

Autonomous Ship



THE HONOURABLE COMPANY OF MASTER MARINERS

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Published 10th January 2023

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Autonomous machines are active in air, sea, road and rail transport as technology moves at a fast pace and now involves artificial intelligence, augmented reality, robotics and autonomy.

The International Maritime Organisation (IMO) has named autonomous solutions for sea vessels as Maritime Autonomous Surface Ships (MASS). In a report, the Maritime and Safety Committee has identified four levels of autonomy:

- a crewed ship with automated processes and decision support
- a remotely controlled ship with seafarers onboard
- a remotely controlled ship without seafarers onboard, and
- a fully autonomous ship.

The UK Maritime Autonomous Systems Working Group (MASRWG), however, has developed the MASS UK Industry Conduct and Code of Practice that differs from the IMO identification. The Society of Maritime Industries UK Maritime has issued the code of practice explaining its terminology, something this paper does not deal with, though it covers levels of control as opposed to IMO degrees of operations.

Classification societies inspecting and verifying hulls, machinery and operational equipment have established standards in MASS vessels. Meanwhile, the Baltic and International Maritime Council (BIMCO) is currently reviewing the SHIPMAN 2009 charter party for adaptation to autonomous ship operation.

The current UK training provider for operation of MASS vessels is SEABOT XR who have an arrangement with the UK Hydrography Centre. Although a webinar by SEABOT XR was held about developing training, all operations are governed according to equivalent qualifications for each vessel's size. Maritime UK also publish templates for MASS generic training, MASS operators record book, MASS mission planning, mission appraisal, and MASS vessel monitoring. The MASS code of practice offers high level operational ideas, whereas classification societies have rules for technical functions of the MASS, including software design.

Currently, the military's embrace of advanced technology, training, and prototypes is considerably in advance of the maritime industry, for it already deploys machines and systems in operations. It is worth noting that these 'improvements' normally cascade into the commercial sector.

From press releases we can glean numerous commercial MASS test areas. These exist on the southern UK coast, Finland, Norway, USA, China and USA. It is expected that more test areas will develop as technology in this area progresses. Current MASS projects in the higher degree areas where seafarers are not onboard include: *SeaKit* (UK), *Mayflower* (UK), *Ocean Infinity* (UK), *Yara Birkeland* (Norway), *SeaFar* (Belgium), and *Nippon Yusen* (Japan). The majority of projects are for small MASS under 24 metres in length, equivalent to workboat regulations, and are for seabed surveying. The *Yara Birkeland* is the largest project with a gearless container vessel. Seafar have two automated inland barges and a shore-side control to reduce crewing of a coastal cargo ship. Active projects are either in domestic waters or involve sailing from a single maritime state to international waters to carry out operations and return. *Ocean Infinity* is preparing for larger MASS ships with different degrees of autonomy. Japan intends to trial an automated container ship on a 236nm journey. The code of practice has mapped out UK commercial and military test areas, significantly on south and west coasts.

There is no consensus concerning the purpose of MASS technology. Some areas of interest include:

- commercial access to a new sector of technology currently worth \$11 billion and aggressively increasing with an estimated \$112 billion already invested in MASS
- the reduction of operational costs for ship operators by not having crew onboard
- the removing of human error through automation and an ability to remove humans from uncontrolled risk
- the advantage of using a smaller unmanned and environmentally, or green, ship that can do the same task as a larger crewed ship.

By removing crew, it is argued that human error and the risk of accident to a human is removed from a difficult environment. A counter argument is that the overall human contribution to safety, the successful safe navigation, and the carriage of goods is not yet assessable. But by removing the possibility of human error through use of automated systems other human factors intervene and new error pathways enter the design and operation of MASS. The safe use of MASS relies on seafarer experience, which remains imperative to successful MASS operation.

The argument of reducing crew cost by removing humans is countered by the increased costs elsewhere:

- a need to set up shore control centres
- the significant cost of communications between shore and MASS which need to be uninterrupted and secure
- the demand for quality bandwidth and how this would operate or be affected over different continents
- the considerable expense of port operations and a reliance on specialised dock MASS facilities.

Operating standards are required to be similar to other conventional ships. What is unclear is the nature of what is required in a remote-control centre (RCC) and the kind of expertise involved. Whoever is involved should reach an approved medical standard. MASS may allow physically challenged people some involvement, though not as an operator (watchkeeper). The RCC should be of a standard comparable to a ship's bridge and emergency or mission room. Operating systems and structures should follow safe operations that are responsive to ergonomic and other human factors. (Mobile operating stations have not been discussed.) In the event of an autonomous vessel and its operation breaking maritime law, because a computer cannot be used in court except in evidence, those persons responsible for the infringement should surrender to international investigations and arrest, and the MASS detained being the asset.

As autonomy in shipping develops, accidents blamed on humans are used to justify increased automation. The MASS training webinar, hosted by the IMarEST, proposed assessment of the pragmatic removal of human's onboard ship and its transfer to a remote station. The webinar explored the reduced risk to a human or if a human remained onboard an autonomous vessel could they do their job efficiently and thereby make the operation safer. It also noted that there is no cost benefit or logic to removing humans from the ship to place them in a shore control centre.

