DOI 10.15302/J-SSCAE-2019.06.005

# Development Strategy of Intelligent Ship Engineering Technology

**Lang Shuyan[1], Zeng Xiaoguang[1], Zhang Min[2]**

1. Shipbuilding Information Center of China, Beijing 100101, China
2. China Shipbuilding & Offshore International Co., Ltd., Beijing 100861, China

**Abstract:** With the rapid development of emerging technologies, intelligent ship development has become an important field in the shipbuilding industry. In this study, the technical classification of intelligent ships is introduced, the current development status of intelligent-ship technology is summarized, the characteristics of its development outside China are discussed, and some existing problems associated with its development in China are analyzed. Furthermore, it is suggested that China should pay equal attention to both the R&D and the application of intelligent-ship technology, promote its development step by step, strengthen cooperation among industry, universities, and research institutes, establish a comprehensive service mode with ship–shore integration, and further strengthen the formation of talent teams.
**Keywords:** ship intellectualization; intelligent-ship technology; intelligent ship

In recent years, with the rapid development of emerging technologies, intellectualization has gradually become a reality. The introduction and application of such concepts as the “smart car,” “intelligent hospital,” and even “smart city” are significantly changing people’s lives. In the traditional shipbuilding industry, due to external technology promotion and endogenous demand, the development of intelligent-ship technology is accelerating, resulting in the development of intelligent ships and advancing the industry to new levels.

## 1 Classification of intelligent-ship technology

Intellectualization refers to applying the use of data transmission technology, information technology (IT), artificial-intelligence technology, and numerical-control technology to an object. These applications mainly include self-learning, fault diagnosis, self-evaluation, situation awareness, and behavioral decision-making [1]. Intellectualization generally has four characteristics. First, the object has the ability to sense external information, collecting and organizing information from its external environment. Second, the object is capable of automatic analysis, in which existing program settings and knowledge reserves are used to analyze, compare, calculate, and predict the induced external information. Third, it has a self-learning ability, which entails analyzing the data and information from previous cases and repeatedly learning the knowledge generated by new environmental changes. Fourth, it has the ability for autonomous decision-making, i.e., analyzing changes in the external environment to form and transmit corresponding countermeasure information.

The “intelligent ship” concept not only includes the ship itself, but also ship design, construction, and operation. The rise of emerging technologies simplifies the ship design and construction processes, optimizes ship functions,

**Received date:** October 12, 2019**;** **Revised date:** October 19, 2019
**Corresponding author:** Lang Shuyan, engineer of Shipbuilding Information Center of China. Major research field is marine equipment technology. E-mail: csic_lsy@163.com
**Funding program:** CAE Advisory Project “Research on Maritime Power Strategy by 2035” (2018-ZD-08); CAE Advisory Project “Strategic Research on the Engineering Science and Technology of Intelligent Marine Transportation Equipment for 2035” (2017-ZCQ-1)
**Chinese version:** Strategic Study of CAE 2019, 21 (6): 027–032
**Cited item:** Lang Shuyan et al. Development Strategy of Intelligent Ship Engineering Technology. *Strategic Study of CAE*, https://doi.org/10.15302/J-SSCAE-2019.06.005

improves efficiency and benefits, and provides cost-efficient alternatives [2]. A classification of intelligent-ship technology is presented in Table 1.

**Table 1.** Intelligent-ship technology classification.

| Technical collection | Technology items |
|---|---|
| Intelligent equipment | Energy efficiency management |
| | Cargo management |
| | Situation awareness |
| | Communication navigation |
| | Ship path planning |
| | Condition monitoring and fault diagnosis |
| | Autonomous voyage |
| Intelligent design | Expert system |
| | Machine learning and assistant decision-making |
| | Deep learning and artificial-intelligence design |
| Intelligent manufacturing | Intelligent workshop |
| | Smart factory |
| Intelligent shipping | Vessel traffic service |
| | Shipping logistics service system |
| | Intelligent port |

## 2 Intelligent-ship development status

### 2.1 Intelligent-ship development status outside China

In the area of intelligent-ship equipment, the advancement of emerging technologies, such as cloud computing, satellite communications, and sensor technology, has driven the ship industry toward digitalization, networking, and intellectualization. Intelligent ships have afforded new opportunities for the development of ship safety, energy efficiency, environmental protection, and high performance. They have brought a new hope to the shipping industry in terms of cost reduction and increased efficiency as well as contributing to a low-carbon economy. Intelligent ships have provided a new impetus and direction for the development of shipbuilding technology [3]. At present, the United States, Japan, South Korea, and some European countries are actively developing intelligent-ship equipment technology. The development paths are mostly similar; however, each path has its own focus.

