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Effects of maritime autonomous surface ships and important problems of maritime autonomous surface ships to strengthen port competitiveness

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항만경쟁력 강화를 위한 자율운항선박의 효과와 자율운항선박의 쟁점 사항

이기영

Abstract

Maritime Autonomous Surface Ships are cutting-edge ships that analyze and operate optimal routes on their own, focusing on core technologies of the 4th Industrial Revolution such as artificial intelligence, blockchain, Internet of Things, and data processing devices. Maritime Autonomous Surface Ships, the fourth industrial revolution on the sea, are ships built on the premise of being eco-friendly and are a high value-added industry that is competitive in the global environment of the decarbonization era.

In the era of the 4th Industrial Revolution, commercialization of Maritime Autonomous Surface Ships is an essential element to strengthen port competitiveness. Therefore, this study examines the effect of introducing Maritime Autonomous Surface Ships through examples in terms of strengthening port competitiveness and examines issues necessary for commercialization of Maritime Autonomous Surface Ships.

Key words: Maritime Autonomous Surface Ships, MASS, Port Competitiveness, AI

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Ⅰ. Introduction

Maritime transportation has played the most important role in realizing international commerce transactions. Maritime transportation has played a leading role in international transportation from ancient times to modern times, and the emergence of containers maximized synergy effects and had a significant impact on the emergence of multimodal transportation. In particular, after World War II, the technology used to build warships was transferred to the civilian merchant shipping sector, leading to larger and faster ships. Since then, the development of information and communication technology has led to further development of the entire industry, leading to the Fourth Industrial Revolution. The 4th Industrial Revolution is affecting all industries and is changing the overall flow of human life based on technologies such as artificial intelligence, cloud, blockchain, and the Internet of Things.

There are a variety of major events in the shipping sector resulting from the Fourth Industrial Revolution, but the most representative one is the emergence of maritime autonomous surface ships. Maritime autonomous surface ships is a ship that recognizes the operating situation and navigates on its own, rather than having humans directly control the ship.

IMO (International Maritime Organization) defines it as a ship in which an intelligent system replaces the role of crew members, and divides it into four levels depending on the level of technology. Maritime autonomous surface ships can improve the economic feasibility of the shipping industry by recognizing, judging, and responding to all navigation situations on their own based on core technologies of the 4th Industrial Revolution such as artificial intelligence, Internet of Things, blockchain, and cloud. In addition, the utility of the shipping industry can be increased in that it can provide optimal navigation through satellites, cope with bad weather, and prevent marine accidents caused by crew members' misbehavior.

According to Markets (MnM), the global maritime autonomous surface ships market size is expected to double from $7.1 billion (KRW 9.3 trillion) in 2019 to $14.3 billion (KRW 18.74 trillion) in 2030.[1] This study aims to confirm trends in maritime autonomous surface ships and the effect of introducing maritime autonomous surface ships to strengthen port competitiveness and examine issues related to the introduction of fully maritime autonomous surface ships in the future. Existing prior research was conducted from a general theory and engineering perspective. However, this study is different in that it examines general theories and presents opinions on controversial issues from the perspective of strengthening port competitiveness.

The introduction of maritime autonomous surface ships still has many challenges to solve compared to self-driving cars and aerial drones. However, there is no disagreement regarding the need for commercialization of fully maritime autonomous surface ships.

As a prior study related to this study, Lee Hyun Kyun (2023) and Cheong Yeong Seok (2023) confirmed the current status of the legal system for

1) https://www.kistep.re.kr/gpsIssueView.es?mid=a30101000000&list_no=48683&nPage=8, 2024.08.11.

the operation of maritime autonomous surface ships and presented opinions on improvements in maritime law. Hong Sang Yong & Jeon Hae Dong (2023) analyzed the liability for damages in the event of a collision accident of a fully maritime autonomous surface ships from various perspectives and argued for risk liability as the most appropriate method. In addition, Jeon Hae Dong (2018) studies changes in the marine insurance system, including the introduction of a marine insurance system suitable for maritime autonomous surface ships when unique maritime risks occur and the need for additional types of maritime risks due to the introduction of autonomous navigation. proceeded. Meanwhile, Lim Jeong Bin (2023) and Lee Gwang Il (2018) studied the remote control system of maritime autonomous surface ships and collision avoidance methods due to control delay from an engineering perspective. Kim In-Yu (2020) presented an opinion on whether liability can be extended to the builder under the Product Liability Act if an accident occurs due to contract liability for maritime autonomous surface ships and the combination of the ship itself. As discussed above, research on the technology and engineering aspects of maritime autonomous surface ships and the issue of applying marine insurance in the event of a maritime accident are continuously being conducted. Research on the effectiveness of issues to strengthen port competitiveness can be another reason why maritime autonomous surface ships must inevitably be commercialized in the shipping and logistics industry. However, this study was based on literature research and was unable to conduct in-depth research from an engineering perspective. In the future, we plan to supplement the shortcomings of this study and study in depth the tasks and prerequisites for introduction from a technical perspective at each stage of international commerce transactions.

