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DEVELOPMENT OF A GOAL-BASED INSTRUMENT FOR MARITIME AUTONOMOUS SURFACE SHIPS (MASS)

Definitions of terminology of MASS and autonomous systems

Submitted by IACS

SUMMARY

Executive summary:	This document outlines the work IACS has undertaken to assess, consolidate and standardize the vocabulary relevant to MASS to support the verification and validation of MASS systems, as contained in the annexes of this document.
Strategic direction, if applicable:	2
Output:	2.23
Action to be taken:	Paragraph 11
Related documents:	MSC 107/WP.9, MSC 107/5/3 and MSC 108/4/1

Introduction

1 IACS understands that concise, targeted, and consistent definitions of Maritime Autonomous Surface Ships (MASS) terminology are critical to facilitating effective communication between various maritime stakeholders throughout the developmental phase and the operational lifecycle of MASS. This document provides the outcome of the exercise performed by IACS to develop definitions of terms and phrases relevant to MASS, which aim to assist the development of the requirements relating to the verification and validation in the MASS Code.

Background

2 In conducting the exercise, IACS aimed to achieve simplicity and specificity of the definitions making them as concise and direct as possible. Noting that there are valid reasons for exploring the context of the use and the origin of these terms, IACS created templates to identify the rationale for each definition. IACS reviewed the necessity of some ambiguous terminology currently in discussions and removed those terms. Also, IACS standardized the terminology used when addressing MASS.

3 IACS believes the proposals to be of assistance to the industry and helpful to achieve standardized and agreed terminology in the MASS Code.

Discussion

4 IACS has reviewed the terminology relevant to MASS, which was developed within the industry, collated from source documents, such as classification society rules/guidelines, industry standards, the outcome of MSC 107 (MSC 107/WP.9 and MSC 107/5/3) and the intersessional MASS Working Group (MSC 108/4/1).

5 The work was started by IACS while reviewing the existing MASS Code terminology and related proposals. In the first phase, a template for each term in the cohort list was constructed consisting of the term under consideration, its source and existing definition(s), the proposed changes to the existing definitions and the rationale for such changes. Also, IACS justified the introduction of any new term and presented arguments for the exclusion of ambiguous terms from the draft MASS Code in the initial stages of development.

6 In the systematic approach to evaluating each identified term in the first phase of the identification of the terminology and definitions, a structured process was followed to ensure comprehensive and precise definitions. This process proceeded as follows:

.1 the extraction of source document text: the relevant source documents were examined, and excerpts were extracted to provide insight into the term's usage. The source documents included material such as MSC documents, ISO 23860, IACS members rules/guidelines, standards, procedures or other relevant references;

.2 the term to be defined: the terms relevant to MASS which require clarification or construction of a definition were identified;

.3 the analysis of existing definitions: the source documents were scrutinized to determine any existing definitions of the identified term. Where multiple definitions existed, each example was enumerated and considered;

.4 the proposal of definitions for inclusion in the MASS Code: after a comprehensive review of the current use of the term, definitions were proposed for the inclusion in the MASS Code. These include refinement of existing definitions and/or new definitions, as needed; and

.5 the rationale for the modification of definitions: this was a critical step where a clear rationale was provided for any modification proposed to the existing definitions. The introduction of new terms was justified or, conversely, arguments were made for their exclusion within the specific context of the MASS Code.

7 The proposals in the annexes introduce definitions to be included in the MASS Code. They were developed in parallel to the discussions which were taking place in the MASS Working Group at MSC meetings and intersessionally.

8 The motivation behind the IACS exercise and these proposals is to ensure the use of the vocabulary in the MASS Code, which is easily understood by the industry and regulators. Furthermore, IACS introduced the principles of verification and validation to prevent potential failures and accidents during operations, by identifying errors and defects committed during the system development stage.

Proposal

9 A set of definitions and terminologies is presented in annex 1, featuring existing definitions of the terms, as per section 7 of part 1 of the draft MASS Code (annex to document MSC 108/4/1). Annex 1 contains definitions of the existing terms, proposed definitions, and the rationale for those proposed definitions. In that respect, IACS considers that the draft MASS Code should not include definitions of terms which are not used in the Code. Therefore, the latter have not been considered in annex 1 (terms 7.4, 7.5, 7.17, 7.22, 7.23, 7.24, 7.25, 7.31, 7.32, 7.35, 7.41, 7.50 and 7.62).

10 Annex 2 contains the terms from the rules/guidelines, practices, and procedures (relevant to autonomous ships) of IACS members, as well as from ISO/TS 23860:2022. These terms are considered to be potentially useful and linked to the topics of the terms included in section 7 of part 1 of the draft MASS Code. They have been collated for reference and information. These terms could be helpful in the process of developing the draft MASS Code. Wherever a new term is suggested, the justification is provided.

Action requested of the Committee

11 The Committee is invited to consider the proposals in paragraphs 9 and 10, and annexes 1 and 2, when developing and finalizing section 7 "Terminology and definitions" of part 1 of the draft MASS Code, and to take action as appropriate.

