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M A S S - THE INEVITABLE FUTURE OF SHIPPING[8]

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Abstract: *With the introduction of Maritime Autonomous Surface Vessels (MASS), the shipping industry is heading for a technological revolution. The way cargo and passengers move across the world's oceans will change significantly as a result of these ships' ability to operate with little or no human intervention. The shipping sector is expected to become safer, more efficient and greener in the future as automation, artificial intelligence (AI) and sensor technologies advance at a faster pace. This article examines the potential impacts of MASS and focuses mainly on the current obstacles as well as the future of the shipping sector.*

Keywords: *Shipping, Sustainability, MASS, Maritime Safety.*

INTRODUCTION

International shipping is undergoing a market evolution with developments of advanced autonomy which has presented assumed opportunities to both increase safety and reduce risk to onboard operations. The autonomous ships market size is estimating to be USD 3,9 billion in 2022 and is projected to reach USD 8,2 billion by 2030, at a CAGR of 9,6% from 2022 to 2030 https://www.marketsandmarkets.com).

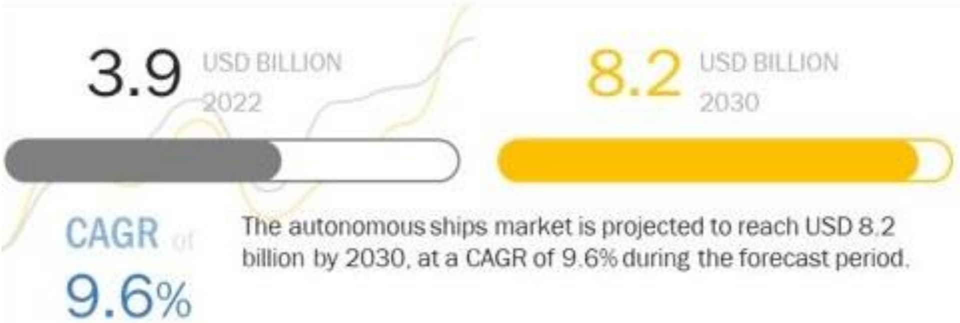

Fig. 1. Autonomous ships market trends

In tandem, industry and nations alike are pursuing aggressive environmental initiatives to develop technologies needed to reduce the shipping industry's contributions to greenhouse gas emissions and other areas of environmental impact. Emerging environmental initiatives are wide-ranging and inspirational, and while industry forges ahead, the means by which shipping interests can meet these goals remains undeveloped (Dimitrakiev et al. 2023). This creates an opportunity for innovation, one that autonomy can support. (Pribyl S., 2023).

The International Maritime Organization (IMO) considering the inevitable introduction of autonomous ships in the maritime industry has been paying more and more attention to this topic in the last decade. The brief history of the decisions taken is:

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- On its 98th session (June 2017) the senior technical body, the Maritime Safety Committee (MSC), noted that the maritime sector was witnessing an increased deployment of MASS to deliver safe, cost-effective and high-quality results and agreed to include in its 2018-2019 biennial agenda an output on "Regulatory scoping exercise for the use of Maritime Autonomous Surface Ships (MASS)" with a target completion year of 2020.
- On 99th MSC session (May 2018) was endorsed a framework for a regulatory scoping exercise (RSE), as work in progress, including preliminary definitions of MASS and degrees of autonomy, as well as a methodology for conducting the exercise and a plan of work, which was approved on 100th session. For the purpose of the regulatory scoping exercise, “Maritime Autonomous Surface Ship (MASS)” is defined as a ship which, to a varying degree, can operate independently of human interaction.
- 101th MSC session further developed and approved *Interim guidelines for MASS trials* (MSC.1/Circ.1604).
- 103th MSC (May 2021) session finalized the RSE and approved the outcome. (IMO, MSC.1/Circ.1638)
- 105th MSC (April 2022) session commenced work on the development of a goal-based instrument regulating the operation of MASS and approved a road map containing a work plan for the development of IMO instruments in the form of a non-mandatory Code.

The ongoing development of diverse maritime autonomous vehicles for varied ocean activities – ranging from scientific research, security surveillance, transportation of goods, military purposes and commission of crimes – is prompting greater consideration of how existing legal frameworks accommodate these vehicles. (Klein N., et al, 2020).

Firstly the autonomous technology was developed on a catamaran by integrating various sensors and power and electrical propulsion systems, navigation and control systems, and communication devices. (Choi J., et al, 2020).

The term "MASS" has been officially recognized by the IMO and in order to facilitate the process of the RSE, IMO defines the degrees of autonomy as follows (non-hierarchically):

Degree One: Ship with automated processes and decision support: Seafarers are on board to operate and control shipboard systems and functions. Some operations may be automated and at times be unsupervised but with seafarers on board ready to take control.

Degree Two: Remotely controlled ship with seafarers on board: The ship is controlled and operated from another location. Seafarers are available on board to take control and to operate the shipboard systems and functions.