Ⅱ. Significance and technical characteristics of maritime autonomous surface ships

1. Significance of maritime autonomous surface ships

1) The concept of maritime autonomous surface ships

The European Commission is a hybrid smart ship, and the American Bureau of Shipping (ABS) uses sensors, automated navigation devices, and propulsion with logic to execute work plans, sense the marine environment, adjust work for the environment, and determine operation without human intervention. and auxiliary systems (John Jorgensen, 2016). In Korea, the Ministry of Trade, Industry and Energy and the Korea Institute of Industrial Technology Evaluation and Management used the term smart ship. Smart ships are connected to stakeholders, provide information and services, and are diagnosed and managed through autonomous or remote control to achieve optimal energy efficiency. It is defined as ships that operate safely and ICT infrastructure for them.[2)]

2) Ministry of Trade, Industry and Energy, Eco-friendly and smart ships, new opportunities for the Korean ship building industry in crisis", 2017.02.01.

Table1. Maritime Autonomous Surface Ships Technology

Field	Detailed technology
AI	Route control, Situational awareness, Equipment control
Security	Prevention of terrorism, Accident response
Land control	Land control system
Network	Onboard data processing and integration
Communication	Data processing, Transmission and reception between land and vessel

Source: Written by the author

In addition, the terms digital ship and unmanned operating ship are also used. This study used the term Maritime Autonomous Surface Ships (MASS) agreed to be used at the 98th Maritime Safety Committee (MSC) of IMO.

Considering the above, maritime autonomous surface ships can be viewed as a ship equipped with a system that can determine its own route and operate regardless of human intervention.

2) Autonomy level of maritime autonomous surface ships

IMO divides maritime autonomous surface ships into four classes. The level of autonomy is determined by function and level of autonomy. Autonomous level 1 is a ship equipped with an automation system for some functions, but with crew members on board to control the operation of the ship and ship systems. Level 2 autonomy is a ship with a crew on board and remote control of the ship from the ground. Level 3 autonomy is a ship that does not have a crew on board and can be remotely controlled from the ground. Lastly, the final stage 4 is a fully maritime autonomous surface ships, which refers to a ship that can decide and take action on matters related to navigation without a person on board.

Table 2. IMO Maritime Autonomous Surface Ships

Level	Detail
1	Supporting crew decision-making
2	Crew on board, remote control possible
3	Remote control without crew on board
4	Fully autonomous operation of the ship itself

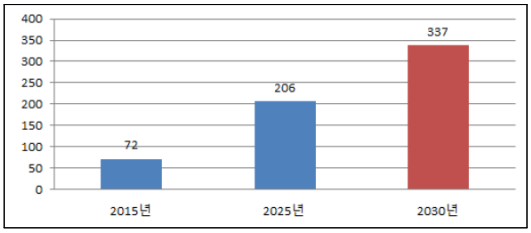
Source: Written by the author

2. Market trends of maritime autonomous surface ships

Under the GATT and WTO systems, world trade grew rapidly, and maritime transportation, which is most suitable for long-distance mass transportation, developed further with the advent of containers. As a result, the shipbuilding industry also grew together, but the long-term recession and oversupply of ships are causing problems of increased ship inventory and rising costs. In addition, as a significant portion of maritime transportation accidents are caused by human error, the demand for maritime autonomous surface ships operation is increasing, and development is accelerating in the ship building industry, especially in advanced countries, as a new Blue Ocean. According to a survey by Markets and Markets in September 2022, maritime autonomous surface ships market is expected to grow at an average annual rate of 7% and reach $13.8 billion in 2030.[3)]

And according to a survey by Business Wire in February 2018, the size of the global maritime autonomous surface ships market in 2016 was estimated at $56.75 billion, and the average annual growth rate was expected to reach 12.8% from 2017 to 2025.[4)] Korea's Ministry of Trade, Industry and Energy predicts that the maritime autonomous surface ships market will grow at an average annual rate of 12.5% to $150 billion after 2025.[5)] According to Korea's Ministry of Oceans and Fisheries, the size of the global maritime autonomous surface ships market in 2023 will be $54.4 billion (about 72 trillion won) in 2015, $155 billion (about 206 trillion won) in 2025, and $254.1 billion (about 337 trillion won) in 2030. It is expected to grow to trillion won).[6)] As can be seen from the forecasts of various research organizations, maritime autonomous surface ships market will grow further.