Whilst the majority of MASS is of workboat size and operations are for surveying there is an appetite to upscale when a business case is proved. Upscaling MASS ships operating at low level degrees of autonomy includes use of a ship's crew as part of risk management and operations that automation cannot abolish. Automation can remove or simplify mundane tasks, such as manual inputting and monitoring of ship systems, involving track and speed keeping of navigation and live feedback to monitoring stations. Automation can also monitor a ship's engine and auxiliary power plants and

intervene without notice to prevent damage. It can track and record large data for commercial advantage.

Very large conventional ships can be 400m in length and carry 23,000 containers. For example, the some of these ships have a safe manning document for a crew of 13 necessary for safe operation of such a large ship carrying multiples of hazardous cargoes. For intense operations riding gangs supplement the crew. While some cargoes may not be classified as hazardous marine pollutant, the accident to the *Rena* in New Zealand demonstrated the significant cost in time, human resource and environmental damage of clearing up containers washed ashore and the cargo spill. A lower degree of autonomy might be a solution, providing support to human agency, or greater degrees of autonomy might make risky operations unmanageable. The grounding of the *Ever Given* in the Suez Canal shows how fragile the supply chain is and how one ship operation can rock the supply chain and national economies.

In the code of practice MASS provides for an emergency or operating platform where local control can be taken. Stena have drafted a design of the *Infinity* Concept Ship involving a ship with some MASS that is green or environmentally friendly and carries multiple types of hazardous cargo. Ocean Infinity propose a survey ship of conventional size with multiple autonomous functions but has crew accommodation and operating areas. If MASS are to operate in high traffic areas in all weathers and regularly enter port and dock then an operating platform will be required. The code of practice discusses the requirement for MASS to operate in search and rescue and be salvaged.

Security, especially cyber security, is paramount in shore and ship operations. The code of practice covers certain perceivable possibilities while offering no solutions. Examples of possibilities include MASS being intercepted by pirate communications and unauthorised persons boarding the MASS structure or entering the RCC premises, the MASS being used as weapon or WMD, and illegal operations or non-compliance with load line regulations. As criminals adapt to new areas of vulnerability and opportunity the maritime world cyber-attacks by organised criminal gangs or rogue states are increasing on company headquarters or ports, and for them MASS presents a new opportunity. Recently a drone with explosives was dropped on an oil tanker killing two crew. Small MASS used for illegal purposes would probably be undetectable and could be used as spyware, whether for espionage or commercial intelligence. Coupled with mine ordinance small MASS could hold hostage a large ship or disrupt a busy port approach.

Viewed positively the use of small MASS carried onboard ship to assist with high-risk tasks could be beneficial. The military are already equipping a conventional surface mother ship with a MASS or UAV. If commercial shipping were to follow suit some interesting applications become possible, such as MASS assistance for a ship operating with restricted visibility by providing a lookout/detection system. In port approaches in unknown or high-risk areas MASS could take depths ahead of the ship and give real time feedback. MASS could aid pollution control by boom laying around a ship. It could send mooring lines in heavy weather or be used to send light parcels of documents ashore or for stores, inspect the waterline or, for subsurface it could inspect below the waterline. Smaller MASS can be used in non-lethal modes as guard vessels in piracy waters.

Because MASS is an embryonic technology with considerable implications for established safe maritime operations, we recommend that The Honourable Company of Master Mariners should:

1] **Continue to contribute to future Codes of Practice.** MASS will affect members in the future and it is appropriate, given the seniority of the HCMM, that the Company should draw on the combined experience of its members. Current investigations concern whether this should cover subsurface sea MASS. A combination of subsurface, surface MASS and unmanned aerial vehicle is possible.

2] **Develop a relationship with IMarEST MASS Special Interest Group.** The IMarEST has held webinars on autonomy at sea and in the air. It has a working group called the MASS SIG, its head being involved with developing training in MASS operation. A question raised was ‘for certificates of competency is the time spent operating MASS equivalent to sea time?’ Whilst the current proformas and code of practice provide guidance there is a need for rigorous training and development of MASS and Operators that provide equivalency between seafarer qualifications.

3] **Lobby for qualified seafarers to be involved in the planning, training and operations of MASS.** With their wide experience in seagoing vessels seafarers have built a reputation for safe operations. Whilst automation can take away mundane or high-risk tasks seafarers still need experience to solve problems. The military successfully combine MASS and UAV operations by using experienced personnel trained for this mode of operation. The commercial sector should follow suit. The cost of providing secure communications has been suggested as a reason to seek a lower standard in operation, but MASS cannot be an excuse for lowest cost when safety is at risk.

4] **Maritime Regulation and Security.** A MASS should fall under the definition of ‘ship’ and abide by the ‘Collision Regulations without exemptions’. This will allow maritime states, especially the UK, to use current Merchant Shipping Acts and other national statutes to control MASS operations to ensure equivalent standards in operations and for operators.

Given the electronics and communications to operate MASS, MASS potential security weaknesses are at the forefront of assessing operations.

5] **There are already different terms and references to MASS between UK and IMO guides which need to be aligned.** The IMO and individual maritime states and projects are using different terms, especially when discussing MASS. HCMM should encourage UK authorities to employ IMO terms. (IMO degrees of autonomy differ from the code of practice levels.)

The P&TC should regularly review this paper to maintain relevance to MASS operations. Technology and MASS are in fast paced development. This paper or information submitted to the P&TC will need to be regularly updated.

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The following are to be thanked for their contribution as a correspondence group,
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