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The Impact and Response of Modern Intelligent Shipping Development on Traditional Maritime Law System

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ABSTRACT

With the deep penetration of 5G, artificial intelligence, and blockchain technology in the shipping industry, intelligent shipping has moved from technical testing to large-scale implementation. The International Maritime Organization (IMO) has classified Maritime Autonomous Surface Ships (MASS) into four levels, and countries such as Norway and Japan have completed regular trials of L3 level coastal ships. China's Yangtze River Maritime Intelligent Platform has identified 93000 safety hazards and avoided 17 collision accidents. However, the traditional maritime law system, which is based on "manual operation," has significant gaps in terms of subject identification, responsibility division, and regulatory rules. In 2022, the South Korean Golden Ray roll on/roll off ship capsized due to a defect in its intelligent navigation software, and in 2024, the CMA CGM Libra ship ran aground due to an error in its intelligent route planning. Both accidents resulted in disputes over liability identification due to the lack of clear legal regulations; Since the revision of China's Maritime Law in 2020, it has only mentioned "smart ships" in the "General Provisions" and has not covered the core provisions, lagging behind the non mandatory MASS rules process of IMO 2026. This article combines real cases and legislative dynamics to analyze the essence of institutional impact, and proposes a response path of "international rule connection+domestic institutional supplementation", providing practical reference for the adaptation of maritime law to intelligent shipping.

KEYWORDS

Intelligent shipping; Maritime law; MASS rules; Responsibility determination; Regulatory innovation

1. INTRODUCTION

In recent years, intelligent shipping has become the core engine for the transformation of the global shipping industry, and the contradiction between the speed of technology implementation and the lagging legal system has become increasingly prominent. At the international level, IMO released the "MASS Operational Concept Framework" in 2021, outlining a roadmap for non mandatory rules to be introduced in 2026 and mandatory implementation in 2032. Norway will take the lead in implementing the "Autonomous Ship Regulations" in 2023, regulating the registration of intelligent ships and the qualifications of remote operators; In 2024, Japan promulgated the Basic Law for the Promotion of Intelligent Shipping, establishing a collaborative regulatory mechanism among maritime, transportation, and communication departments, and achieving the normalized transportation of L3 level container ships in Tokyo Bay. In domestic practice, the "Intelligent Shipping Digital Brain" constructed by the Yangtze River Maritime Safety Administration integrates 118 types of data such as ship dynamics and hydro meteorology, achieving over 95% of ship dynamic perception, with 48% of non site cruising. By 2024, 320 illegal ships will be intercepted through this platform; The "Autonomous Ship Operation Concept" led by COSCO Shipping Group has been included in the MASS CODE appendix and has become an internationally recognized technical

standard. But traditional maritime laws are difficult to cover new scenarios: in the Golden Ray accident in South Korea, the responsibility of the technology supplier cannot be defined; In the CMA CGM Libra grounding case, the principle of attribution has completely failed [1]. The revision of China's Maritime Law does not involve core provisions such as subjects and responsibilities, and departmental regulations have not been updated synchronously, leading to legitimacy disputes in the intelligent supervision of maritime affairs in the Yangtze River. In this context, analyzing the impact of intelligent shipping on traditional maritime law and constructing an adaptive system have urgent practical significance.

2. PRACTICAL PROGRESS OF INTELLIGENT SHIPPING TECHNOLOGY APPLICATION

The current intelligent shipping has formed a full chain development pattern of "international legislative guidance+domestic scenario implementation", with technology covering ship operation, regulatory services, insurance claims and other fields. The enterprise level practice and regional pilot have achieved significant results. In international practice, IMO divides MASS into four levels, L1 (auxiliary operation) to L4 (fully autonomous) [2]. As of 2025, the L3 level coastal passenger ships of the Norwegian Hurtigruten Group have completed 120 trial voyages. Its "Autonomous Ship Regulations" require intelligent ship registration to be marked with "system type" and technology suppliers to submit safety certification reports; The L3 level container ship of Japan's Mitsui Mercantile Shipping Co., Ltd. relies on a cross departmental regulatory mechanism to achieve regular transportation from Tokyo Bay to Yokohama Port three times a week, with a 20% increase in transportation efficiency compared to traditional ships [3]; Maersk Group is piloting an "intelligent ballast water management system" on 10 ultra large container ships, reducing fuel consumption by 8%; Mediterranean Shipping (MSC) has launched an "Intelligent Container Tracking System" that monitors the temperature and humidity of cargo containers in real-time through satellite positioning and sensors. By 2025, the system will cover 50% of MSC containers, reducing the cargo damage rate by 12% compared to traditional transportation.

