Input paper: PAP41-6.1.5.1

Input paper for the following Committee(s): check as appropriate Purpose of paper:

**□** ARM **□** ENG  PAP  Input

**□** ENAV **□** VTS **□** Information

Agenda item 6.1.5

Author(s) / Submitter(s) Netherlands, Singapore

Impact of MASS on Marine Aids to Navigation

# Summary

In light of the Maritime Autonomous Surface Ships (MASS) developments at the International Maritime Organization (IMO) and around the world, it is imperative to develop common global standards for interoperability of the Marine Aids to Navigation including VTS³ to support and integrate ocean-going MASS operations into shipping. The International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA) can help to further encourage the development of MASS-related infrastructure by developing agreed guidelines and standards for MASS trials as well as the operation of MASS.

To harmonise the integration of MASS operations into shipping, IALA should aim to establish common terminology and standards for communication, ship reporting and data exchange, between MASS and various stakeholders. Enhanced inter-operability of various systems would allow international ports to be more accessible to MASS. For a start, the IALA should take guidance from IMO’s MSC regulatory scoping exercise on MASS, including the interim definitions for ships with varying degrees of autonomy.

MASS involves work programs across all IALA technical committees. Collaborative discussions among committees are necessary. This paper proposes to set up an inter-committee task force for MASS, and adopt a common methodology and process for the development of IALA’s Standards, Guidelines and Recommendations on MASS operation.

## Purpose of the document

The development of MASS and MASS-related infrastructure involves all IALA Technical Committees. Discussions have been scheduled in ARM, ENAV, ENG and VTS committees in the coming years. The purpose of this document is:

* To adopt a common framework to facilitate MASS discussion across the Committees.
* To create a common approach of the discussions on MASS in all IALA technical Committees
* To support the development of tasks related to MASS, including emerging technologies and human elements, for the IALA work program 2022-2026
* To provide framework to develop standards, recommendations, guidelines and manuals to implement new and advancing technologies

## Related documents

IALA C71-8.5.1 Paper on the Impact of MASS on VTS (The Netherlands)

IALA VTS49-8.2.4 Scoping exercise on the implications of MASS on VTS documents (China MSA)

MSC 100/20/Add.1- Report of The Maritime Safety Committee on Its One Hundredth Session (Secretariat)

# Background IMPACT MASS

IMO is currently assessing existing IMO instruments to see how they might apply to ships with varying degrees of automation, through a regulatory scoping exercise on MASS. IMO's strategic plan (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, the impact on the environment and on international trade facilitation, the potential costs to the industry, and finally their impact on personnel, both on board and ashore. (IMO, 2020)

IMO recognized that it should take a proactive and leading role, given the rapid technological developments relating to the introduction of commercially operated ships in autonomous/unmanned mode.  IMO started a scoping exercise and is expected to touch on an extensive range of issues, including the human element, safety, security, interactions with ports, pilotage, responses to incidents and protection of the marine environment. (MSC 98, 2017)

## IALA and MASS adoption

The 69th and 70th IALA Council meetings discussed the fast developing of MASS in the maritime domain and agreed that IALA should prepare for the introduction of MASS in the working domain of IALA. On the proposal of The Netherlands a input paper (C71-8.5.1) had been delivered towards the 71st Council with a summary of the adaption of MASS in IMO. A reference to how MASS fits with the goals and strategies of IALA’s Strategic Vision was discussed. Council 71 agreed to send the paper to the Committees and PAP for further analysis and recommendation to Council 72.

At the Committee meetings, VTS50, ENAV26, ARM12 and ENG12 the input paper was not discussed but referred to PAP 40 for consideration. PAP40 considered that it was too early to act on these action points, but would actively monitor MASS developments. The VTS Committee currently has a task item related to action point 5 of the Dutch input paper (C71-8.5.1) and work is currently due to commence on this at VTS50. It was emphasized that MASS is an important topic for all committees, and ENAV would take a coordinating role in the forthcoming work.