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ANNEX 1*

LIST OF TERMS AND THEIR DEFINITIONS (AS PER SECTION 7 OF PART 1 OF DRAFT MASS CODE - TERMINOLOGY AND DEFINITIONS)

(Source = annex to document MSC 108/4/1)

Term to be defined	7.1. **Abnormal situation**
Existing definition(s)	Abnormal situation means a [divergence/deviation][~~disturbance~~] in the normal [operation] [function] which can potentially result in an unsafe state. ~~accidents.~~ (RBAT)
Proposed definition	Not applicable
Rationale	Supportive of the IMO MASS Code definition

Term to be defined	7.2. **Accident**
Existing definition(s)	Accident means an unintended event involving fatality, injury, ship loss or damage, other property loss or damage, or environmental damage. (IMO, 2018).
Proposed definition	Not applicable
Rationale	Supportive of the IMO definition

Term to be defined	7.3. **Administration**
Existing definition(s)	Administration means the Government of the State whose flag the MASS is entitled to fly.
Proposed definition	Not applicable
Rationale	Supportive of the IMO MASS Code definition

Term to be defined	7.3bis. **Agent**
Existing definition(s)	TBD
Proposed definition	Agent means anything that can be viewed as perceiving its environment through sensors and acting upon that environment through effectors. In the draft IMO MASS code, agent may be used for both human and software.
Rationale	Supportive of the Russell & Norvig's definition

Term to be defined	7.6. **Approved**
Existing definition(s)	Approved means approved by the Administration
Proposed definition	To be deleted
Rationale	In draft MASS Code (FR1.4.1), the expression "approved by the responsible person" is also used. To avoid confusion, this term should be used as general verb.

Term to be defined	7.7. **Automated functions**
Existing definition(s)	[Automated functions means automated processes, parts of the system that may be automated when it is not the ship being considered as one whole. [Automated systems was proposed instead of functions but consensus was on functions at this time.] Or

* The annexes are provided in the English language only.

	Autonomous functions are functions (or complete ships) that may operate in complex and open-ended environments with high levels of independence and self-determination. They perceive, learn, reason and [act with self-awareness and] respond [intelligently] [appropriately] to unforeseen changes in the environment. (Denmark proposal from 1.2 (Application)).]
Proposed definition	Automated functions means processes that, under specified conditions, can function without human control.
Rationale	Supportive of the ISO definition of the term "automatic". Distinguish the terms "automated" and "automatic" (refer to 7. and 8.) versus the term "autonomous" (refer to 9.).

Term to be defined	7.8. **Automatic**
Existing definition(s)	Automatic means processes or equipment that, under specified conditions, can function without human control. (RBAT)
Proposed definition	Automatic means process that, under specified conditions, can function without human control. "(ISO/TS 23860:2022)"
Rationale	Correct the reference from "(RBAT)" to "(ISO/TS 23860:2022)". Supportive of the ISO definition. Remove "equipment" as automatic can be used to describe components and systems.

Term to be defined	7.9. **Autonomous**
Existing definition(s)	Autonomous means processes or equipment in a MASS system which, under certain conditions, are designed and verified to be controlled by automation, without human assistance. (RBAT)
Proposed definition	**Autonomous** - possessing the property of autonomy. **Autonomy** - is the ability to perform data acquisition, analysis, decision making and action implementation independent of human control.
Rationale	The source of the existing definition is ISO/TS 23860:2022 and not RBAT. The ISO definition applies to "ships and systems" but autonomy (i.e. independence from human control) can be exhibited by equipment and components (e.g. smart sensors that with self-diagnostics, automatic calibration capabilities.

Term to be defined	7.10. **Autonomous Navigation System**
Existing definition(s)	[Autonomous Navigation System (ANS) means a system which has the functionalities of situational awareness, route planning and determination for collision and grounding risk avoidance, ship's heading, speed and track control, etc. (MSC 107/5/10) or Autonomous Navigation System (ANS) means a set of elements that provide functions related to autonomous navigation within a defined or higher operational envelope. It also should include the possibility of remote control. (MSC 107/5/7)]
Proposed definition	Autonomous Navigation System (ANS) means a system which has the functionalities of situational awareness, route planning and determination for collision and grounding risk avoidance, ship's heading, speed and track control, etc. (MSC 107/5/10)

	An Autonomous Navigation System (ANS) comprises a set of elements that provide capabilities related to navigation within a defined Operational Envelope, independent of human control.
Rationale	Improved the definition to emphasise the goal of an autonomous navigation system of keeping within the defined Operational Envelope and operating independent of human control.

Term to be defined	7.11. **Cargo Ship**
Existing definition(s)	Cargo Ship means any [full or semi-displacement] ship which is not a passenger ship, a ship of war and troopship, a ship which is not propelled by mechanical means, a wooden ship of primitive build, a fishing vessel or a mobile offshore drilling unit. (2008 IS Code)
Proposed definition	Not applicable
Rationale	Supportive of the IMO definition

Term to be defined	7.11bis. **COLREG**
Existing definition(s)	COLREG means the Convention on the International Regulations for Preventing Collisions at Sea (COLREG), 1972.
Proposed definition	Not applicable
Rationale	Supportive of the IMO definition

Term to be defined	7.12. **Company**
Existing definition(s)	Company means the owner of the MASS or any other organization or person such as the manager, or the bareboat charterer, who has assumed the responsibility for operation of the ship from the shipowner and who, on assuming such responsibility, has agreed to take over all the duties and responsibilities imposed on the Company by the MASS Code.
Proposed definition	Not applicable
Rationale	Supportive of the IMO MASS Code definition

Term to be defined	7.13. **Concept of Operation (ConOps)**
Existing definition(s)	ConOps means a document describing the characteristics of a proposed system. The ConOps would be part of the certification of a MASS.
Proposed definition	Not applicable
Rationale	Supportive of the IMO MASS Code definition

Term to be defined	7.14. **Control function**
Existing definition(s)	Control function means actions performed by humans or software for the accomplishment of a functional goal (adapted from IEC, 2000).
Proposed definition	Control function means actions performed by humans or software for the accomplishment of a ~~functional~~ goal (adapted from IEC, 2000).
Rationale	Removed "functional" as it is a redundant word.

