

# Developed Status and Forecast of Intelligent Ship Application

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**Abstract.** The concept of smart ships is not limited to ship autonomous driving, it covers a broader scope, including the full life cycle of ship design, construction, operation and maintenance. By integrating advanced sensors, navigation systems and data analysis platforms, smart ships are able to monitor ship status and the Marine environment in real time, optimize route planning and improve fuel efficiency, thereby reducing energy consumption and greenhouse gas emissions. In addition, smart ships can revolutionize the shipping industry by improving maritime safety and reducing human error through remote control and autonomous decision-making. In recent years, smart ship technology has gradually moved from the theoretical research stage to practical application, and has attracted wide attention from the global shipping industry. A number of international cooperation and research projects have been launched to explore the practical application potential and promotion paths of smart ships. However, the development of smart ships also faces many challenges, including technical difficulties, legal and regulatory restrictions, and public acceptance issues. This paper will deeply discuss the current development status of smart ships, analyze the main challenges it faces, and forecast the future development trend, in order to provide reference and inspiration for the innovative development of the shipping industry.

**Keywords:** Marine transport; Intelligent ship; Automation.

## 1. Introduction

In today's increasingly interconnected and globalized environment, the significance of maritime transport as the backbone of international trade has never been more pronounced. The global economy's intricate network and the escalating volume of trade underscore the pivotal role of maritime transport, which accounts for approximately 90% of world trade [1]. This statistic not only highlights the sector's central position in global commerce but also underlines its indispensable role in sustaining the dynamics of global logistics, transport, and trade flows.

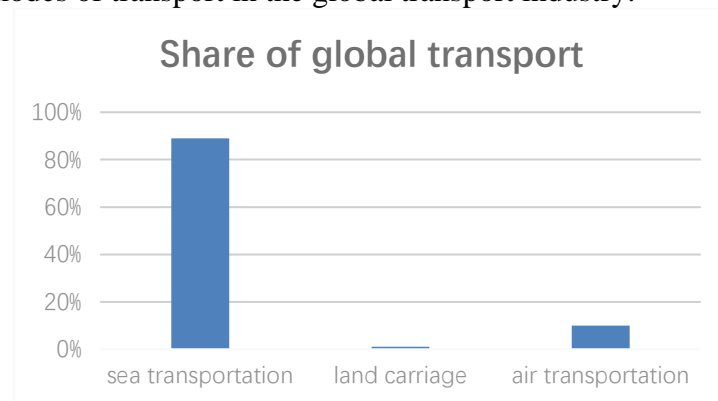
The maritime industry, a vital pillar of global logistics and commerce, finds itself at a crossroads, faced with the dual challenges of enhancing operational efficiency and embracing environmental sustainability. The burgeoning efficiency and environmental protection demands of the global trading system present unprecedented challenges for the shipping industry, including the imperative to improve transport efficiency, reduce operating costs, and transition towards green and sustainable transport methodologies. These challenges are not insurmountable; rather, they have catalyzed the emergence of innovative solutions aimed at revolutionizing the industry.

Intelligent ship technology, leveraging the latest advancements in information technology, automation, artificial intelligence, and big data analysis, stands at the forefront of this innovation wave. Aimed at fostering industry innovation, this technology endeavors to ensure efficient, safe, and environmentally friendly ship operations. The fully autonomous cargo ship Yuna, hailing from Norway, epitomizes the potential that smart ship technology harbors. Alongside Norway, various countries and companies globally are making strides in developing automated docks and remote control technology, illustrating a collective move towards smarter maritime operations.

The literature on maritime transport innovation underscores the sector's critical role in global trade and highlights the emerging challenges and solutions, including the advent of intelligent ship technology. This body of work provides a comprehensive overview of current trends, challenges, and advancements in the field, laying the groundwork for further research and innovation.

This study aims to delve into the nuances of intelligent ship technology within the maritime industry, exploring its potential to redefine the paradigms of efficiency, safety, and environmental

sustainability in shipping operations. In subsequent chapters, we will explore the background and challenges facing the maritime transport sector, provide an in-depth review of the literature on the subject, and articulate the research objectives. This will be followed by a detailed analysis of intelligent ship technology, including case studies such as the Yuna, and an examination of its implications for the future of maritime transport. The study will conclude with a summary of findings, policy recommendations, and suggestions for future research, offering a comprehensive insight into the transformative potential of intelligent ship technology in the maritime industry. Figure 1 shows the share of various modes of transport in the global transport industry.



