Input paper: [[1]](#footnote-1) ARM16-7.3.1

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Agenda item [[2]](#footnote-2) 7.3

Technical Domain / Task Number 2

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AtoN Classification Applicable to Maritime Surface Autonomous Ships (MASS) Guideline

# Summary

In recent years, Maritime Surface Autonomous Ships (MASS) are becoming the focus of attention in the shipping field, and different organizations have defined them with different degrees of autonomy. According to the development of MASS, this paper discusses the intelligent development of AtoN under the development of Maritime Surface Autonomous Ships, put forward the concept of classification and grading of AtoN under the existing MASS framework, and it preliminary divided classification of AtoN at different development stages based on functions, types, sensor configuration, scope of application, service objects, management methods and self-recovery, so as to make AtoN applicable to the development of MASS and able to interact with MASS to help establish a safe environment in which MASS can operate, which will have a positive and far-reaching impact on maritime security.

## Purpose of the document

Considering the information contained in this document, the purpose of this paper is to provide an overview of the classification of AtoN for the ARM Commission's guidance on Autonomous Vessels at Sea and On the Surface.

## Related documents

ARM15-7.3.11 Draft MASS Guideline\_20220317\_V1

ARM15-7.3.3 WP Input paper on the report of IALA WS on MASS (ARM14-7.3.6)

ARM15-7.3.4.1 WP TG.1.2.5 Discussion paper - Implications of MASS from a VTS perspective post plenary

# Background

In May 2018, at the 99th meeting of the International Maritime Organization's Maritime Safety Committee (NSC) held in London, the International Maritime Organization (IMO) defined the maritime surface autonomous ship and proposed a preliminary definition of the degree of autonomy, and divided it into Four levels: Ship with automated processes and decision support, Remotely controlled ship with seafarers on board, Remotely controlled ship without seafarers on board, Fully autonomous ship.

In order to provide support for the research and development of various intelligent ships, China has carried out a lot of work in the formulation of intelligent ship standards and the construction of experimental sites in recent years, including the establishment of two smart ship experimental bases in Zhuhai and Qingdao. In June 2021, “ZhiFei”, China's first intelligent container merchant ship with three functions of unmanned driving, remote control and autonomous navigation, made its maiden voyage in Qingdao. A total of 35 sailing trials have been carried out on the functions of collision avoidance, autonomous tracking navigation, and remote control driving, speed, stability, anchoring and turning. As China's first commercial cargo ship with intelligent navigation capability, “ZhiFei” is equipped with China's self-developed intelligent navigation system, which can realize intelligent navigation environment awareness, autonomous tracking, autonomous route planning, intelligent collision avoidance, automatic docking, and remote control driving. Through multi-network and multi-mode communication systems such as 5G and satellite communication, it can complete coordination with shore-based production, service, dispatching control and supervision institutions and facilities such as ports, shipping, maritime affairs and shipping insurance.

In 2021, the Policy Advisory Panel (PAP) of the IALA approved a proposal submitted by the MASS Working Group, which is to develop a common guideline on MASS for IALA, with each committee contributing relevant content and chapters in their respective areas of expertise. On the 14th meeting, ARM Committee officially started the compilation of recommendations and guidelines for MASS, and formed a preliminary guideline framework through meeting discussions. The guidelines involved chapters that required the classification of AtoN for MASS, so this proposal presented relevant classification of AtoN.

# Discussion

With the current development situation of intelligent ships, it is not difficult to predict that autonomous ships and intelligent ships will completely change the pattern of shipping in the next 20 years. It is clear that in the future all classes of Maritime Surface Autonomous Ships (MASS) will sail from one destination to another, and MASS operations will require digitized and automated processes，meanwhile it also needs to interact with existing AtoN for intelligent navigation.

## Intelligent navigation requirements of MASS

Although Maritime Surface Autonomous Ships (MASS) is an emerging ship type, it should not be viewed in isolation, but rather as a complement to a wide range of ship types in the current Marine field. The operational Marine navigation assistance system needs to be suitable for all vessels, including MASS of course. MASS operates with varying degrees of autonomy and uses AtoN depending on the level of autonomy and the type of technology used. Vision sensors on MASS must be capable of imaging AtoN with sufficient resolution to detect their characteristics, make a positive identification and determine their position through the use of GNSS and ECDIS.