Term to be defined	7.15. **Control action**
Existing definition(s)	Control action means the acquisition of information, analysis of information, decision-making, or implementation of physical actions performed as part of a control function.
Proposed definition	Control action means the acquisition of information, analysis of information, decision-making, ~~or~~ and implementation of physical actions.

Rationale	A control action consists of multiple functions such as • information acquisition • analysis • decision-making • actuation Not the other way around.

Term to be defined	7.15bis. **Correction**
Existing definition(s)	Correction means a successful control action in avoiding the consequence of a fault without having to resort to mitigation either on board the MASS or from Remote Operations Centre.
Proposed definition	Correction means a successful ~~control~~ recovery action in avoiding the consequence of errors, faults and failures independent of human control.
Rationale	The phrase *"without having to resort to mitigation either on board the MASS or from Remote Operations Centre"* was modified to describe the capability to recover without human involvement.

Term to be defined	7.16. **Degradation**
Existing definition(s)	Degradation means the reduced performance of a system or function, but it should still provide safe operations/service in the presence of hazardous events. (MSC 107/5/7)
Proposed definition	Not applicable
Rationale	Supportive of the IMO MASS Code definition

Term to be defined	7.18. **Failure**
Existing definition(s)	Failure means the termination of the intended behaviour of an element or item due to fault manifestations. (MSC 107/5/7) or Failure means the loss of the ability of an item to perform the required (specified) function within the limits set for its intended use. This occurs when the margin (to failure) is negative. (RBAT)
Proposed definition	Failure means the loss of the ability of an item to perform the required (specified) function.
Rationale	Simplified the definition to exclude the severity of failure.

Term to be defined	7.19. **Fallback state**
Existing definition(s)	Fallback state means a designed state that can be entered through a fallback action or process when it is not possible for the MASS with its autonomous or remote-controlled ship functions to stay within the operational envelope. (Germany proposal MASS Code Section 2.1 (Operational Context))
Proposed definition	Fallback state means a designed state that can be entered after recovery and mitigation actions when it is not possible for the MASS to stay within the Operational Envelope.
Rationale	Emphasis on the mitigation, recovery responses to achieve the fallback state as these are more than just functions (e.g. there could be performance requirements on the sequence of functions to correctly respond and bring the MASS to a fallback state.).

Term to be defined	7.20. **Fault**
Existing definition(s)	Fault means an abnormal condition that can cause an element or an item to fail. (MSC 107/5/7)
Proposed definition	Not applicable
Rationale	Supportive of the IMO MASS Code definition

Term to be defined	7.21. **Function**
Existing definition(s)	Function means a group of tasks, duties and responsibilities, as specified in the MASS [~~STCW~~] Code, necessary for MASS operation, safety of life at sea[, security of the vessel] or protection of the marine environment.
Proposed definition	Not applicable
Rationale	Supportive of the IMO MASS Code definition

Term to be defined	7.26. **Human Element**
Existing definition(s)	Human Element means the interaction between the autonomous systems and the human operators involved in the operation and management of MASS. [These factors should, amongst others, include cognitive workload, situational awareness, communication protocols, teamwork, decision-making processes, training requirements for human operators as well as guidelines and best practices to ensure that these factors are adequately addressed in the design and operation of MASS].
Proposed definition	Not applicable
Rationale	Supportive of the IMO MASS Code definition

Term to be defined	7.26bis. **Human Machine Interface (HMI)**
Existing definition(s)	TBD
Proposed definition	Human Machine Interface (HMI) means the part of a system an operator interacts with. The interface is the aggregate of means by which the users interact with a machine, device, and system. The interface provides means for input, allowing the users to control the system and output, allowing the system to inform the users (IMO SN.1/Circ.288).
Rationale	Supportive of the IMO definition

Term to be defined	7.27. **In service**
Existing definition(s)	[(operating, under remote operation, under remote supervision; need to cover in dry dock)] Term to be defined.
Proposed definition	Not applicable
Rationale	Term to be defined.

Term to be defined	7.28. **International Convention on Maritime Search and Rescue**
Existing definition(s)	International Convention on Maritime Search and Rescue (SAR), 1979, as amended.
Proposed definition	Not applicable
Rationale	Supportive of the IMO definition

Term to be defined	7.29. **International Safety Management (ISM) Code**
Existing definition(s)	International Safety Management (ISM) Code means the International Management Code for the Safe Operation of Ships

	and for Pollution Prevention as adopted by the Assembly, as may be amended by the Organization.
Proposed definition	Not applicable
Rationale	Supportive of the IMO definition

Term to be defined	7.30. **Intolerable risk**
Existing definition(s)	TBD
Proposed definition	Identified risk levels will usually be categorized to belong to three categories: intolerable risks which should be reduced, negligible risks which do not require any action, and risks in the ALARP area which should be reduced to as low as reasonably practicable (IMO MSC.1/Circ.1455).
Rationale	Supportive of the IMO definition

Term to be defined	7.33. **Maritime Autonomous Surface Ship (MASS)**
Existing definition(s)	Maritime Autonomous Surface Ship (MASS) means a ship which, to a varying degree, can operate independently of human interaction [if at least all or part of the navigation tasks are automated or remote operated].
Proposed definition	Maritime Autonomous Surface Ship (MASS) means a ship which, to a varying degree, can operate independently of human ~~interaction~~ **control.**
Rationale	Changed "human interaction" to "human control" to reflect the active involvement of crew in different aspects of MASS operations.