Figure 1. Global Maritime Autonomous Surface Ships Market
Unit: trillion won



Source: Ministry of Oceans and Fisheries (2023)

3. Core technology for maritime autonomous surface ships

1) Artificial intelligence

Artificial intelligence technology corresponding to the degree of autonomy of maritime autonomous surface ships can be divided into route decision and control technology and situation awareness technology. First, route decision and control technology related to the level of maritime autonomous surface ships is a technology that allows ships to determine and operate their own routes.

3) https://www.marketsandmarkets.com/PressReleases/autonomous-ships.asp, 2024.08.15.
4) https://www.businesswire.com/news/home/20180223005398/en/Global-Autonomous-Ships-Market-2017-2025-Type-Application, 2024.08.15.
5) https://www.mof.go.kr/synap/view.do?fn=MOF_ARTICLE_54272_2023120818c488896d8550&fd=202408, 2024.08.05.
6) https://m.ceoscoredaily.com/page/view/20230920141629716 96, 2024.8.23.

In general, when a ship decides to sail, it is necessary to comprehensively understand various information such as weather, route, and port information. The same goes for maritime autonomous surface ships. Route decision and control technology is a technology that determines the safest, most economical route with minimal fuel loss and minimal navigation time.

Second, situational awareness technology is a technology that prevents collisions with maritime hazards during navigation and detects danger in advance. When operating with minimal crew or no crew on board, information such as AIS (Automatic Identification System), radar, heat detection, and video, which is an automatic identification system for ships, is collected to prevent collisions with glaciers, marine fixtures, and ships. It is a technology that detects risks based on It is an important skill that must be possessed for the safe navigation of a ship.

2) On board data network platform

The on board data network platform is a system that manages all information generated on board based on data platform technology, engine automation, and energy management technology. Data platform technology is a gateway for linking autonomous ships and land control data. It is a data platform technology that collects and analyzes all information generated on board and processes it into meaningful information that can be recognized by the artificial intelligence of maritime autonomous surface ships. Engine automation and energy management technology is a technology that automatically diagnoses and remotely repairs failures that occur during navigation. In the case of maritime autonomous surface ships without crew members on board, equipment control and engine automation within the ship are essential technologies. Based on this, data within the ship can be integrated and controlled to achieve optimal energy efficiency through fuel supply and storage, and energy storage and consumption system management.

3) Land control system

maritime autonomous surface ships have at least a crew on board or sail completely unmanned. Therefore, technology to monitor ship navigation and control on land is essential. The land control system is a ship's remote control and control technology that monitors all sailing situations in real time and links with the land information system to ensure safe navigation.

4) Communication technology

Long-distance communication technology refers to network technology for safe navigation of maritime autonomous surface ships and for exchanging information with land control systems. Long-distance communication technology is a technology that can transmit and receive various navigation information between ports and ships, ships and ships, and land control systems and ships. Intelligence switching that can communicate with satellites must be possible. And it must be possible to switch to LTE and VDES communication networks in coastal waters. Support for data exchange with land control systems for safe navigation of ships is a technology that must be implemented for the commercialization of maritime autonomous surface ships.

5) Security technology

Security technology can be divided into incident response technology and cyber security technology. First, accident response technology detects accident factors in advance to prepare for accidents that may occur during the navigation of a ship and establishes a rapid action system in the event of a force majeure such as a natural disaster. Includes remote control technology.

Second, cybersecurity technology is an essential technology for cybersecurity in the era of the 4th Industrial Revolution. In particular, it is necessary to establish a system that can actively respond to large-scale cyber terrorism against maritime autonomous surface ships, such as ship capture and hacking. In particular, fully autonomous ships are highly likely to become targets of maritime terrorism. Therefore, the system for self-security and defense is a security technology that allows autonomous ships to respond to situations that are completely different from accidents caused by natural objects at sea. Existing ships are open structures that must be equipped with facilities for crew boarding and living, as well as docks. However, maritime autonomous surface ships are being developed on the premise of having a minimum number of crew members or being completely unmanned, so they must be built in a completely closed manner except for the minimum route to safely protect cargo on board and prevent capture at sea.