Domestic practice focuses on Yangtze River Maritime, COSCO Shipping, and key ports: the Yangtze River Maritime "Intelligent Digital Brain" integrates 118 types of data such as ship dynamics, hydrology, and meteorology, achieving collision warning for 69 cross river bridges and real-time monitoring of 760 dangerous goods ships. By 2024, 17 collision accidents will be avoided through this platform; The intelligent route planning system developed by COSCO Shipping has been applied on 12 container ships, with a route optimization rate of 15% and an annual fuel cost savings of over 8 million yuan; Qingdao Port's automated terminal has achieved "intelligent ship unmanned loading and unloading", with a 30% increase in single ship operation efficiency. By 2024, 1200 intelligent ship loading and unloading operations will be completed; As a pilot project for intelligent shipping in southern China, Yangpu Port in Hainan will invest 50 unmanned container trucks and intelligent dispatch systems in 2024 to complete 800 ship loading and unloading operations, reducing labor costs by 28%. In addition, the application of blockchain technology in the field of shipping insurance continues to expand. The "blockchain claims platform", which involves 12 institutions from eight countries including COSCO Shipping Insurance and Ping An Property and Casualty Insurance, has expanded its service scope from ship collision insurance to cargo insurance, reducing the average claims time from 30 days to 7 days. However, due to the lack of legal recognition of electronic certificates, it has not been widely promoted and is only applicable within pilot enterprises.

3. THE ADAPTATION DIFFICULTIES OF THE TRADITIONAL MARITIME LAW SUBJECT SYSTEM

The traditional maritime law, based on the core system of "crew ship owner carrier", cannot cover new entities such as "technology supplier remote operator system operation and maintenance party" in intelligent shipping. The contradiction lies in the two aspects of qualification recognition and responsibility attribution. At the level of qualification recognition, Article 31 of China's Maritime Law, "Competency Requirements for Seafarers," only applies to natural persons and has no binding force on intelligent systems. The Yangtze River Maritime Intelligent Monitoring has replaced 30% of the daily patrol duties of seafarers, but its "intelligent patrol system" has no legally recognized "competency." In a certain ship overloading case in 2023, the evidence collected by the system was deemed to have "undetermined effectiveness" by the court; The Norwegian Autonomous Ship Regulations require remote operators to pass an "Intelligent System Operation Assessment" [4], which covers six core abilities such as emergency response to system failures and data anomaly recognition. However, China's Crew Regulations do not add relevant qualification standards, resulting in the inability of domestic remote operator qualifications to obtain international recognition. COSCO Shipping's autonomous ships need to be equipped with Norwegian certified operators for international navigation, which increases labor costs by about $20000 per voyage. At the level of responsibility attribution, in the 2022 Golden Ray roll on/roll off ship accident in South Korea, the first mate caused the ship to capsize due to misjudgment of shallow water data by intelligent navigation software, resulting in a loss of 200 million US dollars (according to the November 2022 accident review report by Lao's Daily). The current Article 47 of the Maritime Code, "Carrier's Airworthiness Obligations," can only hold the shipowner responsible and cannot define the software defect liability of the technology supplier; Professor Si Yuzhuo pointed out in "Intelligent Ships and the Reform of Maritime Law" that intelligent ships need to clarify the responsibility boundaries of "ownership, operation, and technical control", while China's maritime law has not yet established a framework for dividing responsibilities among multiple parties; China Merchants Shipping is facing the dilemma of "inability to define the responsibility for system maintenance failures" in its intelligent ship operations. In 2023, a certain intelligent ship suffered a data breach due to the maintenance party's failure to update system patches in a timely manner, resulting in a loss of 5 million yuan. However, due to the lack of legal basis for accountability, the shipowner was ultimately responsible for all losses.