In 2010, Hyundai Heavy Industries launched the Smart Ship 1.0/2.0 plan. The research content of the project aims to develop a remote monitoring system for the main engine of a ship based on the communication technology of the integrated management network of the wireless ship to achieve cost-effective, safe, and efficient navigation services. In 2011, Samsung Heavy Industries developed a ship energy efficiency management system that can collect and organize data from the ship engine room during operation. Through communication, data analysis, and decision support technologies, it improves the intelligence level of ship energy efficiency management. In addition, in December 2012, a number of companies and research institutes, including the Japan Shipbuilding Association and Japan Ship Technology, began to conduct research on the intelligent-ship application platform project. The intelligent-ship application platform is mainly achieved through the development of intelligent information and control systems, enabling the ship to implement engine room condition monitoring, hull external environment sensing, remote operation and maintenance, and other functions (Fig. 1). In 2016, Rolls Royce published the “Advanced Autonomous Waterborne Application” (AAWA) white paper. The AAWA white paper predicts that by 2020, remote operation and auxiliary function operations will be used to reduce the crew on ships; remote control of offshore ships will be implemented by 2025; and remote control of ocean unmanned ships will be implemented by 2030 (Fig. 2).

DOI 10.15302/J-SSCAE-2019.06.005

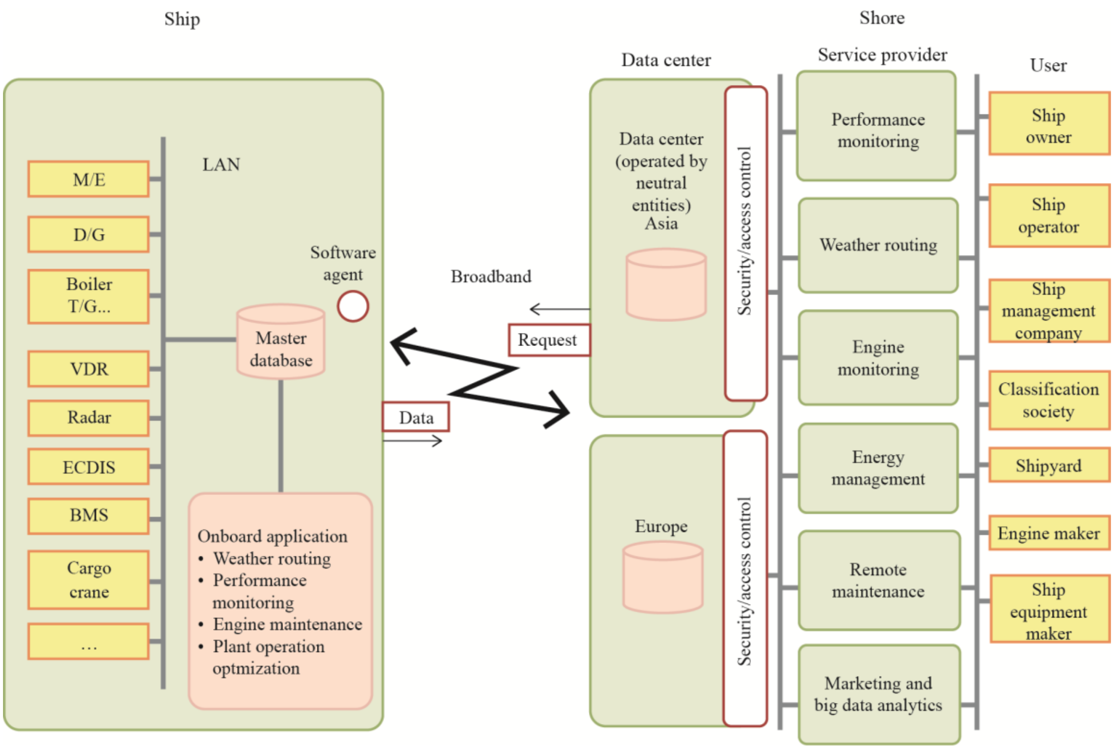


**Fig. 1.** Intelligent-ship application platform system.

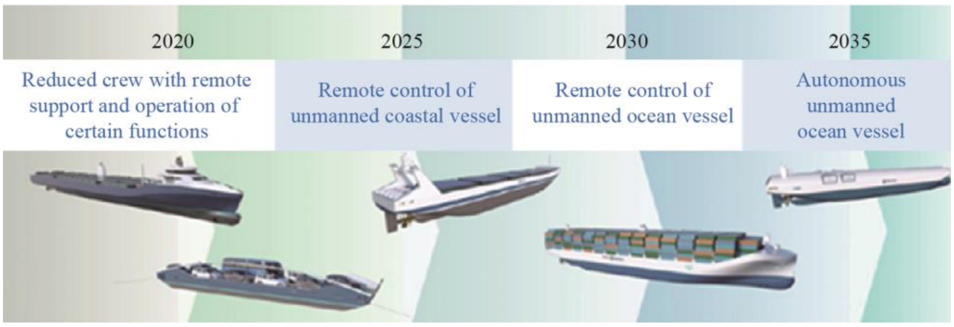


**Fig. 2.** Rolls Royce unmanned-ship technology development roadmap.

In terms of pioneering intelligent-ship design, the United States, Japan, South Korea, and European countries are currently leading the industry, where three-dimensional (3D) design modeling is commonly used. In terms of information integration and sharing, collaborative design and production have been achieved through the use of a product data management system. In 2009, American Electric Ship Corporation completed the research of the Design for Manufacturing project with the goal of building two Virginia-class submarines each year and reducing the cost to $2 billion per ship. In the same year, the United States took computer aided three-dimensional interactive application (CATIA) as the core element in the design of CVN-78 aircraft carriers. Based on the application of cave automatic virtual environment technology, it implemented a new generation of immersive 3D virtual-reality systems, rapidly operationalizing virtual reality, to achieve browsing, roaming, and collaboration based on CATIA design models.

