Modelling of Pilotage Service Portfolio for e-navigation and its application in approaching port

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Abstract. Based on the objectives and requirements of the pilotage service portfolio, using the design standards of HGDM organization, the nodes, activities and certification modules of ships entering and leaving the port are analysed, and the S-100 standard model of pilotage data is established. According to the characteristics and actual needs of pilotage, the technical design mode of C/S (client/server) mode of pilotage service portfolio is determined; the application example of pilotage service portfolio is verified by the service mode of tide riding opportunity in Ningbo waters for large container pilotage.

1. Introduction

The entering and leaving port of ships involves the ship, port, pilotage agency and maritime administration. The establishment of an effective and unified information exchange channel is favour of improving the efficiency and safety of maritime traffic. E-navigation strategy is a solution proposed by the International Maritime Organization (IMO). E-navigation collects, exchanges and displays maritime information on ships and shore bases by electronic means to enhance navigation safety and environmental protection of ships [1]. The environment of pilotage for ship’s entering and leaving port is complex, and the marine operation involves many related parties. Therefore, the research on Pilotage information interaction of e-navigation strategy has certain complexity and significance.

At present, there is no standard format and structure of maritime service portfolio in e-navigation environment. These formats and contents will be studied and determined by National Maritime administrations and international organizations, and then submitted to the International Maritime Organization [2]. The research and submission process includes nine aspects: submitting organization, coordinating bodies, description of maritime service, purpose and operational approach. Among them, the research of MSI and SAR service portfolio has made rapid progress, and the related technologies are relatively mature. Therefore, the initial description of MSI and SAR in the appendix of the circular is relatively complete. There are few researches on pilotage service portfolio, and its preliminary description is a little thin, especially for operational information, which only lists the most basic pilotage information, which is far from the initial strategic vision and ultimate goal of e-navigation[4]. Therefore, this paper will combine the current maritime technical means and the future development direction, focus on the actual needs of the pilot field, and explore the pilot service portfolio from the perspective of innovation and practicality [3].
2. Initial description of Pilotage service portfolio

2.1. Pilotage operation

Maritime pilotage service involves seafarers, pilots, MSA and port companies, and requires pilotage time, place and participants. The pilotage service is responsible for organizing, coordinating and executing the pilotage operation at sea. Ships proceeding or leaving a port or a specific area should have easy access to information regarding the pilotage service provided. Information, such as local regulations, contact, notices, means of boarding, boarding point, limitations, or pilot booking procedures, could be accessible by electronic means, where available. Pilotage service mainly includes standardized pilotage application information, standardized pilotage publishing information and standardized on-scene interactive information, which can be divided into static pilotage information and dynamic pilotage information [4].

Based on the MSP area determined by IMO, the scope of application of pilotage service portfolio is mainly to meet the availability of port waters. As shown in Figure 1, the main process of pilotage operation and the information to be determined are introduced. The research work of this paper is to determine the model structure and parameters of the pilotage service portfolio according to the pilotage operation.

2.2. Purposes and user needs of pilotage service portfolio

The specific content of pilotage service portfolio is formulated by International Maritime Pilots’ Association (IMPA), who is the leading contact unit and submitting agency. IMO and IMPA are the coordinating agencies of pilotage service portfolio. The purpose of pilotage service is to provide information related to pilotage service by using modern technology and common standards when the pilot draws up the operation plan before boarding [5].

Ships are concerned by this service and need to know the pilot boarding / disembarking position, the pilot request procedures, local and special regulations and the compulsory use of tugs. At the same time, in order to improve the navigation safety and economic benefits of ships and port waters, the
demand for pilotage service of ships not only stays in the scope of static information, but also pays more attention to the dynamic information such as boarding time, tide riding time, speed control strategy and the transverse safety distance between large ships and other ships. Combined with the strategic deployment of e-navigation and the development trend of unmanned ships, pilots expect that the service portfolio can automatically provide intelligent, real-time and high matching pilotage information service for navigation tasks and scenarios at the right time.

2.3. Relations to Other MSs
When organizing and implementing the pilotage operation, the pilotage order and update information are the most critical information, which involves the time and the traffic organization in the pilotage process. This part of information belongs to VTS. Therefore, the pilotage service may overlap with MSP1-VTS information service and MSP3-traffic organization service. In addition, the pilotage service and MSP4-port support service have some overlaps in berth or mooring details. In the process of pilotage, information about pilotage rules, contact information, application procedures, mandatory requirements for tugboat assistance and other information overlap with MSP7-tugboat service. Finally, real-time meteorological and hydrological information needs to be obtained during pilotage operation, so the pilotage service may overlap with MSP14- meteorological information service and MSP15-Real-time hydrographic and environmental information services [6].

3. Operational approach of Pilotage service portfolio

3.1. Current and future operational approach
Pilotage technical service mainly focuses on the pilotage scheme part of pilotage scheduling, which mainly exchanges pilotage information between ships and shore, such as berthing and unberthing mode, tugboat configuration, tide riding time, speed control, key waters control, etc. At present, the communication business mainly relies on the traditional ship shore VHF manual communication and on-scene oral interaction.

