



Status of Research and Application Cases in Intelligent Shipping

Jiayi Xu^{1,2}, Zixiang Li^{1,2}, Haifei Sha^{1,2}, and Shiqiang Wu^{1,2}(✉)

¹ Nanjing Hydraulic Research Institute, Nanjing 210029, China
{jyx, sqwu}@nhri.cn

² State Key Laboratory of Hydrology Water Resources and Hydraulic Engineering, Nanjing 210098, China

Abstract. With the rapid development of information technology, the shipping industry is also experiencing an important period of change in the development of transition to intelligence and wisdom. Intelligent shipping is a service system that promotes inter-departmental cooperation, cross-regional information resource integration, transportation efficiency improvement and transportation cost reduction by using cloud computing, big data, Internet of Things, sensors and other technologies as a comprehensive application with the construction of big data center as a pioneer. Intelligent shipping is the innovative application of relevant advanced concepts and high technology in the shipping industry arising from the construction of intelligent society, however, the development of intelligent shipping is still in the primary stage, and relevant literature on the field of intelligent shipping is still lacking. In order to understand and develop intelligent shipping, this paper reviewed and summarized intelligent shipping based on the existing literature. This paper mainly introduced the background, connotation and development status of intelligent shipping at home and abroad, summarized the framework system of intelligent shipping from five aspects: intelligent ship, intelligent port, intelligent shipping insurance, intelligent supervision and intelligent service, summarized several key technologies in intelligent shipping, and gave examples of successful applications of intelligent shipping at home and abroad. Combined with the current research status of intelligent shipping, this paper put forward the shortcomings and challenges of intelligent shipping, and looks forward to the future development and research direction of intelligent shipping.

Keywords: Intelligent shipping · Intelligent ship · Intelligent port

1 Introduction

As an important part of the national economy and an indispensable part of production and life, transportation industry plays an important role. As an important cornerstone of the transportation industry, shipping is a transportation mode with large transportation volume, low energy consumption, low cost and environmental protection. It plays a very important role in the transportation of trade goods in China and the world. In recent years, with the rapid development of big data, artificial intelligence, machine learning and other technologies, new concepts such as smart city, smart water

conservancy, smart maritime, smart robot and smart home have emerged one after another. The concept of “intelligent transportation” originated from land transportation and was later cited to water transportation, resulting in the concept of “intelligent shipping”.

Intelligent shipping is a comprehensive application of cloud computing, big data, Internet of things, sensors and other technologies guided by the construction of big data center. It is a modern shipping service system that promotes cross departmental cooperation, cross regional information resource integration, improves transportation efficiency and reduces transportation costs. The basic components of intelligent shipping include five elements: intelligent ship, intelligent shipping insurance, intelligent port, intelligent supervision and intelligent service. The sustainable development of intelligent shipping requires the organic coordination and common development of all elements.

There are many key technologies used in intelligent shipping, such as cloud computing, big data, Internet of things, sensors and so on. Cloud computing is a new type of IT infrastructure with high performance, high speed and diversification. In the development of intelligent shipping, it will organically combine computing technology with traditional shipping, which is a collision combination of traditional technology and new technology in the development. “Cloud” refers to a virtual network. Cloud computing is a network that provides resources. Resources like cloud can be accepted and used in real time. In the early stage of the development of cloud computing, it is only simple distributed computing, and then the combination of computing results. Now it has developed to decompose the huge data in the cloud into infinite small tasks through computer processing, and then process and analyze these results through the server system and return them to users. Cloud computing technology is the core of making traditional shipping intelligent. Through multi data analysis, it can improve the synergy between ships and logistics and have efficient operation. With the “Internet plus” action and the national big data strategy advancing, data management, data management and data innovation will gradually influence the development of national governance.