## IALA and MASS framework

To integrate new and advancing MASS technologies into the regulatory framework, IMO created a framework for MASS developments for purpose of a scoping exercise on regulations (MSC 100 -2018). Likewise, evolving MASS technologies will impact the works of IALA. To develop regulatory framework for MASS and MASS-related infrastructure on the relevant Marine Aids to Navigation including VTS, it is necessary to consider MASS operations from the technology level, as well as the regulatory level. As MASS infrastructure spans across various IALA committees, it is proposed that an inter-committee taskforce be formed within the PAP to oversee and coordinate the work streams across committees, as well as align the recommendations presented to the IALA Council.

# MEthodology

Given the rapid technological developments relating to the introduction of commercially operated ships in autonomous/unmanned mode and the uncertainty’s of regulations, developers are starting small scale until there is a clear direction in terms of the regulations for MASS. To enable the full potential of MASS, it’s necessary to take a proactive and leading role on regulatory work. In order to achieve a clear development of Marine Aids to Navigation to MASS ships, it is proposed that the steps of a system life cycle method be used in to conceptualise design, construct and operationalise an idea in a iterative process, which involves several feedback loops to achieve functional and technical requirements for future Marine Aids to Navigation.

## Life cycle approach and areas of development

The life cycle approach (further explained in ANNEX 2) is a generic approach for developing and building a product. It consists of several phases that are followed iteratively and cyclically, so that an incremental development of the product could arise. The strength of this approach is that when going through a cycle, the technicality and functionality of the product improve overtime and that the product - even with reduced functionality - can already be put into use in a relatively short time. The scope of this report focuses on defining functional requirements and for this reason not all phases need to be completed. We focus here on the concept and design phase.

The right side of figure 1 shows the different development areas that must be defined during the life cycle approach to determine all aspects of IALA Standards and future Marine Aids to Navigation. This includes determining the functions to be performed and determining who and what should perform these functions including the staff competencies, responsible organization and management. With regard to systems, the required functionality must be appropriate to perform the tasks identified and everything is ready to go operational after the construction phase.

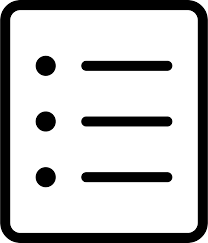
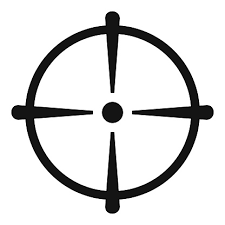
*Figure1: Life cycle approach (left) and areas of development (right*)

## Step by step

Based on the life cycle approach, we propose a structured iterative process that leads the development of functional and technical requirements for future Marine Aids to Navigation as well as the scoping of the impact of MASS on IALA standards. The proposal starts with determining future scenarios (from out of the four IMO degrees of MASS) and describing the needs, purpose of Marine Aids to Navigation Services. From which a scoping exercise on that specific scenario could identify tasks and recommendations for guidelines and regulations.



1. Determining the future scenario (user need)
2. Determining the purpose and services of future Marine Aids to Navigations



1. Scoping exercise
2. Identifying tasks / recommendations for guidelines and regulations

*Figure 2: Proposed steps to start the process with scope*

This approach could also be used in determining the roles and functions of the operators. This will be an iterative process, allowing for more defined scenarios.

### Step one: Determining the future scenario

The starting point of this process is to define future scenarios of Marine Aids to Navigation in combination with MASS making use of the four IMO degree’s earlier referred to. The high degree of variation in the MASS-VTS-Remote Control Centre interactions, for example, requires just as much variation in future scenarios. It is therefore important to start with well-defined and generic use cases as the basis for further steps. Input from Member States and all stakeholders on any MASS-related initiatives would be very welcome. Examples for use cases are available such as the case study navigating from Australia in the year 2030 (AMSA, 2019)

The inter-committee task force should first start to set-up realistic scenarios on different locations and with different users / situations for each of the 4 MASS degrees of autonomy as defined by the IMO. To involve more IALA members these scenarios should be discussed at committee meetings and discussion points could be put forth to the inter-committee task force. The inter-committee taskforce will align all recommendations and considerations, as well as provide advice on scenarios that require further discussion.