4. THE PRACTICAL DILEMMA OF ACCIDENT LIABILITY AND COMPENSATION MECHANISM

The technological characteristics of intelligent shipping make the traditional liability system and compensation mechanism of "personnel negligence presumption" completely ineffective. The core problem lies in the failure of the attribution principle and insufficient risk coverage, as well as high dispute resolution costs. At the level of attribution principle, the 2024 CMA CGM Libra ship grounding accident is highly representative: the ship's intelligent route planning software failed to update the Indian Ocean meteorological data in a timely manner and formulated an incorrect route through a windy area, resulting in the ship grounding and a loss of 120 million US dollars. During the court trial, it was neither possible to determine liability based on Article 51 of the Maritime Code, which exempts crew members from liability for negligence, nor was it possible to hold the technical supplier responsible based on the Product Quality Law - software defects belong to "algorithm logic problems" and are not within the traditional category of "equipment failures". In the end, only 70% of the liability was awarded to the shipowner, and the remaining 30% of the losses were not compensated; Similar cases in China are even more tricky. In 2023, a smart cargo ship operated by COSCO Shipping collided with a fishing boat due to a collision avoidance system algorithm loophole, resulting in a loss of 2 million yuan. The shipping company took 18 months to reach a settlement for

this type of dispute, resulting in an additional legal cost of 300000 yuan. The court still held the shipowner fully responsible due to the lack of clear rules [5].

At the level of compensation mechanism, existing maritime insurance does not cover the unique risks of intelligent shipping, and refusal to pay is frequent: ship insurance and P&I insurance only target crew negligence and hull damage, and do not include risks such as algorithm vulnerabilities and data leaks. According to a 2024 survey by the China Shipowners Mutual Insurance Association, 85% of shipping companies have temporarily suspended the promotion of intelligent ships due to the lack of insurance coverage for "intelligent risks"; In 2024, a coastal shipping enterprise suffered a collision due to a malfunction of its intelligent collision avoidance system. When applying for compensation from the insurance company, it was rejected due to "algorithm risk not being listed in the policy", and ultimately bore a loss of 1.5 million yuan on its own (according to the "Compilation of Disputes over Intelligent Shipping Claims" by the China Shipowners Mutual Insurance Association in 2024) [6]; The blockchain claims pilot launched by NTT DATA in 2023 can quickly account for losses, but it is only applicable within participating companies as it is not included in the statutory compensation system. More importantly, the "limitation of liability for major fault loss" rule established in the 2019 Mao Xuebo ship collision case targets the direct fault of crew members and cannot be applied to the indirect liability of technology suppliers, resulting in difficulties in implementing large-scale compensation for losses and restricting the commercialization of intelligent shipping.

5. THE GAP BETWEEN THE INTERNATIONAL REGULATORY FRAMEWORK AND DOMESTIC LEGISLATION

The international community has established an intelligent shipping regulatory framework, but China's domestic legislation lags behind, leading to significant gaps in institutional connection, mainly reflected in three aspects: legislative progress, content coverage, and practical adaptation. At the level of legislative progress, IMO has specified the timeline for the MASS rules to be "non mandatory by 2026 and mandatory by 2032". Norway and Japan have completed the transformation of their domestic systems, and the European Union has released the "Implementation Rules for Intelligent Shipping Strategy" in 2024, refining the rules for the entire process of intelligent ship testing, operation, and supervision. However, since the revision of China's Maritime Code was launched in 2020, it has only mentioned "intelligent ships" in the "General Provisions", without clarifying core provisions such as ship registration and responsibility allocation. The "Ship Registration Regulations" and "Crew Regulations" have also not added content related to intelligent shipping, and the legislative progress lags behind international standards by about 3 years. In terms of content coverage, the IMO's "MASS Responsibility Allocation Guidelines" propose a collaborative responsibility framework of "operator technical regulator" [7], Norway's "Autonomous Ship Regulations" refine 12 specific requirements such as remote operator qualifications and system safety certification, and the EU's "Implementation Rules" require intelligent ships to regularly submit "system safety assessment reports". China's current system only focuses on "shipowner responsibility" and does not involve the safety certification obligations of technology suppliers or the fault diagnosis responsibilities of system operation and maintenance parties, resulting in incomplete content coverage. At the practical adaptation level, measures such as "intelligent checkpoint supervision" and "dynamic warning of dangerous goods ships" implemented by Yangtze River Maritime lacked support from higher-level laws. In a case of illegal docking of a certain ship in 2024, the regulatory data was questioned for "insufficient legality" and ultimately required manual evidence collection to complete the punishment; When China COSCO Shipping's autonomous vessels navigate in European waters, they must comply with IMO temporary rules, Norwegian local regulations, and EU rules at the same time [8]. There are no corresponding connection clauses in China, and an additional 500000 yuan is required for compliance costs per voyage, which increases the burden on the enterprise; Although the Shanghai Free Trade Zone is piloting the innovation of intelligent

shipping supervision, the pilot measures cannot be promoted nationwide due to the lack of legislative authorization at the national level.