Term to be defined	7.34. **MASS Onboard Crew**
Existing definition(s)	MASS onboard crew means a master, other officers and operational staff physically on board a MASS.
Proposed definition	Not applicable
Rationale	Supportive of the IMO MASS Code definition

Term to be defined	7.36. **Master/master of a MASS**
Existing definition(s)	Master [of a MASS] means the person [having command of] [being responsible for] a MASS (STCW). Key principles agreed/requirements of a master (final location to be confirmed): [.1 there should be a human master responsible for a MASS, regardless of mode of operation; .2 such master may not need to be on board, depending on the technology used on the MASS and human presence on board, if any; .3 regardless of mode of operation, the master of a MASS should have the means to intervene when necessary; and .4 several masters may be responsible for a MASS on a single voyage, under certain conditions, and that only one master should be responsible at any given time (further consideration of what those conditions are is required).
Proposed definition	Not applicable
Rationale	Given the legal and statutory implication, IMO and its constituents will be in a better position than IACS to derive the definition.

Term to be defined	7.36bis. **Minimal Risk Manoeuvre (MRM)**
Existing definition(s)	TBD
Proposed definition	A Minimal Risk Manoeuvre (MRM) means a procedure aimed at minimizing the risk of accidents and which is automatically performed by the system, e.g. when the operator does not respond to a takeover request. (MSC 107/5/7)
Rationale	Supportive of the IMO MSC 107/5/7 definition

Term to be defined	7.37. **Mission**
Existing definition(s)	Mission means the commercial, political (e.g. defence) or public intentions which have contributed to and justifies the vessel concept development and operation.
Proposed definition	Not applicable
Rationale	Supportive of the IMO MASS Code definition

Term to be defined	7.38. **Mission model**
Existing definition(s)	Mission model means the hierarchical breakdown of a vessel mission into a set of mission phases and operations.
Proposed definition	Not applicable
Rationale	Supportive of the IMO MASS Code definition

Term to be defined	7.39. **Mission phase**
Existing definition(s)	Mission Phase means the subdivisions of the mission typically characterized by a recognizable shift in where the vessel is located in terms of geographical surroundings, or the start and end of one or more operations.
Proposed definition	Not applicable
Rationale	Supportive of the IMO MASS Code definition

Term to be defined	7.40. **Mitigation**
Existing definition(s)	Mitigation means a measure implemented to prevent unsafe conditions or modes from resulting in losses (see "Accident").
Proposed definition	Not applicable
Rationale	Supportive of the IMO MASS Code definition

Term to be defined	7.42. **Modes of Operation**
Existing definition(s)	Modes of Operation means the conditions under which the functions of a MASS are controlled, i.e. remote-control or autonomous with or without persons on board. Requirements of Modes of Operation (final location to be confirmed): [A ship may move between modes of operation during one voyage. The use and management of Mode of Operation are defined in the ~~Operational Context~~ Concept of Operation for a given operational envelope as agreed by the Administration.]
Proposed definition	Not applicable
Rationale	Supportive of the IMO MASS Code definition

Term to be defined	7.43. **Operational Envelope**
Existing definition(s)	The Operational Envelope should provide ship's operational capabilities and limitations and ship-specific capabilities and limitations.
Proposed definition	Operational Envelope means the description of the ship's operational capabilities and limitations.
Rationale	Simplified the definition.

Term to be defined	7.44. **Organization**
Existing definition(s)	Organization means the International Maritime Organization.
Proposed definition	Not applicable
Rationale	Supportive of the IMO MASS Code definition.

Term to be defined	7.45. **Process**
Existing definition(s)	Process means a set of interrelated or interacting activities that transforms inputs into outputs (IEC, 2018)
Proposed definition	Not applicable
Rationale	Supportive of the existing ISO TS 23860 definition.

Term to be defined	7.45bis. **Quality of Service (QoS)**
Existing definition(s)	TBD
Proposed definition	A network's ability to achieve maximum bandwidth and deal with other network performance elements like latency, error rate and uptime. Quality of service also involves controlling and managing network resources by setting priorities for specific types of data on the network.
Rationale	Quality of Service (QoS) means any technology that manages data traffic to reduce packet loss, latency, and jitter on a network. QoS controls and manages network resources by setting priorities for specific types of data on the network. QoS is to be characterized by parameters used as a reference to a specific packet forwarding behaviour in a data flow of a network's communication service subscription, e.g. packet loss rate, latency.

Term to be defined	7.46. **Remote control**
Existing definition(s)	Remote control is when the ship, or functions within the ship, are operated from outside the [controller area network of the] ship without interference from anyone on board the ship. Remote control may have direct control of actuators on board, or may just give functional commands to an autonomous function (system). Remote control may have varied complexity, from simple communication of setpoints to full real time control including full virtual feedback from the ship/function. (Denmark suggestion from 1.2 (application))
Proposed definition	Not applicable
Rationale	Supportive of the IMO MASS Code definition

Term to be defined	7.47. **Remote Control Station**
Existing definition(s)	Remote Control Station means a system connected to MASS for its remote control. (MASS-JWG1/WP.1) Control stations are those spaces in which the ship's radio or main navigating equipment or the emergency source of power is

	located or where the fire recording or fire control equipment is centralized. (SOLAS Chapter II – 18) "Remote Operations Workstation" instead of "Control Station" to differentiate from "Control Station" as defined in SOLAS II-1/3.18 to avoid interpretations regarding applicability for these to be applicable on shore. (OneSea proposal). Control and monitoring equipment means the equipment installed for the effective operation and control of the BWMS and the assessment of its effective operation. (Ballast Water Management System (BWMS) Code) Control Stations are those spaces in which the craft's radio or navigating equipment (main displays and controls for equipment specified in 13.2 to 13.7) or the emergency source of power and emergency switchboard are located, or where the fire recording or fire control equipment is centralized, or where other functions essential to the safe operation of the MASS craft such as propulsion control, public address, stabilization systems, etc. are located. (High Speed Craft Code) Operating station means a confined area of the operating compartment equipped with necessary means for navigation, manoeuvring and communication, and from where the functions of navigating, manoeuvring, communication, commanding, conning and lookout are carried out.' (High Speed Craft Code) Control station means a single or multiple position including all equipment such as computers and communication terminals and furniture at which control and monitoring functions are conducted. (ISO 11064-3) Remote Control Station means a place from which MASS, or functions of a MASS can be operated. A ROC may have multiple control stations within its facilities. (MASS Code Remote Operation Section 3.2)
Proposed definition	Control station located in a Remote Operations Centre
Rationale	To simplify the definition and make explicit that it is located in the ROC.

