The Future of Marine Autonomous Surface Ships (MASS)

Future scenarios regarding the development and evolution of MASS

2024

Foreword

In a rapidly evolving world, Marine Autonomous Surface Ships (MASS) stand at the forefront of innovation and transformation. As we venture into the uncharted waters of the future, it is crucial to comprehend the profound implications and challenges presented by the advent of MASS, not only for the shipping industry but also for the fundamental infrastructure that ensures safe and efficient navigation at sea.

We attempt to look into future MASS and its relationship with Marine Aids to Navigation (AtoN). The significance of this work lies in its exploration of the possible future scenarios that may emerge as MASS becomes an increasingly integral part of our maritime domain. The objective is clear: to identify possible future scenarios regarding the development and evolution of MASS, and, subsequently, to identify the requisite future requirements for AtoN.

This document sets out the possible short to medium term future for our members to proactively plan for and engage in this transformative era.

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IALA Secretary-General

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Executive Summary

IALA has proactively sought to establish the short to medium term outlook of MASS. This will benefit our members and better equip them to prepare for a future that involves an increasing number of autonomous ships. In order to ascertain the probable future of MASS, IALA has gathered information from our members and stakeholders including a workshop on MASS held in October 2023.

For the foreseeable future, we will have a mixed fleet of conventional ships with different degrees of automation in combination with an increasing number of MASS. The current outlook on implementing MASS technology in tanker, medium and large passenger ship categories is cautious, with concerns about operational and safety challenges specific to these vessel types. The take-up timing for MASS varies, suggesting a coexistence of conventional and autonomous ships in the maritime industry for an extended period. Unmanned ships face a longer adoption timeline due to technological and legal constraints.

Newly built ships have a typical lifespan of 20 to 25 years, indicating that those entering service will continue operating for several decades. Major shipbuilders have expressed that they are not currently looking to build large unmanned vessels. However, a prevailing trend involves equipping ships with automated processes and decision support systems, enabling partial automation whilst keeping seafarers on board to provide control when needed.

The realization of fully autonomous large ships, capable of independent decision-making, is expected to be at least 20 years away from widespread implementation. While MASS technology is suitable for small and specialized vessels such as inshore survey vessels and ferries, initial deployment may be limited to specific participating states rather than being adopted for all international voyages. The short-term adoption of MASS in larger ships intended for international voyages is not anticipated.

From many sources we have been able to determine the drivers behind why shipowners and other stakeholders would invest in MASS and establish future scenarios that we foresee the mix of traffic, in terms of conventional, automated and autonomous ships, that worlds coastal waters will contain.

The primary drivers we have identified are:

- Investors, including shipowners, shipbuilders, and banks, are driven by the prospect of a favourable business case, seeking opportunities for profitability and returns on investment.
- The shortage of qualified seafarers drives interest in autonomous solutions.
- While there is recognition that human error contributes to accidents, not everyone is convinced that full autonomy is the solution and that, in the case of navigating by remote control, errors may be merely shifted ashore. The complexity surrounding human error, but also preventative human intervention make safety a multifaceted consideration.
- Efficiency gains are a compelling factor for investment. This includes tangible benefits such as fuel reduction and transitioning to cleaner fuels.
- There is a potential benefit of being pioneers with MASS. The prospect of leading the way and being recognized as a "first mover" in this transformative field may result in a boost in publicity for a company. This reputation-building aspect can significantly

influence investment decisions and contribute to a stakeholder's prominence within the industry.

- There is an increasing willingness to address regulatory challenges and enhance cooperation between countries such as examples of bilateral and trilateral agreements, including the MoU between Denmark, Belgium, and the United Kingdom, demonstrate frameworks enabling autonomous operations internationally.

Introduction

In anticipation of the evolving landscape in maritime transportation, IALA has taken a proactive stance in understanding the short to medium-term outlook of MASS. Recognizing the growing need to assist its members and stakeholders in preparation for an increasingly autonomous future, IALA has undertaken a comprehensive examination, gathering insights from various sources, that has included a dedicated workshop on MASS conducted in October 2023.

This document serves as a culmination of IALA's efforts, shedding light on the drivers compelling shipowners and other stakeholders to invest in MASS. Through collaborative engagement with our members and stakeholders, IALA has identified key future scenarios that forecast the dynamic mix of traffic – comprising conventional, automated, and autonomous vessels – in the coastal waters worldwide.