Existing AtoN have a long history and existing visual, radio and audible aids can help form a suitable complement and enhancement service platform for maritime surface Autonomous vessels (MASS). The AtoN currently in use need to be modified/enhanced to meet the needs of MASS to better facilitate machine recognition of their characteristics and positive identification of individual buoys, while various devices need to be installed to interact with the surroundings to obtain more environmental information, such as hydrological sensors, visual cameras, radar radios, etc., add AIS equipment to combine cameras, radars, etc. to achieve interaction with MASS. At the same time, future AtoN should be more intelligent, can take on more roles, provide more information to ships, such as meteorological data, and be able to be placed in strategic locations so that they can become the communication hub for VDES. At the same time, MASS can feedback relevant information to the AtoN operator to verify whether the AtoN is in the correct position and working properly, so as to improve the availability of the AtoN.

In order to better adapt to MASS development, it appears that the maritime AtoN environment can develop a classification system leading to a known environment within the maritime AtoN area, which can provide the intelligent basis for the interaction between MASS and AtoN.

## Classification and grading standard of AtoN

The classification and grading standard mainly classifies the related systems and equipment involved according to the types of AtoN, application scenarios and intelligent functions, and divides the intelligence level and autonomy level of AtoN and system equipment, so as to clarify the attribute characteristics, capability requirements, coverage scope and whether to meet the navigation safety requirements of MASS of all levels and types of AtoN.

AtoN can be divided into 6 levels according to the degree of intelligence, function attributes and so on. The specific situation is shown in the following table.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Level** | **Description** | **Meaning** | **The role of the operator** | **Whether to meet the navigation safety requirements of MASS** |
| Level AL0 | No intelligent | Remote control without telemetry | Traditional lamp, completely rely on manual inspection maintenance | No |
| Level AL1 | Telemetry | The lamp, energy and control units provide remote telemetry of operating status | On shore telemetry management via monitoring centre | No |
| Level AL2 | Telemetry/remote control | The lamp, energy and control part can remotely measure the operation state, and also can remotely control the operation of lamps, energy and others, also can set relevant parameters | Telemetry and remote management can be carried out at any time from shore to perform remote tasks | No |
| Level AL3 | Telemetry/remote control/customized intelligent services | With telemetry and remote control, it can meet the AtoN management based on shore, and can also provide intelligent services according to customized intelligent modules to meet the needs of intelligent navigation of ships | Meet internal management and external customization of intelligent services | Yes |
| Level AL4 | Intelligent management and service | It can autonomously control the operation of the lamp, information broadcast and charging mode conversion according to the Marine environment and various sensor modules that have been configured | The shore-based monitoring centre provides intelligent management and customized services for AtoN according to system telemetry and remote control management and actual risk management, On a daily basis, managers only need to be involved in decision-making when the system fails or prompts the need for intervention. | Yes |
| Level AL5 | Independent management | Autonomous control of operation, information broadcasting, recovery of warning words after failure, decision-making to take collision avoidance warning measures, etc. | Autonomously detect the operating status, and can provide intelligent services according to environmental changes and external needs. In the event of an abnormality, it autonomously perform fault detection and recovery, also can take emergency collision avoidance warning measures and so on. | Yes |

# References

1. ARM15-7.3.3 WP Input paper on the report of IALA WS on MASS (ARM14-7.3.6)
2. ARM15-7.3.4.1 WP TG.1.2.5 Discussion paper - Implications of MASS from a VTS perspective post plenary

# Action requested of the Committee

The Committee is requested to:

1. note the work carried out by China in respect of Maritime Autonomous Surface Ship (MASS) and the classification of intelligent AtoN for Maritime Autonomous Surface Ship (MASS) as proposed in this document.
2. consider the practicability of incorporating the mentioned AtoN classification into IALA's Guidance on Maritime Autonomous Surface Ship (MASS).

1. Input document number, to be assigned by the Committee Secretary [↑](#footnote-ref-1)
2. Leave open if uncertain [↑](#footnote-ref-2)