Ⅲ. Introduction cases and implications of maritime autonomous surface ships

1. Case of introduction of maritime autonomous surface ships

1) Overseas cases

Currently, countries developing maritime autonomous surface ships technology are largely divided into Northern Europe, such as Norway, Denmark, and Finland, and Asia, Korea, China, and Japan. Northern European countries such as Norway and Denmark, which have complex coastlines and islands, have begun developing technology one step ahead of Korea. Due to geographical characteristics, technology development is mainly focused on ships, ferries, and small and medium-sized container cargo ships that operate in coastal islands.

(1) Europe

In Europe, maritime autonomous surface ships are being developed by global shipping companies such as Norway's Kongsberg Gruppen, Britain's Rolls-Royce Marine, Finland's WARTSILA, and Switzerland's ABB. Finland is the world leader in maritime autonomous surface ships technology. In December 2018, Finland boarded 80 passengers on the world's first fully autonomous passenger ship, Falco, and successfully conducted a test operation on the Baltic Sea coast of southern Finland.

Denmark also carried out a project to develop an unmanned autonomous harbor bus that operates on coastal islands, led by the Maritime Administration, and completed verification in

December 2022. The EU has been pursuing the 'MUNIN' project for autonomous ship operation since 2012 and has completed a feasibility review of related projects. Additionally, the Maritime Unmanned Navigation through Intelligence in Networks (MUNIN) project was conducted to evaluate the economic, technical, and legal feasibility of operating a fully smart maritime autonomous surface ships for maritime navigation.[7] In the EU, the concept of Motorway of the Sea (MoS) has been developed since 2001, and the goal of this project is to convert more than 30% of road freight to use complex solutions over 300 km by 2030 and to develop a next-generation system that can be used in a real environment called AUTOSHIP. A project to develop maritime autonomous surface ships is underway.[8]

(2) USA

In the United States, there is strong demand for military maritime autonomous surface ships and technology development is underway centered on startups, and in East Asia, where the three major ship building powers are located, technology development has begun centered on ship building companies. Japan plans to apply and distribute autonomous navigation technology to about 250 ships, led by the Shipping Association.[9]

(3) Japan

Following the success of fully maritime autonomous surface ships operation, Japan plans to begin commercial operations of fully autonomous cargo ships in 2025 and apply fully autonomous operation technology to more than half of Japan's national ships by 2040. Japanese shipping company Mitsui O.S.K. Lines has succeeded in autonomously operating a container ship for the first time in the world. It remains the world's first successful case of fully autonomous navigation on a 298 km long sea route without a single crew member. Japan's 194TEU container ship 'Mikage' did not have a crew on board, and carried out the entire process from port departure to berthing independently using a navigation satellite system (GNSS) and LiDAR. In addition, since the drone mounted on the ship lowered the rope to the port worker and completed the berthing, it is evaluated as having reached level 4 complete autonomous operation for the first time.[10] In Japan, the government has been taking the lead in standardizing ship data through the Smart Ship Application Platform Project, in which all industries participate, since 2013, and aims to build 250 smart ships by 2025. Following the success of fully maritime autonomous surface ships operation, the Japanese government plans to begin commercial operations of fully autonomous cargo ships in 2025 and apply fully autonomous operation technology to more than half of Japanese national ships by 2040.

(4) China

China announced in 2015 that it would actively support the ship building industry through the

7) https://www.researchgate.net/figure/The-MUNIN-project-wwwunmanned-shiporg-Accessed-October-2017_fig1_326238761, 2024.08.02.

8) https://www.autoship-project.eu/, 2024.08.12.

9) https://www.kongje.or.kr/news/articleView.html?idxno=3175, 2024.08.21.

10) https://www.e4ds.com/sub_view.asp?ch=11&t=0&idx=14534, 2024.08.21.

Made in China 2025 plan, and has been jointly promoting smart ship development with Europe since 2016. China has carried out a project to develop a 300 TEU autonomous container ship led by the Ministry of Transport and Communications, and is currently demonstrating it for commercialization.

(5) Singapore

Singapore has developed autonomous navigation and collision detection and avoidance systems through the Smart Maritime Autonomous Vessel (SMAV) Project. It was mounted on a tugboat and completed sea trials in Singapore waters in April 2020, and received certification from ABS, an American classification company, in September 2021.