Degree Three: Remotely controlled ship without seafarers on board: The ship is controlled and operated from another location. There are no seafarers on board.

Degree Four: Fully autonomous ship: The operating system of the ship is able to make decisions and determine actions by itself. (IMO, MSC.1/Circ.1638)

EXPOSITION

Improving maritime safety, reducing hazards and eliminating human error – all of which contribute to the majority of ship accidents – are some of the main forces behind MASS. Compared to human-operated vessels, autonomous vessels equipped with state-of-the-art sensors, artificial intelligence algorithms and real-time data processing can respond to changing circumstances more quickly and precisely. With no or significantly less crew on board, they are able to use operating systems to navigate, avoid hazards and perform various tasks. A significant advancement in the maritime sector, MASS technology aims to increase the efficiency, security and environmental sustainability of ship operations. Its application can reduce accidents caused by operational errors, weather-related problems or fatigue (Dimitrakieva et al. 2023).

There is a chance that autonomous ships will change operational efficiency. Ships can use AI to optimize routes, which can help them avoid dangerous weather conditions, use less fuel and navigate more correctly. This will speed up international trade in general and reduce shipping costs.

In addition, reducing or eliminating the requirement for on-board personnel can enable a more efficient design, greater cargo space and weight savings.

Autonomous ships promise to reduce the impact of shipping, including its significant contribution to greenhouse gas emissions. AI ships can help choose the most fuel-efficient routes, reducing emissions through efficient navigation. In addition, autonomous ships are expected to use electric propulsion, hybrid technology and renewable energy sources more efficiently than conventional ships, helping to maintain cleaner air and water. (Bae I., Hong J., 2023; Dimitrakieva et al. 2022)

This innovative technology has significant financial advantages. Commercial ships that have fewer or no crew members can save a lot of money (Koritarov, 2021). Costs for staff wages, food, accommodation and security measures can be significantly reduced. Shipping companies can reduce the cost of wages, training and onboard amenities by reducing crew. In addition, further reducing operating costs, improved navigation systems optimize the autonomous vessels' fuel usage. Also, fewer accidents on autonomous ships would mean cheaper insurance costs and less liability concerns. (Kretschmann L., et al, 2017)

Still, there is a lot of work to be done for improving autonomous navigation. May be the most important of it is to ensure safe sea passage. The main tasks for improvement are following the waypoints (guiding the vessel along a pre-defined path efficiently and accurately) and obstacles avoiding (detecting and avoiding static and dynamic obstacles without deviating too much from the planned route). While the first one is to complete the sea passage through shortest and safest route, the second is to comply with requirements of regulations for avoiding collisions at sea (IMO, COLREGS, 1972). For achieving compliance with collision regulations, on MASS have to be implemented reliable obstacle detection systems, as well as collision avoidance algorithms. For proper fulfilling the safe voyage, both mentioned systems have to be appropriately integrated, which is a non-ordinary challenge – the software must find a balance between following the planned route and adjusting it to avoid obstacles, ensuring efficient and safe navigation.

Although autonomous shipping has great promise for transforming the maritime sector, it is not without significant drawbacks and challenges:

- The first possible negative feature of MASS is their **security vulnerability**. These are, on the one hand, physical security risks, i.e. terrorism and sabotage, and even piracy (piracy is less likely on an autonomous ship, but presents unique challenges, especially when the crew is minimal or non-existent). Cyber vulnerabilities are equally dangerous and can cause important cyber-security issues that need to be addressed to ensure safe and secure maritime traffic. Reliance on automation and artificial intelligence leads to unique vulnerabilities, such as sensor manipulation (autonomous ships rely on sensor data for navigation and decision-making, and if an attacker manipulates this data, they can mislead the ship's systems, leading to a collision or grounding), software exploits (bugs in the software used to control the ship can be used by hackers to bypass security measures and gain control). MASS operates in a complex network of interconnected systems, including navigation, communication and control systems. This connectivity exposes them to a variety of cyber threats, including malware attacks (cybercriminals can use malware to disrupt operations, manipulate data or take control of the ship), phishing and social engineering (crew and operators can use misleading attacks for messages aimed at stealing credentials or gaining unauthorized access) and Denial of Service (DoS) attacks (which incapacitate a ship's ability to operate by overloading systems with traffic and rendering them ineffective). To reduce cyber-security risks, maritime industry participants must implement a variety of best practices, including thorough risk assessments, contingency plans, regular software updates, and staff training. (Algarni, Thayananthan, 2022)
- The main obstacle to the widespread adoption of autonomous ship technology is currently **legal and regulatory issues**, as they deal with complex issues such as accident liability, compliance with existing maritime law and the treatment of international waters. Current maritime law essentially assigns responsibility to the ship's master and crew. According to current law, the Master is the highest authority on board the ship and should

be responsible for the navigation, operation and compliance with the laws of the sea (UNCLOS, 1982). The Master can be legally responsible for the operation of the vessel, including marine accidents, pollution and regulatory violations. In the case of autonomous ships, however, it becomes unclear who is responsible: the ship owner, the manufacturer of the autonomous system, the software developer or the shore control centre operator. This also leads to uncertainty about insurance. There are still many questions about the legal aspects of MASS. If an unmanned automated vessel is considered an ocean-going vessel under UNCLOS, international and national law, then would a shore-based remote operator and manufacturer of equipment/defective components be considered seafarers? Should automation systems be liable for damages caused by malfunctions and subject to limitations of liability?