In terms of intelligent manufacturing, major shipping companies around the world are actively deploying intelligent manufacturing models, hoping to use the abundance of data available to improve design and construction efficiency. To revitalize the shipbuilding and marine industry, the South Korean government has actively promoted the construction of smart shipyards and proposed a series of key research and development (R&D) plans. The Japanese government has proposed the concept of "i-shipping," which aims to use digital technologies, such as the Internet and big data, to build visual shipyards. In 2016, Daewoo Shipbuilding & Marine Engineering proposed the "Shipyard 4.0" concept, which is intended for building an Internet of Things (IoT) platform, extending the 3D design and production information system to mobile platforms, and supporting enterprises build smart factories. In 2017, Hyundai Heavy Industries proposed the construction of a “smart factory,” which mainly includes the construction of a smart working environment, layout of narrowband IoT, construction of energy storage and energy management systems, and the use of virtual-reality technology for security management and control.

In terms of intelligent shipping, from a global perspective, many countries are actively promoting intelligent-shipping research. Merchant Shipping Mitsui announced the establishment of an intelligent-shipping office, which aims to achieve advanced support technology for safer ship operations through the application of information and communication technology. Mitsui has become a reliable logistics business partner for multiple customers around the world. In 2017, Wartsila acquired the British Guidance Marine company, using the core competitiveness of the Guidance Marine company, including the development of position measurement sensors and systems for high-precision control applications, to complement Wartsila’s activities in the radar technology, navigation, and dynamic positioning fields, and to accelerate the introduction of the shipping industry into a new era of high efficiency.