As a key planning tool, the contents of this document will guide IALA in crucial considerations, specifically aimed at:

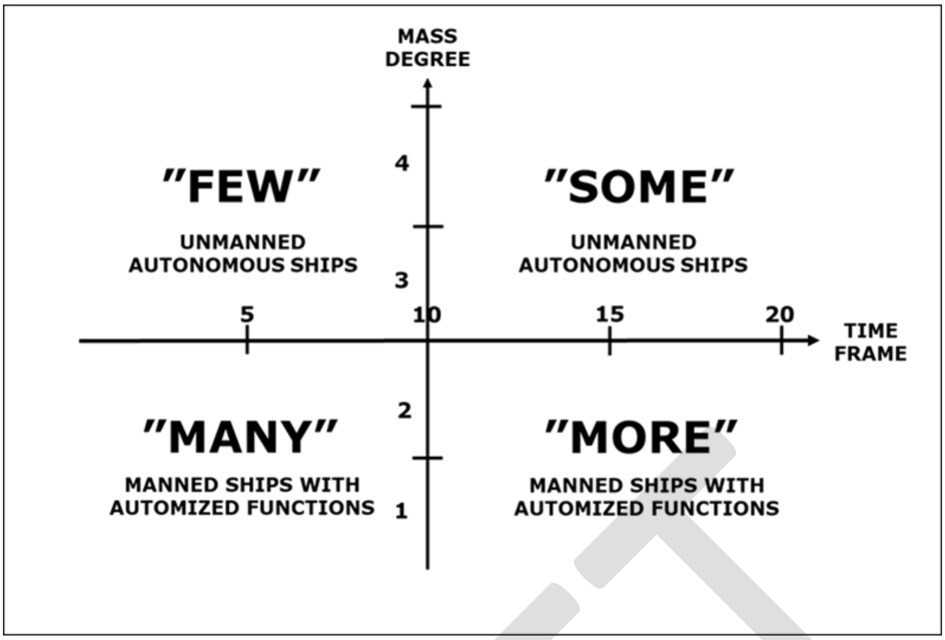
- Analyzing the potential impact of MASS on AtoN.
- Identifying future requirements for AtoN services.
- Pinpointing potential work items related to MASS for the IALA committees.

This comprehensive insight aims not only to enhance the preparedness of our members but also to contribute significantly to the conversation surrounding the integration of automated and autonomous technologies in the maritime domain. IALA remains committed to fostering a collaborative and informed approach as we navigate the waters of the future together.

This document considers the future outlook for the gradual adoption of MASS over the next twenty years and potential drivers and challenges for the technology.

What types of vessels and when

In the illustration provided below, a distinction is made between automation and autonomy in the context of ship operations. Automation, in this context, encompasses the collective set of automated functions and processes employed in onboard activities. On the other hand, autonomy specifically denotes unmanned operations, signifying a mode of functioning without direct human interaction.



While discussions on automation versus autonomy may, to some extent, be construed as debates over wording, definitions, and philosophy, the essence lies in understanding how various types of ships are navigated and controlled. It is crucial to differentiate between automation and autonomy to construct straightforward and illustrative scenarios that capture the evolving landscape of maritime operations.

The four scenarios that sum up IALAs view of the short to medium development of MASS are captured as:

- Many manned ships with automized functions
- Few unmanned autonomous ships
- More manned ships with automized functions
- Some unmanned autonomous ships

These scenarios are elaborated below.

<u>Many manned ships with automized functions</u>

In this scenario, over the next 5 - 10 years, the maritime picture is characterized by the prevalence of many manned ships equipped with automated functions. Ships with automated processes and decision support are already widely implemented in most ships, and the development of remotely controlled vessels with seafarers onboard is expected to increase within the specified timeframe.

The levels in this scenario are considered as degrees of assistance and automation rather than reaching full autonomy.

Ships equipped with automated processes and decision support systems, where some operations may be automated with seafarers on board ready to take control, are already in operation. The initial implementation of MASS is observed in smaller and specialized ships, including tugs and ferries.

Remotely controlled ships with seafarers on board could possibly serve as an interim step toward unmanned remotely controlled ships in the future. However, manned remotely operated ships may face challenges in terms of a business case, as it does not necessarily create additional cargo space and requires both crews onboard and ashore.

The further progression of ships with automated processes and decision support and remotely controlled ships with seafarers on board is reliant on technological advancements both on board the ships and ashore. Additionally, regulatory frameworks set by the IMO and national and local authorities will play a pivotal role in shaping the trajectory of this development. As technology evolves and regulations adapt, this scenario anticipates a continued integration of automated functions in manned ships, paving the way for enhanced operational efficiency in the maritime industry.