In recent years, intelligent shipping has developed rapidly in China and around the world. In China, the proposal of the CPC Central Committee on formulating the 13th five year plan for national economic and social development issued in 2015 mentioned the need to speed up the improvement of water transport infrastructure network and the implementation of high-tech ship intelligent manufacturing; The guiding opinions on the development of intelligent shipping jointly issued by the Ministry of transport and other seven departments in 2019 put forward the strategic objectives and ten tasks for the development of intelligent shipping, carried out the top-level design of intelligent shipping development, and improved China’s shipping competitiveness; In addition, the medium and long term development planning outline of scientific and technological innovation in the field of transportation (2021–2035) issued by the Ministry of transport in 2022 mentioned the need to strengthen the promotion of intelligent shipping technology innovation, so as to promote the application of global shipping service network based on blockchain. Internationally, the 98th meeting of the Maritime Safety Committee of the International Maritime Organization (IMO) (msc98) held in 2017 included “autonomous unmanned ships” as a new topic, and intelligent shipping has gradually become a research hotspot.

With the increase of the number of ships worldwide and the development of large ships, the shipping industry is facing many challenges, such as serious environmental pollution, increased labor cost, insufficient safety and so on. The development of intelligent shipping will effectively meet these challenges. Intelligent shipping can effectively improve shipping capacity, promote the development of green technology, reduce greenhouse gas and pollutant emissions, save energy and improve shipping safety. However, the development of intelligent shipping is still in its infancy, and the literature on the overall framework of intelligent shipping is relatively lacking. This paper mainly summarized the framework system of intelligent shipping from five aspects: intelligent ship, intelligent port, intelligent navigation insurance, intelligent supervision and intelligent service, summarized several key technologies of intelligent shipping, then gave examples of successful cases of intelligent shipping application in China and abroad, and finally put forward the current shortcomings and challenges of intelligent shipping. The future development and research direction of intelligent shipping will be prospected.

2 Intelligent Shipping System Framework

Intelligent shipping is mainly divided into five aspects: intelligent ship, intelligent port, intelligent aviation insurance, intelligent supervision and intelligent service. The overall framework of intelligent shipping is shown in Fig. 1. The following will mainly summarize the definitions and research status of these five aspects, and specifically introduce the two aspects of intelligent ship and intelligent port.