2) Domestic cases

In Korea, the government is currently developing maritime autonomous surface ships. The Ministry of Oceans and Fisheries and the Ministry of Trade, Industry and Energy launched the Maritime Autonomous Surface Ships Technology Development Project Integrated Business Team on June 17, 2020, with the goal of developing autonomous ship technology at the IMO Level 3 level, and will develop core technologies for maritime autonomous surface ships and commercialize them through step-by-step verification. for business purposes. The total project cost amounts to KRW 160.316 billion, and it is a large-scale project in which 51 organizations, including Hanwha Ocean, Samsung Heavy Industries, and HD Hyundai, as well as research institutes, small and medium-sized companies, and universities, participate. Intelligent navigation system, institutional automation system, empirical basis and procedures It consists of a total of 13 detailed technology development projects, including development of operational technology and international standardization. And Avicus, HD Hyundai's autonomous ship operation company, successfully completed the world's first transoceanic autonomous operation of an LNG carrier in June 2022. At that time, a 7% improvement in fuel efficiency and a 5% reduction in greenhouse gas emissions were recorded. Avicus autonomously operated a route totaling 9,334km from Singapore to Brazil several times and collected ship operation data, revealing fuel savings of up to 15%. As fuel usage decreases, carbon emissions are expected to be reduced by up to 10%.[11)]

On November 24, 2022, Samsung Heavy Industries succeeded in autonomously operating the Segero, equipped with a remote autonomous navigation system (SAS), for approximately 950 km for 4 days from November 15. This is the first case of an autonomous ship passing a long section of the domestic coast without incident. SAS is an autonomous navigation solution that is technology-intensive, including automatic engine and rudder control, 360-degree around view, and real-time remote monitoring, and was developed with Samsung Heavy Industries' proprietary technology. The Segye Ro is a 9,200-ton ship based in Mokpo, which signed a business agreement with Samsung Heavy Industries. The starting point of this verification was Mokpo, Jeollanam-do. Passed through the sea, passing through Ieodo and Jeju Island in the South Sea and all the way to Dokdo

11) https://www.waterjournal.co.kr/news/articleView.html?idxno=74533, 2024.08.05.

in the East Sea, under the guidance of SAS.[12] Meanwhile, Hyundai Mipo Dockyard will hold a simultaneous naming ceremony for two container ships, POS SINGAPORE and POS LAEMCHABANG, Korea's first autonomous operation demonstration ship, at its headquarters in Ulsan on March 8, 2024. did it Force Singapore and Force Ram Chabangho, ordered from Pan Ocean in April 2022, are 172m long, 27.4m wide, and 14.3m high and can carry 1,800 20-foot-long containers at the same time. In particular, the Force Singapore is an autonomous operation demonstration vessel that will verify various core autonomous operation technologies such as the intelligent navigation system and engine automation system being developed in Korea.[13]

2. Implications

During a voyage, a ship encounters both normal and emergency situations, and previously, all of these situations were resolved by the crew. Typical situations are those related to navigation, such as normal navigation, vessel arrival and departure, maintenance, and berthing. On the other hand, emergency situations are situations where maritime hazards occur, such as engine failure, piracy, life-saving, fire, collision, and accident. As can be seen through examples, countries around the world are actively promoting it, with governments at the center. The maritime autonomous surface ships developed to date are at a level of technology that can cope with general situations. However, as artificial intelligence technology develops further, it will be implemented to a level where emergency situations can be responded to without crew members. Maritime autonomous surface ships have emerged as a game changer that is rapidly changing the shipping, maritime, port, logistics, shipbuilding, and equipment industries along with the Fourth Industrial Revolution.

Core technologies for maritime autonomous surface ships technology include artificial intelligence technology, complementary technology, network technology, land control technology, and communication technology. In particular, security technologies for land control and hacking defense must be fully implemented to prevent ship capture and ransom attacks of maritime autonomous surface ships. It is also necessary to establish a system that can prevent problems such as ship theft due to cyber terrorism.

Therefore, it is necessary to establish a strong security system using blockchain. Blockchain can prevent intrusions with illegal intentions because transactions occur without third-party intervention, and all transaction information is distributed and stored simultaneously, making it safe from DDoS attacks (Lee Ki Young & Lee Yang Kee, 2023). A truly smart port must ensure safety across all port logistics, including sea, land, and ships.

12) https://www.hankyung.com/article/2022112428401, 2024.08.15.

13) https://esg.hd.com/ko/news/766, 2024.08.23.