### Step two: Determining the purpose and services of the future

After defining the scenarios, the required services will be made transparent in accordance with the different levels of MASS. The second step should deliver answers on the impact of MASS on the services, tasks, roles, functions and Human Machine interface.

Based on the scenarios the inter-committee task force should start to draft for each scenario the possible impact on the current services, tasks, etc. and deliver an overview on new services. Existing mapping methodologies from IALA Member could be useful to explore the impact of MASS on future Aids to Navigation.

The scenarios identified in steps one and two will be given as input to the committee meetings to discuss the purpose and services and propose future changes to the taskforce. The inter-committee taskforce will then align all recommendations and propose a final set of future services to PAP.

### Step three: Scoping exercise

The scoping exercise CHINA MPA suggested using a framework to determine the implications of MASS on the relevant Marine Aids to Navigation , to assess the potential impact of MASS on existing IALA standards using common scenarios within the committees. The third step will make clear which documents are related to future scenarios, their purpose and services and if they are effected by MASS.

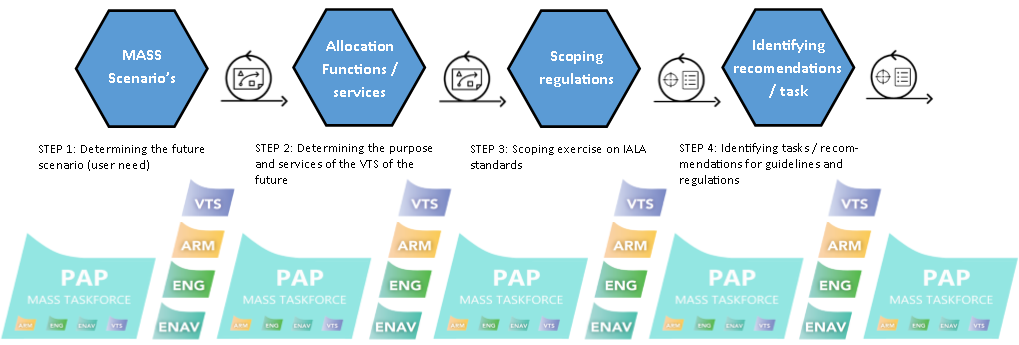
The inter-committee taskforce should first conduct a gaps analysis to select which documents, managed by the committee, are related to the given scenarios and give a classification of MASS implications on IALA documents. Relevant committee meetings would discuss the identified work areas from the gap analysis and provide the inter-committee taskforce with suggestions to clarify the scoping exercise. The taskforce will align all recommendations and provide PAP a final Scoping exercise.

### Step Four: Identifying tasks / recommendations for IALA standards

After scoping the impact of MASS within individual committees, a general overview could be provided on the impact of MASS on IALA standards. The inter committee taskforce will be able to give direction / advice / choices towards the first steps in identifying tasks and recommendations for IALA standards to change.

Based on the scoping exercise the inter-committee task force should draft a proposal for further actions and recommendations on the IALA standards to be reviewed. The draft paper version will be given as input to the committee meetings for discussion. The inter-committee taskforce will align all recommendations and provide a final document to the IALA council for further action.

## Process proposal



**Timeline: 2021 2022 2023**

*Figure 3: Proposed approach with iterative process to achieve inter-committee alignment*

# Action requested of the PAP

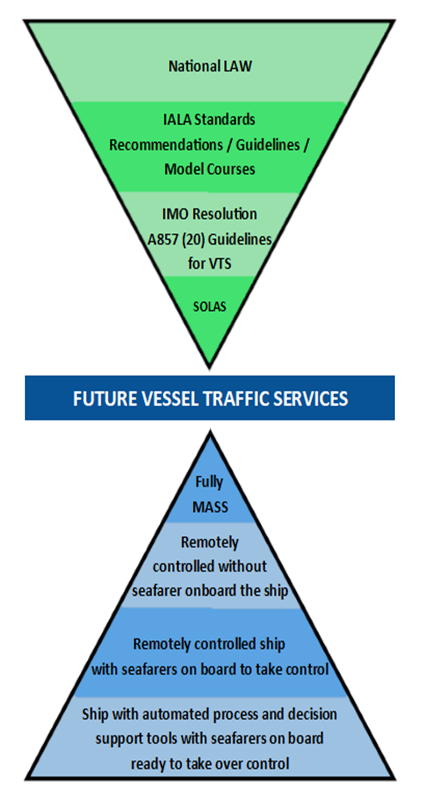
The PAP is requested to:

* Create an inter-committee task force on MASS
* Adopt the methodology and process proposal for all MASS-related work items
* Report to the Technical Committees on the proposed approach

1. IALA and MASS Framework

IALA - Guideline 1150 provides a framework for governments to establish Vessel Traffic Services by promulgating laws and regulations and for taking all other steps which may be necessary to give full and complete effect to the SOLAS regulation V/12 to ensure safety of life at sea and protection of the marine environment.

To integrate new and advancing MASS technologies into the regulatory framework, IMO created a framework for MASS developments for purpose of a scoping exercise on regulations (MSC 100 -2018). Likewise, evolving MASS technologies will impact the works of IALA. To develop regulatory framework for MASS and MASS-related infrastructure on the relevant Marine Aids to Navigation including VTS, it is necessary to consider MASS operations from the technology level, as well as the regulatory level. As MASS infrastructure spans across various IALA committees, it is proposed that an inter-committee taskforce be formed within the PAP to oversee and coordinate the work streams across committees, as well as align the recommendations presented to the IALA Council.

****Top down: The international framework for establishing VTS**

* National Law; Legal basis for VTS giving effect to SOLAS regulation V/12
* IALA Standards; Framework for harmonising VTS technologies and services worldwide
* IMO Resolution A.857(20) Guidelines for Vessel Traffic Services. Refers to IALA Documents (Draft for revision in 2021)
* Principles and general provision for the Operation of a VTS
* International Convention for the Safety of Life at Sea (SOLAS) 1974; Establishment of VTS. Refers to Resolution A857(20)

**Bottom up: MASS technology and the framework for the regulatory scoping exercise (MSC 100, 2018)**

*Degree one:* Ship with automated operations & decision support: Seafarers are on board to operate & control shipboard systems & 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 the seafarers on board: The ship is commanded & operated from another location. Seafarers are available on board to take control & to operate the shipboard systems & functions.

*Degree three:* Remotely controlled ship in the absence of seafarers on board: The ship is commanded & 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 & decide actions by itself.

1. Inter committee scenario approach in interaction with the framework for scoping the implications of MASS on IALA and Marine Aids to Navigation
2. Aim

The aim of a scenario approach of MASS is to determine the implications of MASS on Marine Aids to Navigation, to assess the potential impact of MASS on existing IALA Standards and Aids to Navigation using common scenarios across IALA committees.

1. Methodology

Given the rapid technological developments relating to the introduction of commercially operated ships in autonomous/unmanned mode and the uncertainties of regulations related to MASS, developers are test-bedding MASS on a small scale until there is a clear direction. To facilitate the integration of MASS and MASS-related technologies into shipping, it is proposed that IALA takes on a proactive role to harmonize standards. A system life cycle approach could be used in to conceptualise design, construct and operationalise an idea in a iterative process, which involves several feedback loops to achieve functional and technical requirements for future Marine Aids to Navigation.



*Figure A2-1: Life cycle approach (left) and areas of development (right)*

* 1. Life cycle approach

The life cycle approach (see also the left side of figure A2.1) is a generic approach for developing and building a product. It consists of several phases that are followed iteratively and cyclically, so that an incremental development of the product could arise. The strength of this approach is that when going through a cycle, the technicality and functionality of the product improve overtime and that the product - even with reduced functionality - can already be put into use in a relatively short time. The scope of this report focuses on defining functional requirements and for this reason not all phases need to be completed. We focus here on the concept and design phase.