As an example of this and increasing automation and expected autonomy is the electric 80m container ship, Yara Birkeland. Since its commencement of commercial operations in April 2022 the ship has become a pioneering force in autonomous maritime transport. Currently undertaking two voyages per week, the vessel transports approximately 100 containers on each journey. With further plans in motion to optimize operations, with the aim of increasing the frequency to 3 – 5 voyages per week.

An aspect of the Yara Birkeland's operational efficiency lies in the gradual integration of autonomous functions. This transition has led to a reduction in seafarers onboard, decreasing the crew size from five to three individuals. In the near future, this number is set to further decrease to a crew of two with the aim of achieving the overarching goal of complete autonomy in the ship's operations.

A dedicated shore facility has been established to facilitate the monitoring of the Yara Birkeland and other autonomous vessels, such as Asko's project for trailer ferries across the Oslo fjord. The vessel's remote monitoring means that the ship can be monitored and stopped and anchored if necessary.

Few unmanned autonomous ships

In this scenario, again projected over the next 5 - 10 years, it is expected that there will be a presence of a limited number of unmanned remotely controlled and completely autonomous ships operating. The progression to these stages of MASS is expected to take more time, especially in the context of international waters.

Initially, MASS is expected to find application in small and specialized ships, including tugs and small ferries. However, this implementation may be limited to participating states rather than being adopted universally for international voyages.

It is important to note, however, that MASS vessels are in operation or development for short-sea cargo routes in Europe, China, and Russia. Investment in this sector may increase to maximize cargo capacities and margins as the regulatory framework becomes clearer.

Survey vessels, especially those weighing over 500 tons, are also in development and operation, indicating a strong investment area in MASS.

With this in mind there does not seem to be plans for large-scale implementation of unmanned MASS in the immediate future in international waters, particularly in deep-sea operations. The integration of MASS into the operations of tankers and passenger ships, is anticipated to be very limited within the next 5 - 10 years.

<u>More manned ships with automized functions</u>

This scenario spans a 10-20 year timeframe and illustrates a notable increase in manned ships equipped with advanced automation features and possible remote control.

There is a rise in automation during this period, with an expectation of a greater number of ships integrating more advanced automated functions. Within the "More" scenario, foreseen over the next 10-20 years, an additional development is the increased adoption of partial or full remote-control ships, all while maintaining a seafaring crew on board. This entails the ship being controlled and operated from a different location, while seafarers remain present on board to assume control and manage shipboard systems and functions.

Ships could have the capability to shift between remote control and onboard control modes during a single voyage, adapting to local circumstances and the specific operational environment. However, as already noted there is concern regarding a lack of a business case in this instance.

<u>Some unmanned autonomous ships</u>

In the projected timeframe of 10 – 20 years, this scenario projects the existence of a more substantial number of autonomous and unmanned ships, aligning with unmanned MASS ships.

Increased development is expected in areas where reliable connectivity can be ensured, possibly through the use of mesh networks or terrestrial redundant networks.

MASS is anticipated to impact various ship types, including ROPAX ferries, special-purpose ships (e.g., surveying, navy operations, offshore support), and inland water vessels, many of which have already integrated autonomous systems.

Unmanned ships are expected to have a longer adoption timeline due to various factors, including technological and port and coastal state regulations. Ships built today typically have a lifespan of approximately 20 to 25 years and with major shipbuilders, such as Hyundai, expressing that they are not currently looking to build large unmanned vessels, this indicates that newly constructed vessels will continue to operate for several decades.

Consultation with stakeholders suggests that this scenario may not be feasible in this time frame for international transport, especially for passenger ships and tankers, for at least the next 25 years. The implementation of MASS technologies in large tankers and passenger ships is expected to take an extended period, primarily due to safety considerations, concerning the reliability of communication links for controlling the ship for instance.

The realization of fully autonomous large ships, where the operating system of the vessel can make independent decisions and actions, is projected to be at least 25 years away from becoming widespread.

Drivers and potential challenges of MASS

In contemplating the investment in MASS and the emphasis on its future development, stakeholders give many reasons that underpin investment and the rationale behind efforts for the ongoing evolution of MASS. These include various rationales, drivers, enablers, and prerequisites that collectively shape the trajectory of MASS's evolution and these are discussed below.

Advantages of MASS investments include potential enhanced navigation, predictive analytics to prevent accidents, financial efficiency through reduced operational costs, environmental benefits through green technologies, labour cost reduction, improved traffic management, and a notable reduction in the risk exposure of human life.