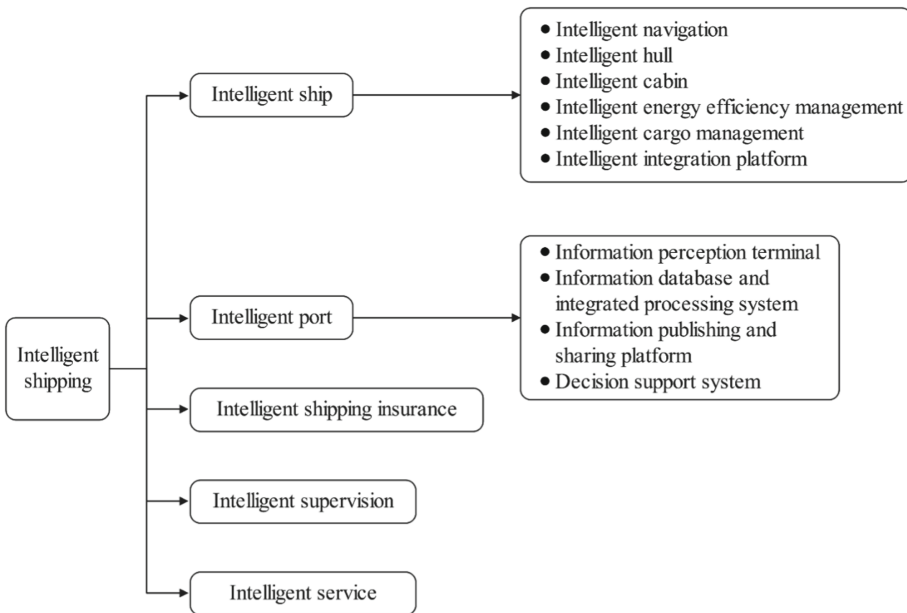


Fig. 1. Framework of intelligent shipping

2.1 Intelligent Ship

Intelligent ship refers to a ship that automatically senses and obtains the information and data of the ship itself, marine environment, logistics, port and other aspects by using technical means such as sensor, communication, Internet of things and Internet, and realizes intelligent operation in ship navigation, management, maintenance and cargo transportation based on computer technology, automatic control technology and big data processing and analysis technology, so as to make the ship safer, more environmentally friendly More economical and reliable (Li et al. 2021). Compared with traditional ships, intelligent ships have significant advantages in economy, safety, reliability, environmental protection and efficiency (Wang et al. 2021). At the same time, although ship intelligence reduces the impact of human factors on navigation safety, the research on its safety is still the focus of research in the shipbuilding industry (Zhang et al. 2021).

Internationally, Japan began to study AI ships with intelligent navigation function in the 1980s; South Korea launched the world's first intelligent ship in 2011. At present, its intelligent ship 2.0 plan is being promoted; Rolls Royce completed the world's first merchant ship remote operation in 2017, developed the world's first fully automatic ferry in 2018, and conducted automatic navigation test at the same time; In 2019, Japan announced that it had completed the world's first sea test of intelligent ships and completed various test projects of the interim guide for autonomous ship test of the international maritime organization. At home, the action plan for the development of intelligent ships (2019–2021), prepared and issued by the Ministry of industry and information technology, the Ministry of transport and the Bureau of science, technology and industry for national defense in 2018, aims to promote the high-quality development of China's shipbuilding industry and keep the development of intelligent ships in China in step with the advanced level of the world. Some intelligent ships that have been developed are shown in Fig. 2.



Fig. 2. Examples of intelligent ship

China Classification Society (CCS) is an organization that provides the world's leading technical specifications and standards and classification inspection services for ships, marine facilities and related industrial products. At the same time, it also

provides legal inspection, notarial inspection, certification and accreditation services in accordance with international conventions, rules and relevant regulations of authorized flag States or regions. Based on the scientific and technological research achievements of China Classification Society in recent years, and taking full account of the application experience of intelligent ships at home and abroad and the development direction of intelligent ships in the future, the intelligent ship system is composed of six functions: intelligent navigation, intelligent ship body, intelligent engine room, intelligent energy efficiency management, intelligent cargo management and intelligent integration platform. The operation diagram of intelligent ship is shown in Fig. 3.

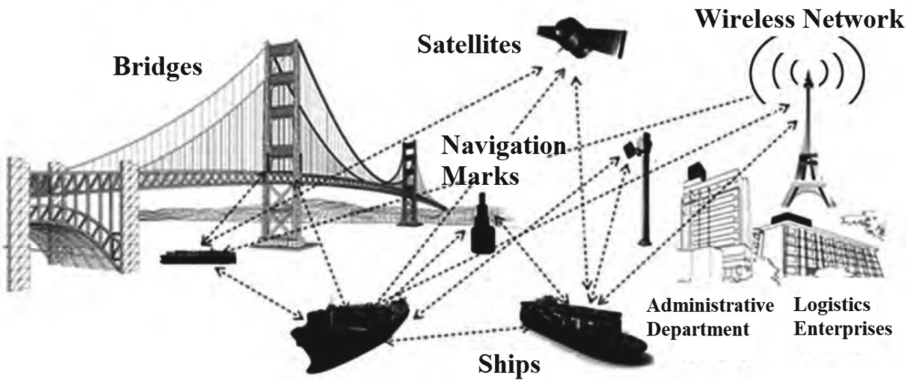


Fig. 3. Schematic diagram of intelligent ship operation (Yan and Liu 2016)