**Fig. 1** Share of various modes of transport in the global transport industry (Photo credited: original)

## 2. Technical Basis And Application Status Of Intelligent Ship

The International Maritime Organization's (IMO) definition of an autonomous surface vessel (MASS) at sea (IMO, 2018a), which defines a MASS as a ship that can operate independently of human interaction to varying degrees [2]. Smart ships represent a major technological advance in the field of ship design, operation and management, combining advanced information technology, automation, artificial intelligence (AI) and the Internet of Things (IoT) to improve the safety, efficiency and environmental sustainability of ships. A smart ship can be defined as "a maritime asset with significant automation, data communication, system monitoring and data management [3]." The following are some of the key technical foundations and application status of smart ships.

### 2.1. Technical Basis

As a technology-intensive industry, smart ships contain a variety of high and new technologies, among which the most critical technologies of the current smart ships are automation, Internet of things, navigation technology, etc. The application of each technology will be explained in detail below.

**Automation and remote control technology:** Smart ships rely on highly automated systems and remote control operations that allow the vessel to operate with reduced or no human presence on board.

**Artificial Intelligence and machine Learning:** One of the key issues that needs to be addressed at the forefront of smart ship development is navigation situation safety awareness technology. The development of intelligent navigation safety technology is severely restricted by the problems such as the challenging mining and accurate measurement of ships encountering dynamic spatio-temporal change laws and unknown nonlinear spatial representation information [4]. Through AI and machine learning algorithms, intelligent ships can carry out functions such as autonomous navigation, obstacle avoidance, diagnosis and maintenance, improving the safety and efficiency of navigation.

**Internet of Things (IoT) :** Data acquisition is the basis and premise of smart ship data application, comprehensive analysis, evaluation and decision-making using IoT technology, ships can monitor the status of their key structures and systems in real time, and achieve real-time data collection and analysis for optimizing ship performance and maintenance [5]. Developments in the Internet of

Things can be leveraged to deliver smart ships to improve operations, availability and profitability for shipowners, users and workers [6].

**Data communication technology:** Through satellite communications and other wireless technologies, smart ships can exchange real-time data with shore-based control centers, other ships and shipping management systems.

**Integrated Navigation Systems:** Smart ships employ advanced integrated navigation systems that integrate radar, GPS, electronic charts and Automatic identification systems (AIS) to support accurate and safe navigation.

Application status

**Automated operations:** There are already several experimental and commercial projects demonstrating the automated navigation of ships, including short-haul transport and monitoring tasks by unmanned ships.

**Remote Control Centers:** Some shipping companies and technology vendors have established remote operations centers that can remotely monitor and operate ships, especially in complex or high-risk environments.

**Smart Fleet Management:** Through the use of AI and big data technologies, companies are able to optimize fleet operational management, including route planning, fuel consumption optimization, and maintenance planning.

**Environmental Monitoring and Protection:** By monitoring emissions and the surrounding environment, smart ships can help reduce the environmental impact of ships and promote more sustainable shipping practices.

## 2.2. Application Status

Although the development and application of smart ship technology has broad prospects, its commercialization and popularization still face many challenges, including technical standardization, regulatory restrictions, safety issues and high initial investment costs, etc., just like the emerging autonomous vehicle, it is also accompanied by a variety of responsibilities, personal safety, and even ethical issues. In the future, with the advancement of technology and the improvement of relevant policies and regulations, smart ships are expected to play an increasingly important role in the global shipping industry.

Currently, the development of smart ships is in its infancy, but there are several high-profile projects and trials. For example, Yara Birkeland, the world's first fully autonomous cargo ship, made its maiden voyage in Norway, marking an important milestone for smart ship technology. In addition, several countries and companies are conducting research and development of smart ships, exploring a variety of applications including automated dock operations, remote control centers, and ship autonomous navigation technology.

## 3. Discussion

Although the development and application of smart ships have broad prospects, they also face many challenges. These challenges need to be addressed through innovative and collaborative approaches to promote the widespread adoption and sustainable development of smart ship technology. Here are some of the major challenges and their possible solutions.