The first phase of the system-oriented life cycle (the concept phase) is all about determining the higher goal of the future Marine Aids to Navigation (the socio-technical system including the network of parties involved) and the resulting services. The developments within MASS concepts and Remote Control Centre (RCC) will vary greatly across location and operation result in variations in the interaction between VTS, ship and RCC, pilot and planning and other Marine Aids to Navigation. Which means that the interaction of the personnel within the socio-technical system will differ greatly per port and requires a multiple scenarios approach. After specifying and allocating the tasks and functions to either the technology or the operator, the next phase is to determine the qualifications and competences of the future operators.

The design phase focuses on the step-by-step organization of the work and the identification of functions, roles and responsibilities. In the example of future VTS operation, the VTS staff evaluates future scenarios (based on the concept phase) in an experimental VTS environment, which gives the staff a realistic picture of the future. Guidelines and locations for testing future solutions are thereby key for designing new VTS services. Being able to work with simulated traffic, both conventional and MASS, clarifies the description of new needs and makes it possible to try out new solutions, such as adjusting roles and tasks. Moreover, in this environment it is also possible to test initial concepts of new support functions and a new user interface. Finally, traffic scenarios that approach the limits of the system can be tested in the experimental VTS environment. On the basis of these experiences, definitive user and functional requirements will be gradually established.

The above phases form an example of an iterative exploratory process, in which the different types of traffic images are taken into account per port and the results of which may differ per port. This requires flexible experimental environments in which users could participate and evaluate from the scenarios. To organize this in a structural manner per port, a step-by-step plan has been devised which is described in the next section.

* 1. Areas of developments

figure A2-1 shows the different development areas that must be defined during the life cycle approach in order to determine all aspects of future VTS. This concerns:

* Determining MASS Scenario’s to align Committee tasks
* Determining the functions to be performed who and what should perform these functions.
* Scoping the regulations to be changes and provide
* The competencies the staff should have and which organization of the team and the management thereof should be determined.
* Establishment of required functionality. Appropriate to the tasks and with regard to systems, ,
* Aligning the competencies and task of the personnel.
* performing an operational check on all functionalities and tasks
  1. Step one: Determining the future scenario in relation to MASS :

The starting point of this process is to define future scenarios for VTS services in combination with MASS making use of the four degrees. This also includes an inventory of the operational phases, actors and environment of VTS personnel. The high degree of variation in the MASS-VTS interaction requires just as much variation in future MASS scenarios. It is therefore important to start with well-defined and generic use cases as the basis for further steps. Input from Member States and all stakeholders on any initiatives that could involve into these use cases would be very welcome..

1. The definition and some assumptions of MASS

|  |  |  |
| --- | --- | --- |
| Degree of autonomy | contents | Assumptions |
| Degree one | Ship with automated processes and decision support | MASS of degree one is considered as a conventional ship with some additional functions to support human decision making. The specific automated process and decision support are not considered due to their diversities. |
| Degree two | Remotely controlled ship with seafarers on board | No matter if MASS can be operated from another location, seafarers on board are assumed to be able to meet all the operation and control requirements. |
| Degree three | Remotely controlled ship without seafarers on board | The ship is controlled and operated from another location with 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. |

1. Template for future scenario

|  |  |  |
| --- | --- | --- |
| Scenario nr:### | MASS degree | Operational phase within Traffic Separation Zone, Port and/or Inland waters |
| Added services degree of autonomy | AS-ISS |  |
| DEGREE ONE |  |
| DEGREE TWO |  |
| DEGREE THREE |  |
| DEGREE FOUR |  |

* 1. Step two: Determining the purpose and services of the VTS of the future

After defining the scenarios, the VTS service provision is made transparent in accordance with the different levels of MASS. The second step should deliver answers on the impact of MASS on the activities and interactions between actors. Questions could be raised on services, tasks, roles and functions, collaboration and Human Machine interface.

*Services.* VTS services are designed to suit that situation. What is the goal, what changes are we dealing with? What should the VTS services respond to?

*Tasks.* The above questions lead to the definition of tasks within the entire traffic management system. Of both the tasks of the various partners and the tasks within the own VTS centre. This concerns both traffic control and traffic management as well as information flows.