Intelligent navigation is to use technical means to analyze and process meteorological and logistics information, and design and optimize ship route and speed based on the analysis results. It can also have the function of autonomous navigation in open waters and advanced autonomous navigation ability of automatic berthing and disembarking from the wharf; Intelligent hull is to establish and maintain the hull database, and provide auxiliary decision-making for the safety and structural maintenance of the hull in the whole life cycle based on the database data; The intelligent engine room monitors the operation status of the main engine, auxiliary engine and shafting in the engine room, and analyzes and evaluates the operation status and health status of mechanical equipment according to the collected data; Intelligent energy efficiency is the on-line monitoring and automatic data collection of ship navigation status and energy consumption status. According to the collected data, the ship energy efficiency status, navigation and loading status are evaluated; Intelligent cargo management is an effective method to realize the monitoring, alarm and auxiliary decision-making of cargo hold and cargo, so as to optimize the stowage of cargo; The intelligent integration platform integrates the data of three systems: intelligent navigation, intelligent engine

room and intelligent energy efficiency management. It can integrate the existing onboard information management system and subsequent new systems to realize the comprehensive monitoring and intelligent management of ships (Lei et al. 2018).

2.2 Intelligent Port

The development of the port is divided into four stages. The first generation is the “transportation center”, which realizes the functions of port loading and unloading, transshipment, storage and goods receiving and dispatching; The second generation is “transportation center + Service Center”, which provides some industrial and commercial value-added services based on the transportation center; The third generation is “international logistics center”, which forms logistics services integrating goods, technology, information and capital; The fourth generation is the “supply chain center”, which is an important link in the supply chain and has brand-new port characteristics.

As the latest fourth generation port form, intelligent port is a typical representative. Taking the information physical system as the framework, the intelligent port integrates the communication between the logistics supplier and the demander into the integrated system of collection, distribution and transportation through the innovative application of high and new technology; Greatly improve the comprehensive information processing capacity of the port and its related logistics parks and the optimal allocation capacity of related resources; Intelligent supervision, intelligent service and automatic loading and unloading have become its main forms, and can provide high safety, high efficiency and high-quality services for the modern logistics industry. The system structure diagram of intelligent port is shown in Fig. 4.

The world is setting off an upsurge in the development of intelligent ports. In China, the Ministry of transport issued the notice on carrying out intelligent port demonstration project in 2017, and a large number of Chinese scientific and technological innovation enterprises participated in it with artificial intelligence as the starting point. The schematic diagram or model diagram of some intelligent ports is shown in Fig. 5.

2.3 Intelligent Aviation Insurance

The core elements of intelligent navigation support system include shore based system, ship shore communication, navigation and positioning, information service and data standard. Ship shore communication is a channel that provides all information exchange and sharing. Intelligent ship navigation requires a large number of data exchange between ship and shore and between ships, which requires faster data communication bandwidth and more efficient and convenient data communication technology. Navigation and positioning provides basic location information, dynamic change information and unified reference time scale for all other technical elements and system cores. The data model includes data exchange standard protocol and data structure model. It integrates all marine related information, transmits according to the unified business model and data, and establishes a complete information service system to meet the needs of users (Gao and Wang 2019).