In the future, based on the standardized pilotage service data structure, the pilotage service system can seamlessly exchange pilotage service information between various business nodes using Internet, 3G / 4G / 5G and other communication methods, as shown in Figure 2.
3.2. Operational nodes and activities
Operational node refers to the logical entity participating in the action. Pilot station is the operational node of pilotage. Pilotage service supports the operational activity of displaying pilotage information on ECDIS. Users can search for pilotage service instances in maritime cloud service registration centre, and display relevant pilotage information on ECDIS during pilotage [7].

3.3. Standard model of pilotage data
In this paper, unified modeling language is used to build the data model of pilotage information. The UML diagram of the established pilotage information data model is shown in Figure 3.

![Figure 3. Data model of maritime PILOTAGE information.](image-url)
4. Technical design of pilotage service portfolio

4.1. Instruction of technical design of pilotage service portfolio
Considering the characteristics of pilotage and the actual situation, the technical design mode adopted in this paper is C / S (client / server) mode. The shore end and ship end software are established respectively, and the socket network communication mode is adopted in the LAN environment for information transmission.

After using UML to build the data model of maritime pilotage information in the service specification, in order to transmit the pilotage information between different systems, it is necessary to use the appropriate coding language to encode the data. In S-100, it is recommended to use XML to encode the data file. XML has a unified standard syntax and strong interoperability between different systems. Therefore, this paper uses XML to encode the pilotage data model to facilitate data transmission [8].

4.2. Service interface design
The detailed service interface design of pilotage service is shown in Figure 4.

5. Service instance of pilotage service portfolio
Taking Ningbo Zhoushan port as an example, this paper studies the implementation process of "feasible tide time" in pilotage. As 200000 DWT container ships enter and leave Meishan port through shallow water area (as shown in Figure 5), the pilot should fully consider the "feasible tide time" when determining the boarding time. In the process of ship entering and leaving the port, the draft of the ship is large. In order to pass through the shallow water area, we need to use the tide height to further improve the depth of the water, so that the bottom of the ship will not touch the bottom of the sea, resulting in grounding or collision accidents. The tide changes periodically with time, so it is necessary to predict the time window of the ship passing through the shallow water area in advance by using the tide forecast, so that the water depth of the ship in the shallow water area can meet the conditions.
5.1. Key technologies for determining feasible tide time

"Feasible tide time" is mainly affected by ship draft, ship speed, squat, chart depth, tide time and tide height. Among them, the calculation of ship sinking is the key to provide accurate service. Based on the comparative analysis of six commonly used squat calculation formulas and real ship test results at different speeds, considering both safety and economy, the navigation sinking of large container ships in Meishan port area is calculated by referring to Barrass formula when entering and leaving the Fudu waterway and arriving at Meishan container terminal.

Figure 5. Service coverage area diagram.

Figure 6. Comparison between predicted and measured squat.

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Where: \( V_k \) is the speed (kn); \( K \) is the channel section coefficient, \( K=5.74Q^{0.76}(1\leq K\leq2) \), \( Q=A_c/A_s \), \( A_s \) is the cross-sectional area of the ship, \( A_s=0.98Bd \), \( A_c \) is the channel section area, \( K \) is 1 for open water area, \( A_c=Wh+nh^2 \) for trenching channel (\( W \) is the channel bottom width, \( n \) is the channel slope).

5.2. A case study of "feasible tide time" prediction in shallow water

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According to the ship's speed, draught and the date of arrival at the port, the time window of the ship safely passing through the warning area (shallow water) can be calculated by using the squat. According to the interface prompt, we can get the time period of the ship safely passing through the warning area (shallow water) under different speed and draught. The details are shown in Figure 7.

Feasible tide time and tide height arrangement: In 2020 October 13, when the recommended speed is 16 knot, recommended draught is 16 m, the tide time interval crossing shallow water area is 02:25~05:54 or 14:57~18:34.

In order to ensure that the pilot can choose the right time to board the ship and pass through the shallow water area by adjusting the speed in real time during the pilotage process, the pilotage scheduling provides the shore-based services of the tide riding time based on the port tide data and ship information, including the initial boarding time and the optimization strategy of the speed in the pilotage process.

6. Conclusions

According to the construction guide of maritime service portfolio, combined with the characteristics of China's maritime pilotage service, this paper summarizes the maritime pilotage service portfolio, establishes the service specification of maritime pilotage service portfolio, the technical design of maritime pilotage service portfolio and the service example of maritime pilotage service portfolio, and completes the establishment of Maritime pilotage service portfolio.

Acknowledgments

This work was partly supported through grants from the National Natural Science Foundation of China (No. 51679025), Natural Science Foundation of Liaoning Province (No. 20170540093), and Research
Funds for the Central University. The authors would like to thank the anonymous reviewers for their valuable comments.

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