### 2.2 Intelligent-ship technology development status in China

In terms of intelligent-ship equipment, in 2017, the China State Shipbuilding Corporation Limited (CSSC) delivered the first intelligent ship in the world, Dazhi. Compared with conventional ships, Dazhi can provide ship owners a more comprehensive and in-depth data collection, analysis and mining, and optimized decision-making services, thereby reducing operating costs, reducing key system and equipment failures, and reducing equipment maintenance costs, while also making ships safer, environmentally friendly, and more comfortable [4]. In 2018, construction of the Wanshan unmanned-vessel offshore test site in Zhuhai, Guangdong Province, was officially started. According to relevant plans, as the first unmanned marine test site in Asia, the Wanshan marine test field will be the largest unmanned marine test field in the world after completion.

In the area of intelligent design, Shanghai Shenbo Information System Engineering Co., Ltd. and Shanghai Shipyard jointly developed the shipbuilding 3D design system SB3DS in 2017. In 2012, based on a digital design (computer-aided design) system, COSCO Kawasaki in Nantong developed a digital process design (computer-aided process planning) and digital manufacturing (computer-aided manufacturing) system that integrates the design and manufacturing systems.

In terms of intelligent manufacturing, the fourth robot automation production line of COSCO Kawasaki in Nantong was completed and put into production in 2015. This production line has a high degree of automation, the robot and welding parts can be flexibly adjusted, efficiency can be improved by more than 40%, and the complete process can be operated throughout the day. In 2018, the China Shipbuilding Industry Corporation (CSIC) launched the first intelligent unmanned production line in the Chinese shipbuilding industry, which can produce 30 000 pieces of special pipe fittings. A laser vision system is used to start the assembly welding system process, which can increase the production capacity of the existing production line by 15%, and to achieve the flexible fully automatic unmanned manufacturing of straight pipe.

In terms of intelligent shipping, the Shanghai Yangshan Deep Water Port construction officially started its fourth-phase in 2014. The terminal is a “green terminal” with zero emission. It adopts a multiple-yard operation interaction mode and uses electric-powered technology, second generation port ship–shore-based power supply, new energy-saving light fixtures, solar-assisted heating, among other technologies. In 2018, the new e-commerce platform website of COSCO SHIPPING was officially launched. The new version of the website shifts from the perspective of the previous ship owner to the perspective of the user, starting with customized services to meet customer needs, continuously optimizing various functions and processes around the many user needs, and launching active information services for customers.

### 2.3 Summary

#### 2.3.1 Development of intelligent-ship technology outside China has been carried out and implemented in stages

From the perspective of the development route, intelligent-ship technology outside China has successively experienced the information integration stage, information interconnection and interoperability stage, information analysis and processing stage, and real-world ship application demonstration stage. In the information integration stage, a representative information integration platform can collect data on hull energy consumption, navigation environment, and shipboard equipment. The interconnecting stage is mainly focused on the development of

DOI 10.15302/J-SSCAE-2019.06.005

communication technology; for example, the wireless/integrated ship management network communication technology is designed to establish ship–shore as well as ship–ship information interaction. In the information analysis and processing stage, Internet technology, artificial intelligence technology, and data analysis technology are applied to the ship data processing and analysis to monitor and control the operating status of the ship. Finally, the real-world ship test and application demonstration stage is primarily focused on intelligent-ship development [5,6].

2.3.2 Assisted decision-making and autonomous navigation play a key role in the development of intelligent-ship technology

Auxiliary decision-making refers mainly to the establishment and maintenance of the hull database, which provides auxiliary decision-making information for the safety and structural maintenance of the hull throughout its life cycle. Simultaneously, it can also provide auxiliary decision-making for ship maneuvering through automatic collection and monitoring of hull-related data. Autonomous navigation refers to the use of computer and control technology, among other factors, to analyze and process the perceived and acquired information and to design and optimize the ship's route and speed. With a shore-based support center, ships could achieve autonomous navigation to automatically avoid collisions in open waters, narrow waterways, and complex environmental conditions.