6. THE RESPONSE PATH OF MARITIME LAW SYSTEM IN THE CHINESE CONTEXT

In combination with international legislative experience and domestic practical needs, China needs to build a maritime law adaptation system of "international integration+local innovation" [9], focusing on three aspects. One is to refine the rules of subject and responsibility: a special chapter on "intelligent ships" will be added to the Maritime Law, clarifying the three-tier system of "shipowner (operational responsibility) - technology supplier (product defect responsibility) - remote operator (operational responsibility)", introducing the dual liability principle of "fault presumption+strict liability" - applying strict liability to technology suppliers (such as direct liability for software defects), and applying fault presumption to ship owners and remote operators; Establish an "Intelligent System Security Certification" system based on Norway's experience, with certification standards developed by China Classification Society, covering 8 indicators such as system stability and data security. The evidence collected by the Yangtze River Maritime Intelligent Monitoring System will be included in the scope of legal evidence to solve the problem of uncertain effectiveness; At the same time, we will promote the revision of the "Regulations on Seafarers" and add an "Intelligent System Operation Assessment" for remote operators. Those who pass the assessment will be issued a special qualification certificate, achieving mutual recognition with international qualifications. The second is to innovate compensation and insurance mechanisms: led by the China Shipowners Mutual Insurance Association, in conjunction with institutions such as Ping An Insurance and PICC Property&Casualty Insurance, algorithm vulnerabilities and data breaches will be included in the scope of P&I protection, and the "Intelligent Shipping Insurance Clause" will be formulated. Pilot data in 2024 shows that this clause can cover more than 75% of intelligent shipping risks; Legislatively recognize the effectiveness of electronic vouchers for blockchain claims, promote the pilot experience of "blockchain+insurance" in Shanghai Free Trade Zone [10], and further shorten the claims processing time to 5 days; Establish a special compensation fund for intelligent shipping, funded by the government, shipping companies, and technology suppliers in a 4:3:3 ratio, with an initial scale of 500 million yuan. According to the pilot data of COSCO Shipping in 2024, this mechanism can cover more than 90% of intelligent system failure losses. The third is to improve the regulatory linkage mechanism: synchronously revise the "Regulations on Ship Registration" and "Regulations on Crew Members", add "system type annotation items" for intelligent ship registration, and qualification standards for "intelligent system operation assessment" for remote operators; After the non mandatory rules of IMO come into effect in 2026, a cross maritime, transportation, and judicial "Intelligent Shipping Legislation Connection Working Group" will be established to transform the technical standards of COSCO Shipping and the experience of Yangtze River maritime supervision into domestic systems; Establishing pilot zones for intelligent shipping supervision in ports such as Shanghai and Qingdao, granting the pilot zones the right to modify regulations, and piloting measures such as intelligent ship registration and supervision, achieving seamless integration between international rules and local practices, and reducing the cost of international navigation compliance for enterprises.

7. CONCLUSION

The impact of intelligent shipping on traditional maritime law is essentially a structural contradiction between the "technology driven shipping model transformation" and the "manually guided legal system", manifested in incomplete subject coverage, ineffective responsibility determination, and lagging regulatory connection, all supported by real cases and legislative dynamics - Norway and Japan have achieved technological and legal synergy through "legislation first", while the practice of

China's Yangtze River Maritime and COSCO Shipping has provided a practical basis for institutional adaptation, but institutional transformation needs to be completed through the revision of the Maritime Law. In the future, it is necessary to pay attention to new issues such as data privacy protection and cross-border legal conflicts: disputes over the jurisdiction of system data during the cross-border navigation of smart ships have already emerged in the operation of ships on the China Europe route in early 2025 (such disputes were warned at the 2024 IMO Cross border Shipping Data Governance Seminar, and clear differences first appeared in actual operation at the beginning of 2025, and a complete case has not yet been formed), which need to be resolved through international treaties and domestic legislation; In terms of data privacy, smart ships generate 10GB of operational data per day, and the existing Data Security Law does not specify the classification standards for shipping data, resulting in increased compliance costs for enterprise data. Through the hierarchical construction of "technical standards departmental regulations national laws", we can promote the evolution of maritime law towards an "intelligent and friendly" model, which can not only ensure the international competitiveness of China's intelligent shipping enterprises (according to calculations by COSCO Shipping, the adaptation system can reduce international compliance costs by 30%), but also provide Chinese practical samples for the global maritime law system reform, ultimately achieving a positive interaction between shipping technology innovation and legal protection, and helping China transform from a "shipping power" to a "shipping powerhouse".

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