- The economic benefits of MASS are undeniable, but they are associated with a **high initial price**. Refitting existing ships or building new ships with advanced technology requires significant capital. For smaller shipping companies these costs can be prohibitive and lead to sector fragmentation where only larger companies can compete. (Kretschmann L., et al, 2017)
- **Impact on the labour market.** The transition to autonomous ships may raise concerns about job losses, but it also offers opportunities for training and job creation. As the industry evolves, there will be greater demand for professionals with experience in technology, data analysis and ship maintenance. This change can also lead to a more efficient allocation of human resources, with an emphasis on higher-value tasks and strategic oversight.
- **Technological limitations**. Despite rapid progress, technological barriers still need to be overcome before fully autonomous ships can be deployed at scale. These include the reliability of the AI in complex conditions, the accuracy of the sensor in bad weather, and the need for backup systems to ensure safety. Although technology is advancing, full autonomy is still far from certain.
- **Human factor and training**: A limited crew must be trained to handle both technology and emergency situations, as insufficient training can lead to an inadequate response during a crisis. If shore operators are in control of the vessel, they must be well trained because they must effectively control the automated systems. Poor judgment or lack of supervision can lead to a serious accident. In an emergency, people will need to make decisions quickly with limited information. The effectiveness of their response may depend on their familiarity with the system and the degree of automation available. Another challenge may be the cooperation of the reduced MASS crew and shore operators. Mutual trust must be fostered. Otherwise, overconfidence or scepticism can lead to insufficient supervision and inappropriate decisions in critical situations. The interaction between human operators and AI systems can also lead to challenges in the decision-making process. Operators must understand when to intervene and how to trust automated recommendations. (Wahlstroma M., et al, 2015)
- There are also operational risks: Autonomous ships must co-exist with manned ships, for which clear protocols are needed to ensure safe interactions and prevent accidents. MASS can also face the challenges of logistics and port business, especially if the port infrastructure is not equipped to handle automated ship (Koritarov, Dimitrakiev, 2021). This means that existing port facilities must be redesigned and adapted for autonomous ships.

In the coming decades, MASS has the potential to transform the shipping industry, creating a situation where cargo is transported faster, more efficiently and with less impact on the environment. The introduction of MASS will lead to the creation of a hybrid fleet, both manned and unmanned, during the transition period, ultimately paving the way for fully autonomous global shipping and more widespread use of alternative and hybrid propulsion. Sensors, platforms, software, and technologies are rapidly evolving, as well as processing and algorithm development, often outpacing the operational capability to apply these new concepts in the field. (Costanzi R., et al, 2020)

Replacing the conventional ships with MASS is not a question of "if" but "when". With pilot projects already underway by major shipping companies, such as Rolls-Royce's partnership with Finferries on the world's first self-driving ferry (Fig. 2a) and the autonomous zero-emission container ship "Yara Birkeland" (Fig. 2b), the future of autonomous ships is closer than one many think.

Fig 2a. Autonomous ferry "Falco"

Fig. 2b M/v "Yara Birkeland"

Having in mind the inevitable future of autonomous shipping, IMO continue work on legal side of the issue. On its 108th session (May 2024) the MSC approved the report of Working Group on MASS (MASS-JWG 3) and revised the Road Map for the development of a MASS Code, as follows:

- May 2025 - finalize and adopt non-mandatory MASS Code
- First half of 2026 - develop framework for an experience-building phase (EPB)
- 2028 - commence development of the mandatory MASS Code, based on the non-mandatory Code, and consider amendments to SOLAS (new chapter) for the Code's adoption
- By 1 July 2030 - adoption of the mandatory Code, for entry into force on 1 Jan 2032

CONCLUSION

However, MASS are in the early stages of improvement and testing, but there are numerous tasks and projects underway worldwide to improve these ships, and they will most likely become more adopted and sophisticated in the coming years as the technologies are improving and legislation is evolving.

Autonomous technology has the potential to revolutionize maritime transport in ways previously unthinkable. By improving safety, reducing costs and increasing sustainability, MASS are set to emerge as an essential part of the transport scheme in the 21st century. While demanding situations remain, including regulatory challenges and cyber-security dangers, the advent of autonomous ship is undeniable. As the international transportation of goods continues to expand, the adoption of autonomous, unmanned transportation will play a key role in shaping the destiny of maritime transportation. Although demanding situations remain, MASS's ability to contribute to more efficient, safer and sustainable maritime transport will increase significantly. The subject remains a developing area of research with interesting opportunities for improvement, mainly as marine industries undertake more innovative responses.

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