Term to be defined	7.48. **Remote Operator**
Existing definition(s)	Remote Operator means a qualified person who is employed or engaged to operate some or all aspects of the functions of a MASS from a Remote Operations Centre.
Proposed definition	Not applicable
Rationale	Supportive of the IMO MASS Code definition

Term to be defined	7.49. **Remote Operations Centre**
Existing definition(s)	Remote Operations Centre means a location remote from the MASS that can operate some or all aspects of the functions of the MASS.
Proposed definition	Not applicable
Rationale	Supportive of the IMO MASS Code definition

Term to be defined	7.51. **Remote operations**
Existing definition(s)	TBD
Proposed definition	Not applicable
Rationale	Term to be defined.

Term to be defined	7.52. **Risk assessment**
Existing definition(s)	Risk Assessment means an assessment undertaken in line with/meeting the requirements of section 2.4 of this Code.
Proposed definition	Risk Assessment means an assessment undertaken in line with/meeting the requirements of Part 2 Section 4 of this Code.
Rationale	Supportive of the IMO MASS Code definition with correction of the reference.

Term to be defined	7.52bis. **Safe state**
Existing definition(s)	TBD
Proposed definition	Safe state means where a system is operating inside its normal (and safe) Operational Envelope.
Rationale	As opposed to the definition of "Unsafe State"

Term to be defined	7.54 **Secure position/Location**
Existing definition(s)	TBD
Proposed definition	Not applicable
Rationale	Term to be defined.

Term to be defined	7.53. **Situational awareness**
Existing definition(s)	Situational Awareness means the perception of environmental elements and events with respect to time or space, the comprehension of their meaning, and the projection of their future status (Endsley 1995). (RBAT). Note - the classification of situational awareness capabilities should be categorized by mode of operation because the details of situational awareness will vary depending on the subject for which it is provided (crew, remote operators, and so on) and the functionality should differ. (MSC 107/5/7).
Proposed definition	Situational Awareness means the perception of environmental elements, **the condition of MASS systems** and events with respect to time or space, the comprehension of their meaning, and the projection of their future status.
Rationale	Expanded the definition to include knowledge of the physical condition of MASS systems as these are relevant in the safe execution of planned control actions. i.e. lack of condition knowledge will lead to incorrect control actions.

Term to be defined	7.55. **SOLAS**
Existing definition(s)	SOLAS means the International Convention for the Safety of Life at Sea, 1974, as amended.
Proposed definition	Not applicable
Rationale	Supportive of the IMO MASS Code definition

Term to be defined	7.56. **Software**
Existing definition(s)	TBD
Proposed definition	A set of instructions, data and programs that are used to operate MASS systems to achieve specific tasks.
Rationale	A definition that covers the main categories of software such as 1. Application software – which includes algorithms (AI) that achieve specific tasks e.g. localization, computer vision, CBM, decision-making, etc. 2. System software – including operating system SW, device drivers that manage the computing and memory resources required by the different application software. 3. Middleware – which provides the communication and data management between software applications.

Term to be defined	7.57. **STCW Convention**
Existing definition(s)	STCW Convention means the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978, as amended.
Proposed definition	Not applicable
Rationale	Supportive of the IMO MASS Code definition

Term to be defined	7.58. **Support**
Existing definition(s)	TBD
Proposed definition	Not applicable
Rationale	Term to be defined.

Term to be defined	7.59. **System**
Existing definition(s)	System means the combination of interacting ~~elements~~ functions organized to achieve one or more stated purposes, i.e. goals (IEC, 2018).
Proposed definition	System means the combination of interacting elements organized to achieve one or more stated purposes, i.e. goals (ISO/IEC 15288).
Rationale	Supportive of the existing definition sourced from ISO/IEC 15288. "Elements" is more appropriate than "functions" as they are more descriptive of the different constituents of a system.

Term to be defined	7.60. **Task**
Existing definition(s)	Task means a set of [control] actions taken to enable functions and perform operations. A task may involve interactions with several different functions or systems, but also with humans.
Proposed definition	Task means a set of **~~[control]~~** actions taken to enable functions and perform operations.
Rationale	Tasks are not limited to "control actions".

Term to be defined	7.61. **Third parties**
Existing definition(s)	Third parties means persons that are not involved in the operations but engaging with the MASS, e.g. VTS, ports, pilots or other persons in the ROC for maintenance reasons, persons in distress, other vessels.
Proposed definition	Not applicable
Rationale	Supportive of the IMO MASS Code definition

Term to be defined	7.63. **Unsafe state**
Existing definition(s)	Unsafe state means where a system is operating outside its normal (and safe) operating envelope due to degraded performance (e.g. [faults or] failures) or exceeded capabilities which, if left [uncorrected or] unmitigated, has the potential to directly cause an accident. (RBAT)
Proposed definition	Not applicable
Rationale	Supportive of the IMO MASS Code definition

Term to be defined	7.64. **Verification**
Existing definition(s)	TBD
Proposed definition	Testing and evaluation to prove that MASS, its systems including hardware and software components meet the technical requirements at a particular stage of their development.
Rationale	Covering the spectrum of assessment activities relevant to MASS, its systems and granular components during the engineering, SW engineering, integration, etc. phases of the development, i.e. are we building the MASS and its components correctly?