Ⅳ. Efficacy of autonomous ships and important issues of maritime autonomous surface ships

1. Effects of utilizing maritime autonomous surface ships

1) Establishment of maritime safety system

If fully maritime autonomous surface ships are commercialized and used for navigation, a safe maritime safety system can be established and maritime safety can be achieved. Most maritime accidents occur due to navigational negligence by crew members. According to the Central Maritime Safety Tribunal, the number of domestic marine accidents is steadily increasing from 2,101 in 2015 to 3,156 in 2020, and the cause of marine accidents is more due to human error than natural factors such as sea deterioration and ship factors such as aging of ships. It accounts for as much as 90%.[14] Since most accidents that occur during voyages are caused by man-made disasters, the commercialization of self-driving ships has a positive effect.

2) Reduce logistics costs

In general, labor and fuel costs account for more than 80% of the total cost of operating a ship. Maritime autonomous surface ships have no labor costs paid to crew members and can reduce fuel consumption by navigating the most optimal route. According to data from the Maritime Autonomous Surface Ships Technology Development Project Integrated Business Group, maritime autonomous surface ships can reduce up to 22% of current cargo ship operating costs. HD Hyundai's autonomous ship operation subsidiary Avicus analyzed the autonomous operation data of Pan Ocean's 325,000-ton ultra-large ore carrier from August 2023 and found that fuel savings of up to 15% were achieved on a total 9,334 km voyage from Singapore to Brazil. It has been proven that there is. Automation of port operations has various positive effects, such as reducing port operating costs and increasing efficiency and productivity through unmanned work processors(Ha Do Yeon, Kim Chi Yeol, Kim Yul Seong, 2024).

3) Increased cargo loading effect on ships

Maritime autonomous surface ships sail with minimal or unmanned crew. Therefore, there is no need for a space for the crew to live and a movement route, and there is no need to equip equipment for the crew's escape in the event of a maritime accident. Therefore, space utilization for cargo loading increases and cargo loading efficiency can be achieved.

4) Realization of smart ports

The importance of smart ports is increasing as the shipping industry, including ports, moves away from being a capital- and labor-intensive industry and introduces various 4th Industrial Revolution technologies such as artificial intelligence, Internet of Things, big data, and blockchain(Ryu Won Hyeong & Nam Hyung Sik, 2024). A smart port is a port that operates in an unmanned system by automating tasks that occur at the port, such as unloading, storing, importing, and exporting goods. Ports will continue to become electronic,

14) https://esg.hd.com/ko/news/766, 2024.08.23.

automated, and unmanned in order to increase efficiency and reduce costs, and in order to keep up with this, there is no choice but to move toward standardized containerization(Shin, Hak sung & Cho Sang Ri, 2023). To realize a complete smart port, in addition to smartening port operations, activities such as shipping docking and towing must be automated. Therefore, commercialization of maritime autonomous surface ships is also an essential element in implementing smart ports. The connection between maritime autonomous surface ships and smart ports can optimize port logistics efficiency by optimizing all tasks and ship-related activities within the port.

5) Eco-friendly carbon neutral

The shipping sector accounts for 13% of greenhouse gas emissions in the transportation sector. In July 2023, IMO agreed that the international shipping sector would also reach carbon neutrality by around 2050. And at the 81st Marine Environment Protection Committee held in London, England in March 2024, a draft IMO net zero framework containing carbon neutrality was agreed.[15] As a result, a carbon tax will be imposed on greenhouse gases emitted by all ships around the world starting in 2027. Therefore, in order to operate eco-friendly ships, shipping companies need cooperation between shipbuilders to improve existing ships and receive orders for eco-friendly ships. As an alternative, the need for maritime autonomous surface ships is increasing. Basically, maritime autonomous surface ships are being developed with the ultimate goal of being eco-friendly ships, and maritime autonomous surface ships currently being prepared for commercialization are effective in reducing carbon emissions. Maritime autonomous surface ships use artificial intelligence to perform navigation-related activities. In particular, it searches and determines the optimal flight route. As a result, fuel consumption is reduced and carbon dioxide emissions can be reduced.

6) Strengthening port and logistics competitiveness

More than 90% of world trade transportation is maritime transportation by ship. And IMO's imposition of a carbon tax on ships for carbon neutrality will have a significant effect in reducing greenhouse gas emissions. However, the ships provided by shipping companies are not eco-friendly ships. Therefore, from the perspective of shipping companies, IMO's policy is a huge burden. There is a saying that a crisis is an opportunity. Greenhouse gas emission regulations are an inevitable policy to preserve the global environment, and no country disputes this. Therefore, ships that use eco-friendly fuel must be designed from the start of ship construction. In addition, the construction of smart ports and the commercialization of maritime autonomous surface ships must also be realized. Eco-friendly autonomous ships will become an important source of port competitiveness and a stepping stone for Korean shipbuilders and shipping companies to enter the global market.