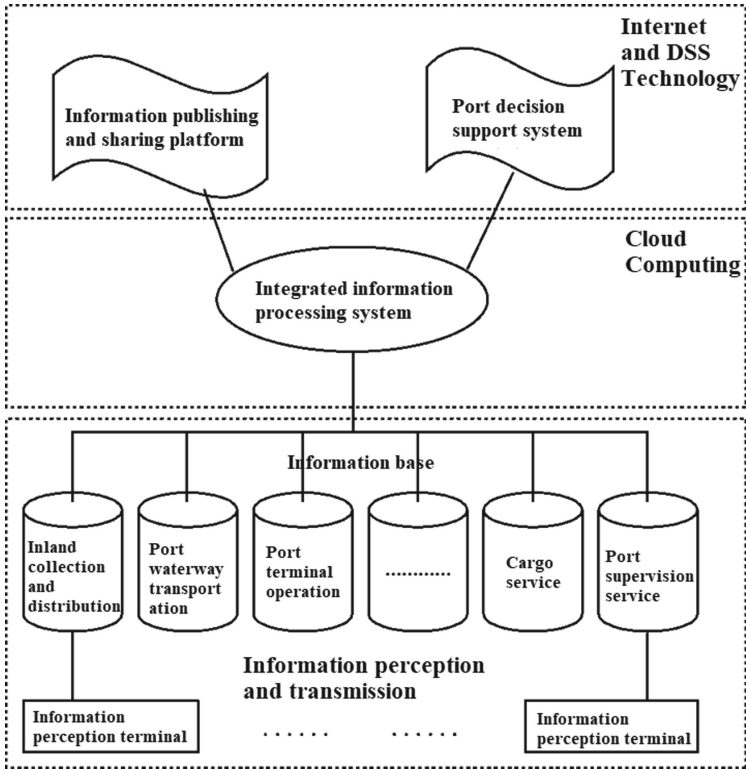


Fig. 4. System structure diagram of intelligent port (Bao 2013)

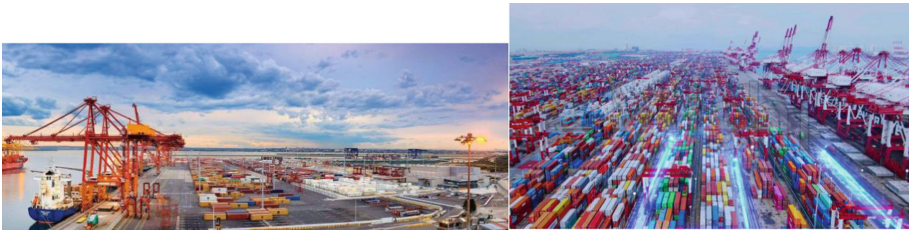


Fig. 5. Schematic diagram of intelligent port

2.4 Intelligent Supervision

With the intelligent development of ships and ports, shipping supervision must change and progress, realize intelligent supervision in ship inspection, safety supervision, health and epidemic prevention, border inspection and commodity inspection, promote the integration and sharing of information, realize a single window, comprehensively create a new pattern of shipping supervision with information and intelligent means, develop and utilize supervision resources and improve quality and efficiency.

2.5 Intelligent Services

Intelligent service is to realize intelligent shipping scheduling and shipping service through an open, standard and unified shipping comprehensive information service system based on multi-dimensional information resources. By exchanging and sharing data resources, various intelligent information services such as channels, ports, ships, logistics, pilotage, rescue, shipping management, shipping market and public services can be realized; Realize the release, exchange and sharing of information among shipping participants; Integrate various shipping business application systems, process and exchange relevant data and information, and provide government services, business services and public information services for all shipping participants.

3 Typical Cases of Intelligent Shipping

3.1 COSCO Intelligent Ship

Intelligent ship is an important part of intelligent shipping. The core of intelligent ship is ship energy efficiency system. Energy efficiency system is a cooperative system between ship and shore, and a control system for ship operation information and performance indicators. Ocean Shipping Group will cooperate with group A in the 20th century. According to the group’s intelligent technology, the installation of its ships can monitor and detect the marine environment and ship performance. After mastering the data, it can monitor the operation of the ship and even the whole team. After half a year of trial operation, it will evaluate the economy before and after operation. The following table shows the economic improvement results between intelligent ships and traditional ships (Table 1).