Term to be defined	7.65. **Validation**
Existing definition(s)	TBD
Proposed definition	Testing and evaluation to prove that MASS, its systems including hardware and software components are effective, dependable and safe during real world operations. This means satisfying **all** the technical requirements representative of normal, abnormal and adverse operating conditions
Rationale	Definition distinguishing validation from verification, in terms of realistic testing conditions, i.e. have we built the right MASS? Does it satisfy the end users expectations under different conditions?

Term to be defined	7.66.1 **Control**
Existing definition(s)	Control: Purposeful action on or in a process to meet specified objectives. (IEC,2013) (RBAT)
Proposed definition	Not applicable
Rationale	"Control" is taken as synonymous to "control action" which is already defined the IMO MASS Code.

Term to be defined	7.66.2 **Monitoring**
Existing definition(s)	Monitoring: An operator control mode with operations which monitor a situation but do not take any action to influence necessary processes. In monitoring mode, operators may adjust non-necessary processes or equipment to facilitate gathering of information. Monitoring can, for example, be to adjust a system for exclusively human use, such as external lights or cameras, or to inspect equipment or trends in performance parameters (MSC 107/5/3).
Proposed definition	The use of measurements and analytical methods to understand the condition including changes in the state of MASS including its systems and components.
Rationale	Definition covering the monitoring of both hardware and software components of MASS.

Term to be defined	7.66.3 **Supervision (active/passive)**
Existing Definition(s)	Supervision: A role with an explicit responsibility to monitor system performance and detect abnormalities so that the desired outcome can be achieved through implementation of corrective responses (RBAT).
Proposed definition	Not applicable
Rationale	Supportive of the RBAT definition.

Term to be defined	7.66.4 **Strategic control**
Existing definition(s)	Strategic control: An operator control mode with operations to issue fleet-wide instructions that implement and, if appropriate, define specific functions to be used by the automatic decision-making units (MSC 107/5/3).
Proposed definition	To be deleted.
Rationale	Term not used in the IMO MASS Code.

Term to be defined	7.66.5 **Tactical control**
Existing definition(s)	Tactical control: An operator control mode with operations to influence the conclusion made by the automatic decision-making units of the autonomous ship for a particular purpose. Tactical control includes, for example, changing the required minimum closest point of approach to other ships or the port of destination and letting the autonomous ship system afterwards construct the avoidance manoeuvre or route itself. It can also be adjustment of a technical alert level, based on prevailing conditions, for example, the time delay in actuation of the bilge alarm (MSC 107/5/3).
Proposed definition	To be deleted.
Rationale	Term not used in the IMO MASS Code.

Term to be defined	7.66.6 **Supervisory control**
Existing Definition(s)	Supervisory control is a role with an explicit responsibility to monitor system performance and detect anomalies so that the desired outcome can be achieved through implementation of corrective responses. An important principle is that the supervisory agent cannot be the same as the agent performing the control action(s) being supervised. The supervisor has an overriding authority of the control action performance and is responsible for its outcome. Supervisory control can take different forms and be performed by either a software or human agent (MSC 107/INF.8).
Proposed definition	To be deleted.
Rationale	Term not used in the IMO MASS Code.

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ANNEX 2

LIST OF RELEVANT IACS AND ISO TERMS AND DEFINITIONS

(Sources = IACS members rules/guidelines, practices, and procedures relevant to autonomous ships and ISO/TS 23860:2022 - General Terms)

Term to be defined	1. **Automation system**
Existing definition(s)	Automation - implementation of processes by automatic means.
Proposed definition	**Automation** - implementation of processes by automatic means. **System** - combination of interacting elements organized to achieve one or more stated purposes
Rationale	Separation of the term "Automation" from "System". There are existing, clearly understood definitions for each term -automation and system derived from ISO standards.

Term to be defined	2. **Autonomous control**
Existing definition(s)	Option 1 [(IACS)] the use of the term "autonomous" should be limited to the highest degree of automation and avoided for the other degrees of automation. Option 2 [(IACS)] "Autonomous system refers to something or someone who governs itself, lives by its own rules, independent. It is a composition of "autos" (self) and "nomos" (law). In autonomous systems actions are determined by a decision taken by the system itself on the basis of its knowledge of the environment, the ship, the overall situation, and an evaluation of the possible consequences of such actions based on a set of "good/bad" criteria"
Proposed definition	**Autonomy** - is the ability to perform data acquisition, analysis, decision making and action implementation independent of human control. **Control** - purposeful action on or in a process to meet specified objectives
Rationale	Separation of the term "Autonomy" from "Control". Any autonomous system will have control capability, so the combination of these terms is unnecessary.

Term to be defined	3. **Autonomous system**
Existing definition(s)	Option 1 [(IACS)] the use of the term "autonomous" should be limited to the highest degree of automation and avoided for the other degrees of automation. Option 2 [(IACS)] "Autonomous system refers to something or someone who governs itself, lives by its own rules, independent. It is a composition of "autos" (self) and "nomos" (law) In autonomous systems actions are determined by a decision taken by the system itself on the basis of its knowledge of the environment, the ship, the overall situation, and an evaluation of the possible consequences of such actions based on a set of "good/bad" criteria"

Proposed definition	**Autonomy** - is the ability to perform data acquisition, analysis, decision making and action implementation independent of human control. **System** - combination of interacting elements organized to achieve one or more stated purposes
Rationale	Separation of the term "Autonomy" from "System"

Term to be defined	4. **Autonomous vessel/Autonomous operation ship**
Existing definition(s)	Option 1 [(IACS)] the use of the term "autonomous" should be limited to the highest degree of automation and avoided for the other degrees of automation. Option 2 [(IACS)] "Autonomous operation ship means a ship is capable of fully autonomous operation in open waters or during the entire voyage without seafarers to operate on board." Option 3 [(IACS)] "Autonomous Vessel: Means that the vessel can perform operations for navigation or machinery control or both with reduced attention or no attention from the crew. This does not necessarily mean that no human is present. Such vessels plying on the surface are called Autonomous Surface Vessels (ASVs)."
Proposed definition	See definition for Maritime Autonomous Surface Ship MASS
Rationale	Autonomous vessel is synonymous to a MASS. Autonomous Operation Ship should be removed as it is not a useful phrase.