Business case

One driving force behind MASS investment lies in the appeal of a solid business case. Stakeholders, including shipowners, shipbuilders, and financial institutions, are inherently attracted to opportunities that promise favourable financial outcomes. Their pursuit of a "good business case" underscores the pivotal role that profitability and return on investment may play in their decision-making.

An additional advantage associated with full autonomy in MASS is the prospect of optimizing space utilization. By relinquishing the need for crew accommodation and navigational areas, stakeholders envision the conversion of these spaces for cargo storage. This potential for more space bolsters the economic appeal of MASS.

The potential cost savings associated with autonomous ships lie in reduced crew-related expenses. However, it is essential to recognize that crew costs, especially on larger vessels, constitute a small fraction of the total operational costs. Consequently, the overall savings from removing or reducing onboard crew are limited. Reduction in labour costs and reduced manning should also be weighed against employment concerns and potential job losses. Additionally, the further development of autonomous ships entails increased costs including technological infrastructure ashore, spanning vessels, ports, communication systems, maintenance and liability insurance.

When evaluating the business case for autonomous ships, it is crucial to consider the broader impact. This assessment should encompass financial benefits for various stakeholders, potential new career opportunities to attract qualified staff.

In cases involving remotely operated ships, stakeholders recognize that crew costs may persist at elevated levels, albeit relocated ashore and do not yield space for cargo. In addition, ships require maintenance that is currently conducted by the crew whilst underway. The removal of personnel may result in this maintenance being conducted whilst alongside, which may result in additional costs and time lost. This acknowledgement informs their investment decisions, particularly when assessing the cost-effectiveness of remotely operated alternatives.

Lack of seafarers

A compelling driver for the continued advancement of autonomous ships is the current shortage of seafarers encompassing deck and engine departments. The maritime industry is currently facing a shortage of qualified individuals.

The maritime industry is currently grappling with a significant shortage of qualified seafarers, as highlighted by the BIMCO and ICS Seafarer Work Force Report (July 2021). According to the report, the demand for officers to operate the global merchant fleet is expected to rise substantially, with an anticipated need for an additional 89,510 officers by the year 2026. This demand is further intensified by a shortfall of 26,240 STCW certified officers.

The Seafarer Workforce Report from BIMCO and ICS, delves into the specifics of this shortage. The report predicts a surge in demand for STCW certified officers and estimates that the world merchant fleet, consisting of over 74,000 vessels, with a total of 1.89 million seafarers currently serving.

Despite an overall increase of 10.8% in the supply of officers since 2015, the current deficit suggests that the demand for seafarers has outpaced the available supply. The report attributes this shortfall to a reported rise in the number of officers required on board vessels, averaging 1.4 officers required per berth.

Notably, the shortage is not evenly distributed across all categories. The report identifies a particular scarcity of officers with technical expertise, especially at the Management Level. Furthermore, the tanker and offshore sectors are facing a pronounced shortage of Management Level Deck Officers.

This scarcity of qualified seafarers has prompted the maritime industry to explore alternative solutions, leading to the development of MASS. A primary motivation behind the exploration of autonomous solutions is the desire to address crew shortages and ensure a sufficient pool of skilled personnel. The prospect of reducing reliance on human crew members remains a central driving force for stakeholders seeking innovative responses to the challenges posed by the shortage of qualified seafarers.

Safety of navigation

Navigational safety considerations generally form a significant component of the rationale for investing in MASS. The advantage of MASS from a safety perspective is dependent upon enhanced navigation and predictive analytics that can assist in the prevention of accidents. Improved traffic management, leading to enhanced coordination and optimization of maritime traffic, serves as a potential driver for improved safety.

Autonomous systems present the capability to respond more swiftly and accurately to emergencies, thereby reducing the likelihood of human errors. Ideally, MASS technology should contribute to minimizing failures caused by humans. However, the question arises as to whether MASS technology is genuinely safer than conventional manned ships.

It is important to recognize that machines do not get tired and do not forget, offering a potential advantage in terms of operational safety. Yet, humans, despite making errors, also play a preventative role. There is a balance to be met to prevent potential over-reliance on technology, and the reduction in human errors should be weighed against potential system errors.

Trust emerges as a pivotal keyword in relation to safety. While highly developed technology may not guarantee public trust in the systems, gaining widespread acceptance and confidence is a gradual process. This will involve establishing reliable safety records, demonstrating consistent performance, and transparently communicating the systems' capabilities and limitations to prospective users and regulatory bodies. A lack of acceptance or hesitation in MASS development could be considered a social barrier, potentially prolonging the implementation life cycle.