### 3.1. Challenge And Solution

Countries around the world have been actively involved in autonomous navigation testing and verification research. While the main focus is on establishing test platforms, there is still a serious lack of specific test and verification technologies and systems, as well as a lack of comprehensive test guidelines and standards. There has been a significant lack of progress in researching testing and verification methods for intelligent or unmanned systems, especially when compared to intelligent connected road vehicles [7]. **Technical standardization and compatibility:** Since smart ship

technology is relatively new, there is a lack of uniform technical and safety standards, which may hinder the development and application of the technology. Legal and regulatory issues: Most existing maritime regulations and agreements do not take into account the situation of unmanned and highly automated vessels, which creates uncertainty regarding the operation and liability of smart vessels. Safety and security issues: The use of automation and remote control technologies can expose ships to hacking and cybersecurity threats, increasing the risk to navigational safety.

Technical reliability and personnel training: Smart ships that are highly dependent on advanced technology require high system reliability, as well as training of crew and shore-based operators in new technologies. Cost issues: The high cost of developing and operating smart ships, especially in the initial stages, may limit their widespread application.

Strengthening international cooperation and standardization efforts: The International Maritime Organization (IMO) and other relevant organizations should strengthen cooperation to develop international standards and guidelines for smart ships to promote technology compatibility and interoperability. Develop and update regulations: Governments and international bodies need to update existing legal frameworks to clarify the legal status, responsibilities and attribution of responsibility for smart ships, as well as safety and environmental requirements. Enhance cyber security: Adopt advanced cyber security measures, including encrypted communications, intrusion detection systems, and regular security audits to protect smart ships from cyber attacks. Training and education: Develop specialized training programs to enhance the understanding and operational capabilities of crew and shore-based operators of smart ship technology, ensuring that personnel can effectively manage and maintain highly automated ship systems. Economic assessment and financial support: Conduct a comprehensive economic assessment to clarify the cost-effectiveness of smart ships and explore government subsidies, private investment and other financing mechanisms to reduce initial investment costs and risks. Through the implementation of these solutions, the related technologies and applications of smart ships can be developed more safely and effectively, and ultimately achieve the goals of automation, intelligence and greening of the shipping industry.

### 3.2. Development Prospect And Trend Forecast

The shipping industry is the main way of transnational and even trans-continental transportation of cargo personnel in the world today, and for a long time in the future, ships will still be an indispensable means of transport for human society, which is irreplaceable. With the accelerated development of intelligent technology in the shipping industry, the demand for technology development aimed at using the latest intelligent technology to improve competitiveness is also increasing [8]. Nowadays, the Internet of Things, the Internet of everything, high-precision navigation systems and artificial intelligence continue to emerge and upgrade, making the manufacturing of intelligent ships and a wide range of applications possible. At present, energy conservation and emission reduction is also an important direction of global development, intelligent ships as a new type of ship, with low emissions, high fuel utilization and other advantages, not only save the economy, but also reduce emissions. Hybrid architectures with advanced control strategies can reduce fuel consumption and emissions by up to 10-35%, while improving noise, maintainability, maneuverability and comfort [9], which is conducive to the further development of smart ships. In addition, smart ships can detect fuel leakage by themselves, which greatly reduces the occurrence of fuel leakage accidents [10]. Traditional ships have high requirements for crew, which leads to high labor costs. Smart ships have a high degree of integration and relatively low requirements for labor, which not only reduces shipping costs, but also reduces the cost of shipping. It also reduces the operation errors caused by human factors in the course of ship navigation, so as to cause unnecessary losses. Therefore, the future development of smart ships should be in an upward trend. But smart ships will also have a series of problems, safety issues, ethical issues and so on. The joint efforts of governments, scientific institutions and shipping companies may make the development of smart ships even faster.

## 4. Conclusion

The advancement of intelligent ship technology is reshaping the global shipping industry by harnessing automation, artificial intelligence, the Internet of Things, and data analytics. These innovations enable autonomous navigation, optimize routes, enhance fuel efficiency, and minimize environmental impact, thus bolstering maritime safety and efficiency. Amidst growing globalization and trade, the significance of maritime transport escalates, highlighting the benefits of smart ships, exemplified by Norway's project "Una."

Nonetheless, the path forward for smart ships is fraught with challenges, including the need for standardized technology, updated legal frameworks, cybersecurity safeguards, technical reliability, personnel training, and the management of research and operational costs. Overcoming these hurdles requires international collaboration among the shipping industry, academia, and governmental bodies to foster smart ship development through updated regulations, enhanced security measures, professional training, and financial support.

Looking ahead, as technology and regulations evolve, intelligent ships are poised to play a pivotal role in the shipping industry, enhancing operational efficiency, safety, and environmental sustainability. Despite the obstacles, the potential for transformative impact and long-term industry advancement remains vast, signaling a promising horizon for smart ship technology.

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