15) https://greenium.kr/news/32042/, 2024.08.25.

2. Issues related to commercialization of maritime autonomous surface ships

1) Liability and insurance for maritime accidents

The purpose of marine insurance, from adventure rental to current cargo insurance, is to ensure the safe return of ships and cargo to port and to prepare for marine damage due to maritime accidents. In the case of maritime autonomous surface ships without a captain or crew, if a control function problem, collision between ships, or berthing accident occurs, rather than a natural disaster, etc., the question is who will be held responsible. In particular, in the case of level 4 fully maritime autonomous surface ships, when an accident occurs during operation, it is difficult to determine who is responsible for the accident under the current legal system(Han Sung Hoon & Song Young Jo, 2022). Responsibility cannot simply be placed on the shipowner or the shipping line. And there is no legal basis for this. There are no international standards yet, and it is currently impossible to establish customs through court rulings. Therefore, discussion on this will become one of the important issues in the commercialization of fully maritime autonomous surface ships in the future.

2) Crew unemployment and training of control personnel

An maritime autonomous surface ships is a ship that operates with a minimum number of captains and crew or operates completely unmanned, depending on the degree of autonomy. Therefore, the problem of unemployment among seafarers arises. In the case of captain level, it takes considerable time and experience to acquire expertise. This is also true for sailors. If fully autonomous ships are commercialized, it is necessary to prepare for the upcoming unemployment problem of seafarers. And thorough preparations are needed to train customs system personnel. Training facilities and instructor training are needed to operate the control system, and an education system must also be established. The speed of scientific and technological development evolves much faster than human imagination. In particular, smart technologies based on technologies related to the Fourth Industrial Revolution are growing faster. Therefore, thorough preparations are needed from now on to address unemployment issues and train government personnel.

3) Increased burden on shipping companies due to carbon tax imposition

IMO's regulations on greenhouse gas emissions will be a huge burden on the shipping industry. The shipping industry must reduce greenhouse gas emissions by 40% by 2030 and 70% by 2050 compared to 2008. Although there may be differences in timing, if the carbon tax is imposed from 2027, the carbon tax burden on shipping companies that operate existing ships will be very large, and will have a significant impact on corporate management. Therefore, government-level financial support is needed for shipping companies to respond with eco-friendly ships. There is an urgent need to improve existing ship finance or establish a new financial support system.

4) Legal issues for commercialization

In order for maritime autonomous surface ships to be commercialized, there are challenges that must be resolved from a legal perspective. Although Korea does not have an IMO international agreement on self-operating ships, it has enacted a law on promoting the development and commercialization of maritime autonomous surface ships and is preparing to implement it. However, concrete implementation is difficult without revision of legal regulations related to ship operation and marine insurance. It must be comprehensively regulated within one system to accommodate situations where autonomous ships and previous types of ships are mixed together(Lee Hyun Kyun, 2023). There are no legal regulations related to autonomous ships, such as the Maritime Act, Commercial Act, and Seafarers Act, and there are no regulations on control systems or artificial intelligence to replace sailors and captains. In particular, the ship's seaworthiness and duty of care have a significant impact on legal rulings when a maritime accident occurs. In addition, the duty to pay attention to airworthiness also affects marine insurance and transportation contracts and should be reflected in maritime construction law regulations. In addition, clear regulations must be established regarding the obligation to prevent damage from maritime accidents that occur during the voyage of autonomous ships. In addition, the maintenance of legal regulations related to maritime autonomous surface ships, such as P&I insurance, is undoubtedly an important issue related to the commercialization of maritime autonomous surface ships.

Ⅴ. Conclusion

With the advent of the Gelion ship, East-West trade became more active, and after World War II, GATT, IBRD, and IMF were established centered around the United States for post-war recovery. Afterwards, as GATT transformed into the WTO system, world trade grew rapidly centered on the WTO. As trade volume has increased, the world economy has also grown, and developing countries are also making efforts to revitalize trade. However, negative aspects contradicting the positive results also resulted. Due to the increase in trade volume, the shipping industry needed to increase the speed and size of ships, and the revitalization of maritime transportation also had negative consequences such as an increase in maritime accidents. And with the increase in ship operations, the use of fossil fuels also increased, resulting in a sharp rise in carbon emissions.