2.3.3 Intelligent-shipyard technology develops rapidly, gradually forming a three-step development strategy

In recent years, ship enterprises (including those in Japan and South Korea) have performed extensive work in the implementation of the intelligent shipyard and have gradually formed a three-step development strategy in the R&D process. For example, the first step in South Korea's three-step strategy is to achieve the integration of its information management systems, comprehensive automation, digitalization and intellectualization of manufacturing processes, and real-time monitoring and management of all elements based on IoT technology. The second step is to implement the construction of a digital virtual intelligent shipyard. The third is to advance toward implementing the intelligent shipyard with the coordination of humans and the environment. Japanese shipbuilding enterprises aim at advanced IT, promoting the deep integration of big data, IoT, virtual-reality technology, and industrial development with the purpose of: (1) developing visualization and a data-based operation process, (2) promoting an intelligent shipbuilding cluster to reduce waste in all shipbuilding aspects, and (3) introducing intelligent equipment to optimize the construction process.

2.3.4 Intelligent shipping is moving into the unmanned operation era, and an integrated service platform ensures the development of intelligent navigation

Given cloud storage and big-data analysis technology, intelligent shipping using unmanned ships is increasingly feasible. By calculating the cargo delivery, arrival time, and optimal navigation route information, the unmanned vessel adjusts the navigation plan and realizes the optimal navigation route according to the analysis of real-time weather, sea conditions, and port information data [7]. In addition, through the use of IoT technology and automatic identification system positioning technology for the dynamic monitoring and perception of shipping status, the integrated service platform can achieve cross-departmental and cross-regional information resource sharing, business collaborative processing, reduced logistics costs, energy efficiency and emission reduction, and a smooth, efficient, safe, and environmentally friendly modern shipping system.

## 3 Current intelligent-ship technology situation in China and development gaps

In terms of intelligent-ship equipment, the Chinese shipbuilding industry has made some strides. However, in a time of rapid development, the problems and challenges encountered restrict the development of the shipbuilding industry in China. The arrival of intelligent ships represented a breakthrough for the Chinese shipbuilding industry to accelerate its transformation and upgrading, seize potential market opportunities, and enhance its core competitiveness. In recent years, the pace of R&D of intelligent ships in China has been accelerating. Based on previous research it is determined that China has made some important achievements in the development of intelligent ships. A comparison with global intelligent-ship development shows that, although there is still a gap between China and other countries in some aspects, the overall gap is decreasing.

Presently, 3D modeling has been applied in the intelligent design process of ship enterprises in China; however, it is far from a comprehensive implementation of 3D design in the entire process. Moreover, design and construction still operate as two independent systems that fail to form collaborative operation. Design results are not directly applied to construction. In some stages of design and construction, digitalization is applied, but the complete design to construction process is not considered comprehensively, and the degree of digitalization is still low.

In terms of intelligent manufacturing, as a whole, China is still in the planning and exploration stage. This is mainly reflected in the following: (1) the lack of digital technology reserves in ship design; (2) the low automation and intelligence levels in ship manufacturing equipment and systems; (3) the lack of effective data support in shipbuilding process management and control; and (4) the serious lack of digital process design capacity, including the non unique data source of 3D digital modeling, incomplete process information, and lack of process database support [8].

In terms of intelligent shipping, China still lags behind the developed in some European and American countries, and is immature regarding both vision and technology. Traditional and outdated theories and methods are often used for information system management and development, and the information among enterprises varies significantly. It does not match the management services of shipping enterprises. Thus, satisfactory services cannot be provided. The shipping enterprises do not have a deep understanding of intelligence, cannot clearly formulate the requirements for intelligent shipping, and lack a scientific and sustainable intelligence plan [9].

## 4 Safeguard measures and suggestions for the development of intelligent-ship technology in China

### 4.1 Strengthen top-level design and formulate a phased R&D strategy

At this stage, countries worldwide have formulated detailed R&D strategies in the technological development of their intelligent ships. They have advanced their development plans and goals step by step according to time nodes. In addition, their main intelligent-ship R&D institutions assign great importance to the development mode of combining the R&D process and product application, and they have launched a series of different intelligent-ship types. Therefore, it is suggested that in promoting its R&D projects for intelligent ships, China should pay attention to formulating more detailed R&D strategies and promoting the development of technologies related to intelligent ships according to the plan. It should simultaneously strengthen the promotion and application demonstration of intelligent-ship design and promote the industrialization of intelligent ships.