Table 1. Benefit evaluation of single ship intelligent ship (Duan 2017)

Projects	Saving ratio	Amount (thousands of US dollars)
Route	1.5%	50
Speed	0.5%	150
Course	1.5%	50
Equipment	1.0%	75
Fuel	0.5%	150
Maintenance	1.0%	75
Testing	1.5%	50
Operation index	1.5%	50
Assets	1.0%	75
Other	2.5%	30
Total	12.5%	755

In terms of operation results, the installation of energy efficiency system can upgrade traditional ships to intelligent ships, which can save about US \$7.855 million per ship every year, save human resources, save expenses and improve management level in daily operation. This result improves the feasibility of changing from single ship intelligence to fleet intelligence in the future, which not only saves expenses, but also saves resources, protects the environment and liberates the labor force.

3.2 Xiamen Ocean Automation Terminal

When artificial intelligence and 5g emerging technologies are organically combined with Xiamen ocean terminal, the automatic shipping terminal brings not only management transformation and efficiency improvement, but also a milestone of national marine terminal automation. In the upgrading process of traditional wharf, mechanical automation came first, and now it is a comprehensive intelligent simulation platform. Compared with traditional container terminals, fully automated container terminals can reduce operation and operation costs, save energy by more than 25% and reduce carbon emission by more than 16%.

Thanks to the help of intelligence, Xiamen ocean automation terminal saves more than 25% of energy, improves efficiency by 20% and reduces front-line operators by 70% compared with traditional terminals. The container throughput has increased from 300000 containers at the beginning of production in 2011 to more than 2 million containers in 2018. After seven years of production, the terminal throughput has increased nearly seven times. In 2019, Xiamen ocean automation terminal will continue to maintain double-digit growth. Since Xiamen ocean terminal fully automated wharf was put into commercial operation in March 2016, it has achieved “zero” safety accidents, and the container volume, work efficiency and economic benefits have been accelerated. The construction and completion of Xiamen ocean automation terminal is leading the new trend of terminal development in China in the future. Xiamen ocean automation terminal is shown in Fig. 6.



Fig. 6. Xiamen ocean automation terminal

4 Conclusion and Prospect

Starting from the concept and background of intelligent shipping and the current economic and social environment, this paper introduced the connotation of intelligent shipping and the research status in China and abroad, and gave examples of the excellent application of intelligent shipping. Intelligent shipping, as a new term with a short history and rapid development, has brought many conveniences and advantages. At the same time, there are still many problems in the development of intelligent shipping, such as the immature technology of intelligent system; relevant top-level design, policies and regulations are not perfect; network security risks and increased firewall security risks and so on. Compared with the problems, the greater impact must be positive. China's shipping industry has been at a low ebb since reaching its peak in the early 20th century, and its development speed is slow. The emergence of intelligent shipping is the industrial transformation of the shipping industry in the new era stage in combination with emerging technologies. It deepens the innovative ideas of intellectualization, modernization and efficiency into the shipping industry, promotes the transformation and upgrading of shipping, and intelligent shipping plays an important role in building a new shipping format. It plays an important role in building a transportation power, realizing transportation modernization, improving service level and people's satisfaction. Promoting the upgrading of intelligent shipping in the direction of water conservancy is also one of the tasks in the new stage.

For the further development of intelligent shipping, some constructive suggestions are put forward:

- (1) In terms of management methods, China should strengthen the construction of intelligent shipping laws and regulations, establish a set of basically perfect shipping process operation management system within the Ministry of transport, and realize shipping standardization and intelligence.
- (2) In terms of technology, it is necessary to strengthen the research on intelligent shipping technology, actively learn from the advanced experience of foreign intelligent shipping, make it suitable for local conditions, and create a set of mature intelligent shipping system technology.
- (3) In terms of talent training, we should strengthen the training of intelligent shipping related talents, so that young people can use more flexible ideas to contribute to the intelligent shipping system. We will vigorously carry out the integration and intersection of disciplines, so that different professional and technical personnel can develop intelligent shipping from different angles.
- (4) In terms of top-level design, we should not copy the technologies of other countries, but firmly grasp the core technologies in our own hands that cannot be copied by other countries to realize the great rejuvenation of the Chinese nation.

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