As a result, the IMO's strong regulation of imposing a carbon tax to reduce emissions is expected to be implemented. Therefore, in order to reduce the risk of maritime accidents during navigation, the commercialization of eco-friendly autonomous ships is necessary to improve the maritime control system and achieve efficient safe navigation. Maritime autonomous surface ships are superior to existing ships in terms of economic efficiency because they reduce manpower and fuel consumption and operate on optimal routes, allowing them to arrive at their destination quickly. Additionally, space for crew members and safety equipment can be utilized solely for cargo loading, increasing cargo loading efficiency. However, there are many difficult problems that need to be

solved, such as unemployment issues, maritime accident liability and insurance, securing connectivity with smart ports, improving laws and systems, international cooperation, land and sea data exchange, and establishing a security system to prevent cyber terrorism. In October 2021, Korea presented a roadmap for preemptive regulatory innovation in the field of maritime autonomous surface ships, containing major tasks to be pursued by 2030 to promote the development of autonomous ship technology and early commercialization.

The 'Act on the Development of maritime autonomous surface ships' was prepared in August 2022 to create a foundation for the safe operation of maritime autonomous surface ships and to provide a legal basis for pilot operations and verification. And the 'Act on Promotion of Development and Commercialization of Maritime Autonomous Surface Ships' is scheduled to go into effect in January 2025.[16)]

The global competitiveness of a port is the competitiveness of a country. Building a smart port and realizing the commercialization of maritime autonomous surface ships are tasks that must be realized to secure the competitiveness of shipbuilders and shipping companies. In particular, the government needs to develop continuous support policies and systems to develop ICT technology and land control technology to improve the autonomy of self-driving ships, train operating personnel, and establish a smart port logistics ecosystem. And I plan to conduct continuous research on issues in the transportation and insurance fields related to the commercialization of maritime autonomous surface ships.

16) https://economist.co.kr/article/view/ecn202401300025, 2024.08.02.

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부표 1. 단위근 검정 결과

해기사-부원					
LagLength:0(Automatic-basedonSIC,maxlag=6)				수준	차분
				prob.*	prob.*
해기사수	O	ADF		0.3976	0.0043
		Test C.V	1%level		*
			5%level		
			10%level		
부원수	R	ADF		0.7471	0.0044
		Test C.V	1%level		*
			5%level		
			10%level		
해기사임금	W_O	ADF		0.8889	0.0018
		Test C.V	1%level		*
			5%level		
			10%level		
부원임금	W_R	ADF		0.7479	0.0009
		Test C.V	1%level		*
			5%level		
			10%level		
해기사/부원임금	W_O/W_R	ADF		0.0076	
		Test C.V	1%level	*	
	W_R/W_O		5%level		
			10%level		
교역액	G	ADF		0.7263	0.0003
		Test C.V	1%level		*
			5%level		
			10%level		
기술진보	T	ADF		0.7965	0.0035
		Test C.V	1%level		*
			5%level		
			10%level		
선복량	K	ADF		0.4383	0.0018
		Test C.V	1%level		*
			5%level		
			10%level		
매출액	Q	ADF		0.7506	0.0006
		Test C.V	1%level		*
			5%level		
			10%level		

부표 2. 공적분 검정 결과

종속	독립	Hypothesized No.ofCE(s)	P-value	Trace 통계량
해기사	W_O,W_R,K,G,T,Q	**None***	**0.0026**	**143.4716**
		Atmost1*	**0.0644**	**94.1229**
		Atmost2	**0.1236**	**64.4925**
		Atmost3	**0.2950**	**38.1624**
부원	W_O,W_R,K,G,T,Q	**None***	**0.0001**	**161.2951**
		Atmost1*	**0.0074**	**106.5463**
		Atmost2*	**0.0458**	**70.2940**
		Atmost3	**0.1761**	**41.4064**

항만경쟁력 강화를 위한 자율운항선박의 효과와 자율운항선박의 쟁점 사항

이기영

국문요약

자율운항선박은 인공지능, 블록체인, 사물인터넷, 데이터 처리 장치 등 4차 산업혁명의 핵심기술을 중심으로 스스로 최적 항로를 분석하고 운항하는 최첨단 선박이다. 바다 위의 4차 산업혁명인 자율운항선박은 친환경을 전제로 건조하는 선박으로 탈탄소화 시대의 글로벌 환경 속에 경쟁력을 갖춘 고부가가치 산업이다.

4차 산업혁명시대에 자율운항선박의 상용화는 항만경쟁력 강화를 위한 필수적 요소이다. 따라서 본 연구는 항만경쟁력 강화 측면에서 사례를 통해 자율운항선박의 도입 효과를 살펴보고 자율운항선박의 상용화에 필요한 쟁점 사항을 살펴보고자 한다.

주제어 : 자율운항선박, MASS, 항만경쟁력, 인공지능