### 4.2 Enhance technology R&D capacity through multiparty cooperation with the help of external forces

Intelligent-ship technology involves many advanced technologies in many industries. In the process of promoting technology R&D, intelligent-ship R&D institutions in other countries have adopted a multiparty cooperation strategy to enhance the development of intelligent-ship technology. This cooperation is not limited to the shipbuilding industry, but is also implemented in a large number of R&D institutions or enterprises that occupy a leading position in their respective fields, such as data information processing, satellite communication, and computer technology, which have become the object of cooperation in the shipbuilding industry outside China. Therefore, it is suggested that the Chinese shipbuilding industry should strengthen inter-industry and mutual cooperation, cooperation with enterprises that possess technological advantages in relevant fields, promote the cooperation of the intelligent-ship industry with academic and research institutions, and promote the comprehensive development of intelligent-ship technology.

### 4.3 Strengthen the interconnection and enhance the comprehensive service support capacity of ships

Ship–shore integration is an important aspect of intelligent-ship technology and development. Through the establishment of information interaction platforms and shore-based centers, the information interconnection among ships, shore-based centers, ship owners, and shipbuilding enterprises can be achieved. Simulatenously, the shipyard also changes from single-ship manufacturing to the full-life-cycle direction of the ship to provide better services for ship operation. It is suggested that China should focus more on the construction of shore-based centers in the intelligent-ship R&D process and build a global service platform for intelligent ships. Special emphasis should also be placed on supporting equipment in order to adapt to the new mode of intelligent-ship development. The goal is to achieve the transformation from simple ship manufacturing to a comprehensive service.

DOI 10.15302/J-SSCAE-2019.06.005

### 4.4 Strengthen the formation of multilevel talent teams and pay attention to international technical exchanges and cooperation

To attract high-level talent in the area of intelligent ships in a variety of ways, a sizeable group of leading and top young talented individuals should be trained, and a professional network and talent training system for disciplines related to intelligent ships should be constructed. International technology exchange activities should be encouraged, and measures such as scientific and technological cooperation, technology transfer, technology merger and acquisition, joint development and resource utilization, and participation in international forums should be implemented to rapidly improve the development level and innovation ability of intelligent-ship technologies in China.

## References

[1] Liu C G, Chu X M, Xie S, et al. Research status and prospect of ship intelligence [J]. Ship Engineering, 2016, 38(3): 77–84. Chinese.

[2] He C. CCS《Rules for intelligent ships (2015) 》requirements for six functional modules [J]. China Ship Survey, 2016 (3): 84–85. Chinese.

[3] Liang Y F, Xie J Y, Chen H Z, et al. Research on the development of intelligent ships [C]. Zhoushan: Proceedings of the Academic Conference Commemorating the 20th Anniversary of the Founding of Ship Mechanics, 2017. Chinese.

[4] Zeng X G. Intelligent breakthrough of Japanese shipbuilding [J]. China Ship Survey, 2018 (7): 36–37. Chinese.

[5] Lin S Y, Zhong T. Discussion on the relationship between intelligent ship and intelligent aviation security [J]. Science and Technology Innovation Herald, 2018 (25): 120–122. Chinese.

[6] Xia Q B, Wang Y L, Chen R. Research on the development of intelligent shipping [J]. Navigation, 2018 (2): 43–46. Chinese.

[7] Zheng R C, Yang G L, Li Z G, et al. Overview of integrated bridge system [J]. Journal of Chinese Inertial Technology, 2009,17(6): 661–665. Chinese.

[8] Yang J B, Lin C F. Study on the design of marine fuel cell module system [J]. China Water Transport, 2017 (2): 46–47. Chinese.

[9] Zhang Y. Key technologies and application prospects of energy saving for bubble ships [J]. China Water Transport (Second Half of the Month), 2015, 15(2): 94–95. Chinese.