. (2016). The research on the marine ship – to – shore communication used in e – Navigation framework. *Ship Science and Technology*, 38, 82-84.

Wang, Y. (2017). Discussion on the actual application and development of virtual navigation mark. *China Water Transport*, 3, 11-12.

Wang, Y. L. (2014). Maritime Service Portfolios (MSP) - The Key for Implementation of e-Navigation. *China Maritime Safety*, 6, 54-56.

Xiong, Y. Y. (2016). New development of maritime communication technology - VDES system. *Satellite Application*, 2, 35-40.

Xu, Y. (2017). Brief on the work progress and future development of IHO on the condition of e-Navigation. *China Maritime Safety*, 4, 55-57.

Yang, C. T. (2017). Explore large data driven green communications network. *Public Communication of Science & Technology*, 2, 13-14.

Yang, L. (2012). The digital communication in e-Navigation. *China Maritime Safety*, 7, 49-52.

Yang, Y. (2016). Discussion on the development of vision aids to navigation under the e-navigation strategy. *China Maritime Safety*, 5, 46-48.

- Zeng, G. Y. & Zhang, W. & Wang, D. & Luo, G. (2016). VSAT Satellite, Internet, Telephone, TVRO System Combined Researching and Application. *Ship Engineering*, 38, 15-17.
- Zhang, G. Q. & Li, Y. L. (2016). Application of Beidou navigation system in maritime distress and safety information broadcasting. *Technology and Economic Guide*, 29, 49-50.
- Zhang, J. (2016). Mobile Internet and satellite communication. *Satellite & Network*, 5, 20-28.
- Zhang, T. J. & Zhu, Y. Q. (2012). A Study on Development of ECIDS under E-Navigation. *China Maritime Safety*, 1, 46-49.
- Zhang, X. G. & Zhou, S. B. (2013). Realization of integrated navigation-aid information system. *Journal of Shanghai Maritime University*, 3, 15-18.
- Zhu, M. & Axel, H. & Yuan, Q. & Wen, F. Z. (2016). Maritime Unmanned Vehicle Cruise Path Planning for Maritime Information Collection. *IFAC-PapersOnLine*, 49(23), 103-108.

Appendix A

Navigation guarantee information service user need survey questionnaire

User description	Industry	
	Specific post	
User need	Description	Index requirement
Current product and service content		
Gap analysis		
To be developed perfect product service		