*Roles and functions.* Next we answer the question which roles and responsibilities are linked to the tasks defined in the previous step. Again, it is not only about the roles and functions of the VTS personnel within the traffic control centre; The roles / functions and responsibilities of the other players in the traffic system must also be clarified (such as other ships with or without crew on the bridge, RCC operators, pilots, etc.).

C*ollaboration*. This concerns organizing cooperation within the major traffic system and the local VTS exchange. This also results in HRM-related aspects such as adjusted competence profiles within the VTS centre.

*Human Machine Interface (HMI) principles*. This part deals with defining HMI principles. How is information exchanged? Oral or digital? What division is there between auditory and visual information?

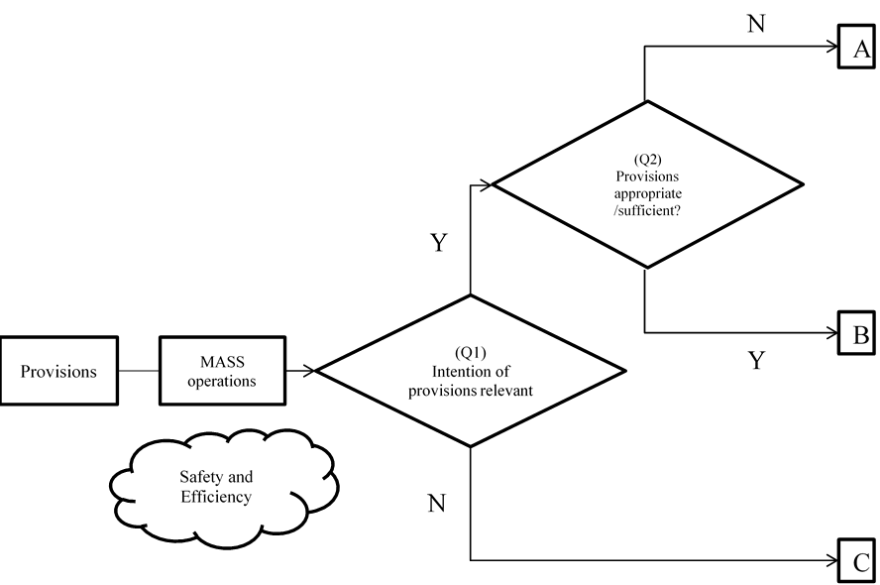
1. Template for service provision

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Scenario nr:### | MASS degree | Operational phase | Actors | Activities and interactions |
| Added services degree of autonomy | AS-IS |  |  |  |
| DEGREE ONE |  |  |  |
| DEGREE TWO |  |  |  |
| DEGREE THREE |  |  |  |
| DEGREE FOUR |  |  |  |

* 1. Step three: Scoping exercise

The scoping exercise CHINA MPA suggested gives a framework to determine the implications of MASS on VTS, to assess the potential impact of MASS on existing VTS documents in IALA using common scenario’s within the committees. The third step will make clear which documents are related to the future scenario’s, purpose and services and if they are effected by MASS

1. Select which documents, managed by the committee, relate to the given scenarios
2. Classification of MASS implications on VTS documents within the given scenario’s
3. apply to MASS and do not impede the function of VTS on MASS, but may need to be amended or clarified, and/or may contain gaps; or
4. apply to MASS and do not impede the function of VTS on MASS, and require no actions; or
5. do not apply to MASS and impede the function of VTS on MASS.
6. The identification process can be presented in the following flow chart:



1. Template for scoping

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Scenario nr:### | Degree of autonomy | Standards / provisions to be addressed | Classification of implications (ABC) | Description of implications |
|  | DEGREE ONE |  |  |  |
| DEGREE TWO |  |  |  |
| DEGREE THREE |  |  |  |
| DEGREE FOUR |  |  |  |

* 1. Step four: Analysis of the most appropriate way of addressing MASS implications

The inter committee taskforce will be making choices towards the first steps in identifying tasks and recommendations for IALA standards to change.

* Classification of the most appropriate methods to address the implications of MASS:

1. equivalences as provided for by the instruments or developing interpretations; and/or
2. amending existing documents; and/or
3. developing new documents; or
4. none of the above as a result of the analysis.