Term to be defined	5. **Control**
Existing definition(s)	Option 1 [(ISO)] Purposeful action on or in a process to meet specified objectives (IEC 60050-351). The term control does not preclude that the action is only to monitor the process, e.g. to raise an alarm or to request intervention. Control can be exercised by a human or by automation. Option 2 [(IACS)] The process of conveying a command or order to affect the desired action. Option 3 [(IACS)] controlling a ship consists in operating devices related to its navigation or its operations. Ships may be controlled either by the crew, or remotely by operators, or by automation systems with or without human interaction. Option 4 [(IACS)] "The process of maintaining or conducting a system in a desired status. In automated systems, control is essentially based on acquisition of data from transducers, processing of such data to obtain information about deviations from the expected system behaviour and computation of corrective actions to eliminate these deviations. Conversely, in autonomous systems, the control process is much more complex. While, as for automated systems, the control loop's starting point is acquisition of data from transducers, the amount and variety of data acquired is much greater and is aimed

	to achieve a complete situational awareness rather than simple information about system deviation from conditions established at design stage. Situational awareness is the level of information required by autonomous systems to allow the next step, i.e., creation of knowledge. Knowledge can be intended as the result of processing, organizing and structuring information and has to do with the capacity to understand, explain and negotiate concepts, actions, and intentions. Knowledge allows to organize information in models for reliving the past and anticipating or creating future. Knowledge has the potential of dynamically modifying the attitude to react to events and enables new behaviours to be envisaged. Through knowledge, autonomous systems develop the ability to rank scenarios and recognize which is better and which is worse. In other Terms, the system makes judgments and decisions and selects the right things to do.
Proposed definition	Purposeful action on or in a process to meet specified objectives (IEC 60050-351)
Rationale	Supportive of the IEC 60050-351 definition for conciseness and clarity

Term to be defined	6. **Control station**
Existing definition(s)	Single or multiple position including all equipment such as computers and communication terminals and furniture at which control and monitoring functions are conducted (ISO 11064-3)
Proposed definition	Not applicable
Rationale	Supportive of the existing definition sourced from ISO 11064-3

Term to be defined	7. **Crew**
Existing definition(s)	All persons carried aboard the ship to provide navigation and maintenance of the ship, its machinery, systems, and arrangements essential for propulsion and safe navigation or to provide services for other persons aboard (IMO resolution MSC.266(84)).
Proposed definition	Not applicable
Rationale	Supportive of the existing definition sourced from IMO.

Term to be defined	8. **Decision Support System**
Existing definition(s)	"The system can perform information acquisition, information analysis and suggest actions to the operator to take decisions."
Proposed definition	System that can perform data acquisition and analysis for the purpose of suggesting actions.
Rationale	Improvement of the definition for conciseness and clarity.

Term to be defined	9. **Hazards**
Existing definition(s)	Option 1 [(IACS)] Conditions that exist which may potentially lead to an undesirable event. Option 2 [(IACS)] Any source of potential damage or casualty, or any situation with potential to cause it.

	Option 3 [(IACS)] Anything that may cause harm. Option 4 [(IMO)] Hazards are all situations having the potential to threaten human life, health, property or the environment (MSC.1/Circ.1394/Rev.2, appendix 3).
Proposed definition	Hazards are all situations having the potential to threaten human life, health, property or the environment (MSC.1/Circ.1394/Rev.2, appendix 3).
Rationale	Supportive of the existing definition sourced from IMO.

Term to be defined	10. **Operator**
Existing definition(s)	Option 1 [(IACS)] The qualified personnel who is responsible for the supervision and potential intervention for autonomous functions or is responsible for the remote control for remote control functions. Option 2 [(IACS)] All persons in the remote-control centre to provide remotely navigation and maintenance of the ship, its machinery, systems and arrangements essential for propulsion and safe navigation or to provide remotely services for other persons aboard. Option 3 [(IACS)] Organization responsible for operating and maintaining the UMS.
Proposed definition	Not applicable
Rationale	"Remote operator" already defined in the MASS Code

Term to be defined	11. **Operational Design Domain (ODD)**
Existing definition(s)	Option 1 [(SAE)] Operating conditions under which a given driving automation system or feature thereof is specifically designed to function. Option 2 [(IACS)] ODD refers to the design range in which a system can operate properly. ODD includes both ODDi, which is related to internal events such as system failures, and ODDe, which is related to external events. The following are possible as ODDe: ✓ Geographical factors such as navigational sea areas ✓ Environmental conditions such as day and/or night, weather and sea conditions, etc. ✓ Degree of traffic congestion ✓ Overboard monitoring and support environment, including port facilities, if applicable In this document, ODD is used to indicate the safe operating limits of the system (machine), and OE is used to indicate the safe operating limits of MASS (ship = machine + human). As the degree of autonomy of MASS increases, the difference between ODD and OE decreases because of the smaller human involvement. While crewed MASS is maintained within a safe area by humans functioning in the loop of a large system called

	MASS, fully autonomous ships eliminate the difference between ODD and OE because there is no human involvement.
Proposed definition	Operating conditions under which a maritime autonomous surface ship and its systems or features thereof is specifically designed to function.
Rationale	IACS members support the inclusion of ODD as a unique terminology, in addition to Operational Envelope. While ODD and OE have certain similarities, ODD focuses on the conditions considered during design, whereas OE emphasizes the overall range within which the system can operate safely.