Despite several arguments favouring autonomous ships for enhancing safety, concerns persist about their reliability, especially in complex and unpredictable maritime environments. Potential malfunctions, software bugs, or communication failures could lead to accidents and collisions, posing greater harm due to the absence of a human crew to handle emergencies. While human error contributes to maritime incidents, not all stakeholders are wholly convinced that complete autonomy is the sole remedy. The effectiveness of full autonomy in eliminating accidents remains a subject of differing viewpoints within the maritime industry.

<u>Efficiency</u>

Efficiency stands out as a key driver and advantage for MASS, with the overarching goal not being crewless ships but rather operating more efficiently and safely, as emphasized by participants during the workshop.

This efficiency manifests in various forms, autonomous ships can operate with a higher degree of precision, adhering to optimized routes and adapting to changing conditions. This increased efficiency may translate to more efficient transit times, better resource utilization, and reduced congestion in busy waterways.

It is important to consider that efficiency drivers can be rooted in diverse factors, such as maximizing endurance at sea, cargo capacity optimization, and manning level considerations aligned with desired workforce demographics.

The range of efficiency goals encompasses increased precision in operational functions and optimizing fuel and battery usage. Furthermore, efficiency goals extend to enhancing navigational safety through interaction with AtoN. Faster reaction to critical incidents, leading to increased life-saving efficiency, is also a notable possible outcome.

A majority of ships worldwide with automated processes and decision support have already achieved efficiency in performance and crew reduction. This efficiency serves as a compelling incentive for MASS investments, attracting stakeholders with the promise of tangible benefits like fuel reduction and the adoption of cleaner fuels. Strategies such as Just-in-Time (JIT) arrival, which ensures increased operational efficiency, gain considerable attention.

Further advantages and drivers concerning efficiency for MASS investment include relieving road congestion by utilizing inland waterways, developing infrastructure that supports efficient transport, enabling autonomy within national waters, and promoting coastal shipping for enhanced efficiency in maritime operations.

Boost to profile

Being pioneers in the field of MASS offers a potential advantage with notable benefits. The opportunity to lead the way and establish a reputation as a "first mover" in this transformative sector can be a significant boost to a company's publicity. This aspect of reputation-building has the potential to enhance a stakeholder's prominence within the industry. The recognition and potential attention associated with being at the forefront of MASS development can carry lasting benefits for a company's standing and visibility in the market. An example of this is the high profile Yara Birkeland project as mentioned previously.

Regulation

The current international regulatory framework poses a potential barrier to MASS implementation in international waters. However, examples of bilateral and trilateral agreements, such as the MoU between Denmark, Belgium, and the United Kingdom, demonstrate frameworks enabling autonomous operations internationally.

The international regulatory framework for autonomous ships is evolving, varying between countries and regions. Standardized international regulations addressing liability, insurance, safety standards, and operational protocols are crucial. Upcoming frameworks include the IMO's non-mandatory goal based MASS code completion will take effect in 2025 and mandatory code will enter into force on 1 January 2028, as well as the IHO's S-100 ECDIS mandatory compliance after 1 January, 2029.

Environmental considerations

MASS development is potentially aligned with global environmental objectives, supporting emission reduction initiatives like the United Nations Sustainable Development Goals and the European Green Deal. Autonomous ships, optimized for fuel efficiency, route planning, and emissions reduction, contribute to minimizing fuel and energy consumption. This leads to decreased greenhouse gas emissions and positively impacts the environment. Additionally, MASS has a sustainability spin-off effect by reducing road traffic, lessening truck queues, noise, particulate matter, and infrastructure needs.

Contributing organizations to the Workshop on Establishing Scenarios for the Development of MASS – October 2023

Aivenautics

American Pilots' Association

Avikus

BIMCO

Danish Maritime Authority

DG Move

Direction générale des affaires maritimes, de la pêche et de l'aquaculture (DGAMPA), France

Finnish Transport and Communication Agency

German Federal Waterways and Shipping Agency

International Chamber of Shipping (ICS)

International Harbour Masters Association (IHMA)

International Hydrographic Organization (IHO)

International Maritime Pilots' Association (IMPA)

Japan Coast Guard

Kongsberg Maritime

Korea Maritime Cooperation Center

Le Conseil International pour les corridors maritimes intelligents (CI CMI)

Maritime and Port Authority of Singapore

Navantia Systems

One-Sea

Swedish Maritime Administration

Swedish Transport Agency

The Nautical Institute

UK Hydrographic Office (UKHO)

US Coast Guard