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| IALA Guideline |

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IALA GUideline on developments in maritime autonomous surface ships

Edition 1.0

Document date

Revisions to this IALA Document are to be noted in the table prior to the issue of a revised document.

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# Introduction

Maritime Autonomous Surface Ships (MASS) are defined by the International Maritime Organisation (IMO) as being:

*A ship which, to a varying degree, can operate independently of human interaction.*

There are ongoing discussions and trials surrounding MASS and some of these are being conducted by non-traditional operators. It is imperative that IALA take note of and support these initiatives to ensure that the AtoN environment is and remains fit for purpose as the MASS technologies advance.

## Background

To facilitate the progress of the regulatory scoping exercise the IMO identified degrees of autonomy:

1. 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.
2. 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.
3. Degree three: Remotely controlled ship without seafarers on board: The ship is controlled and operated from another location. There are no seafarers on board.
4. Degree four: Fully autonomous ship: The operating system of the ship is able to make decisions and determine actions by itself.

In the discussions at IMO it was noted that MASS could be operating at one or more degrees of autonomy for the duration of a single voyage.

Both physical and electronic Aids to Navigation (AtoN) have a significant role to play in the MASS domain as this matures.

# Aims and Objectives

The aim of this guideline is to provide guidance to IALA members who may be undertaking testing and trials of MASS systems. This guideline also provides guidance for organisations implementing policy, procedures and technical solutions to support the introduction of MASS.

# Overview of MASS

IMO's [Strategic Plan](http://www.imo.org/en/About/strategy/Pages/default.aspx) (2018-2023) has a key Strategic Direction to "Integrate new and advancing technologies in the regulatory framework". This involves:

* balancing the benefits derived from new and advancing technologies against safety and security concerns,
* assessing the impact on the environment and on international trade facilitation,
* identifying the potential costs to the industry, and
* assessing the impact on personnel, both on board and ashore.

In 2017, following a proposal by a number of Member States, IMO's Maritime Safety Committee (MSC) [agreed](http://www.imo.org/en/MediaCentre/MeetingSummaries/MSC/Pages/MSC-98th-session.aspx) to include the issue of marine autonomous surface ships (MASS) on its agenda. It was agreed that this would be in the form of a scoping exercise to determine how the safe, secure and environmentally sound operation of MASS may be introduced in IMO instruments.

The MSC 101 session, in June 2019 approved Interim guidelines for MASS trials.

Among other things, the guidelines indicate that trials should be conducted in a manner that provides at least the same degree of safety, security and protection of the environment as provided by the relevant instruments. Risks associated with the trials should be appropriately identified and measures to reduce the risks, to as low as reasonably practicable and acceptable, should be put in place.

It is important to recognise that an autonomous vessel does not mean an unmanned vessel: an autonomous vessel may still be manned.

## Levels of Autonomy

To facilitate the progress of the regulatory scoping exercise the IMO identified degrees of autonomy:

1. 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.
2. 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.
3. Degree three: Remotely controlled ship without seafarers on board: The ship is controlled and operated from another location. There are no seafarers on board.
4. Degree four: Fully autonomous ship: The operating system of the ship is able to make decisions and determine actions by itself.

Although the IMO have identified four levels of autonomy for the purposes of the RSE, more finely graduated definitions are available in other industries. These can include anywhere from 5 – 10 levels for autonomy. An example from [reference] is:

1. Level 1 – The computer offers no assistance, human in charge of all decisions and actions
2. Level 2 – The computer offers a complete set of decision alternatives
3. Level 3 – The computer narrows alternatives down to a few
4. Level 4 – Computer suggest a single alternative
5. Level 5 – The computer executes the suggested action if the human approves
6. Level 6 – The computer allows the human restricted time to veto before automatic execution
7. Level 7 – The computer executes automatically, when necessary informing human
8. Level 8 – The computer informs human only if asked
9. Level 9 – The computer informs human only if it (the computer) decides so
10. Level 10 – The computer does everything autonomously, ignores human

While the detail contained in the 10 levels presented, the introduction of additional levels of autonomy in the maritime industry could be confusing.

Until the IMO revises its identified degrees of autonomy, it is recommended that IALA use these same four degrees of autonomy to ensure coherence with IMO documentation.

## IALA and MASS

The establishment of safe and secure environments in which MASS can operate can be helped through the provision of AtoN. IALA provides guidance on AtoN systems that can be used to support a MASS environment, including:

1. Fixed shore side AIS AtoN systems
2. Floating AIS AtoN systems
3. Virtual AIS AtoN
4. Marking of physical AtoN using Synthetic AIS AtoN
5. The transmission of local and applicable Meteorological and Hydrological data using Application Specific Messages (ASM) contained in IMO Circular SN.1/ 289
6. The tracking of all vessel within a Vessel Traffic Services (VTS) environment

The above requires digital communication systems that include AIS. The ASM is evolving within VDES. The VDE component, when available, will also be relevant.

Other digital data exchange capabilities, including developments in 4G and 5G, digital VHF Voice and satellite technologies will also be relevant to establishing a suitable MASS environment.

# MASS and Maritime Services

Based on the four levels of autonomy that IMO have developed, IALA recognises that there will primarily be four operational environments with regards to MASS:

1. Degree one exclusive environments
2. Degree one and two exclusive environments
3. Degree three and four exclusive environments
4. Environments that allow Degree one to Degree four autonomous vessels to operate

The services delivered using physical, electronic and virtual AtoN environments for each of the four environments could be different.

## IALA MASS services considerations

The AtoN services to be delivered to support the various degrees of autonomy for MASS operations need to be identified considering:

1. Risk Mitigation
2. IALA services to be rendered
3. Channels for service delivery / provision
4. MASS service requirements unknown
5. Proprietary MASS services
6. Pilot needs / wants
7. Remote pilotage including legislation
8. Remote berthing and connections to shore services
9. Legislation to allow / enable remote pilotage
10. VTS environment interaction
11. Route Message transfer
12. Local situational awareness
13. Metrological systems and data
14. Hydrological systems and data
15. AtoN availability
16. Vessel traffic and density

# Development of MASS

[Sources of information ]

Website for updates on MASS developments? (perhaps an opportunity to provide IALA members with an online calendar of MASS activity / conferences; reference materials?)

# Definitions

*Suggested text:* The definitions of terms used in this IALA Guideline can be found in the International Dictionary of Marine Aids to Navigation (IALA Dictionary) at <http://www.iala-aism.org/wiki/dictionary> and were checked as correct at the time of going to print. Where conflict arises, the IALA Dictionary should be considered as the authoritative source of definitions used in IALA documents.

[Need to consider adding definitions to support MASS as appropriate]

# Acronyms

IMO International Maritime Organization (Acronym style)

MASS Maritime Autonomous Surface Ships

AIS Automatic Identification System

ASM ASM as part of the VHF Data Exchange System

ASM Application Specific Message

VDES VHF Data Exchange System

VTS Vessel Traffic Services

# References

https://www.maritimeuk.org/media-centre/publications/maritime-autonomous-surface-ships-uk-code-practice/

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AWA Position paper, Rolls Royce, Remote and Autonomous Ships, the next steps

Review of Maritime Transports, 2018, UNCTAD