Term to be defined	12. **Reasonably foreseeable operating conditions**
Existing definition(s)	Conditions in which the UMS can be reasonably foreseen to operate in an intact, degraded, aged and/or damaged state. They are normally defined in the ConOps.
Proposed definition	Conditions in which the Maritime Autonomous Surface Ship MASS can be reasonably foreseen to operate in an intact, degraded, aged and/or damaged state.
Rationale	Adopted the definition to MASS specifically.

Term to be defined	13. **Remote**
Existing definition(s)	A location which is not located within the vessel where the function takes place. This may be at a location on land or on a vessel other than the vessel where the function takes place.
Proposed definition	See definition for "Remote functions" below
Rationale	The terms "remote" and "remote functions" are closely related, IACS members have decided to define “remote functions”

Term to be defined	14. **Remote control functions (Remote functions)**
Existing definition(s)	Option 1 [(IACS)] Remote Control Functions. Functions which are controlled from a remote location i.e. a location on land or on a vessel other than the vessel where the Function takes place. Option 2 [(IACS)] Remote Control - control of an operation at a point distant from the controlled device, using the transmission of information by telecommunications techniques. Option 3 [(IACS)] "Remote Control: Operational control of some or all operations or functions of vessel, at a point remote from the vessel. "
Proposed definition	**Remote functions** - Functions which are implemented from a remote location i.e. a location on land or on a vessel other than the vessel where the function takes place
Rationale	Removed "control" as remote functions can also including monitoring capabilities among others. Definition improved to emphasise the importance of communication technologies in enabling remote function

Term to be defined	15. **Remote control ship**
Existing definition(s)	Option 1 [(IACS)] Remote control ship means that the ship can be controlled by a remote-control station or position other than the ship to achieve the operation of the ship.

	Option 2 [(IACS)] Vessel for which one or more key functions are remotely controlled from a remote-control centre, possibly by assistance from personnel on board To support safe and efficient operation of the vessel, the remotely controlled key function(s) is arranged with a defined level of automation ranging from simple decision support to complete automatic control. The extent of support from on-board personnel and the level of automation should be detailed in document Concept of Operation (ConOps)".
Proposed definition	Ship under the operational purview of a Remote Operations Centre.
Rationale	Improved the definition to emphasise the scope/responsibility of the ROC in operating a MASS ship.

Term to be defined	16. **Simulation tests**
Existing definition(s)	"Simulation test" means a control system testing where the equipment under control is partly or fully replaced with simulation tools, or where parts of the communication network and lines are replaced with simulation tools.
Proposed definition	The use of simulator(s) to evaluate the sensing, analysis, understanding, decision-making, planning and control software and artificial intelligence components of the autonomous system against requirements.
Rationale	The revised definition emphasise what is being tested.

Term to be defined	17. **Simulator**
Existing definition(s)	""Simulator" refers to an interactive simulator that enables various verifications and human training by reproducing the usage environment as much as possible for the task. This is also used for verification of human-machine interface."
Proposed definition	Computer program that can emulate the characteristics and behaviours of assets and physical phenomena.
Rationale	A simulator can be used in the entire lifecycle of the system (not limited to verification) from design and development, testing and evaluation to investigation of accidents via scenario recreation.

Term to be defined	18. **Technical personnel**
Existing definition(s)	Persons temporarily embarked aboard a ship equipped with automation systems for the purpose of its maintenance or time-limited technical intervention.
Proposed definition	Not applicable
Rationale	Given the legal and statutory implication, IMO and its constituents will be in a better position than IACS to derive the definition.

Term to be defined	19. **Uncrewed ship**
Existing definition(s)	An uncrewed ship is a ship with no crew on board.
Proposed definition	Not applicable
Rationale	Supportive of the existing ISO TS 23860 definition

Term to be defined	20. **Unmanned ship**
Existing definition(s)	Option 1 [(ISO TS 23860)] An unmanned ship is a ship with no humans on board.

	Option 2 [(IACS)] An unmanned vessel is a vessel with no humans aboard. Option 3 [(IACS)] Means that there is no human present on the vessel bridge to perform or supervise operations. Crew may still be on board the vessel. Crew does not include passengers or special personnel.
Proposed definition	An unmanned ship is a ship with no humans on board
Rationale	Supportive of the existing ISO TS 23860 definition

Term to be defined	21. **Autonomous ship system**
Existing definition(s)	All elements that interact to ensure effective functioning of the autonomous and non-autonomous processes and equipment that are necessary to perform the ship's operation or voyage.
Proposed definition	**Autonomy** – is the ability to perform data acquisition, analysis, decision-making and action implementation independent of human control. **System** – combination of interacting elements organized to achieve one or more stated purposes.
Rationale	Separation of the term "Autonomy" from "System" and removal of "Ship"

Term to be defined	22. **Connectivity**
Existing definition(s)	Network facilities to maintain communication between the ship and other parts of the autonomous ship system.
Proposed definition	Technologies that allow all ship systems, the Remote Operations Centre and other stakeholders to connect to a communication network.
Rationale	Improve the definition to cover both intra-vessel and inter-vessel e.g. vessel to vessel, vessel to ROC, vessel to "X" connectivity.

Term to be defined	23. **Fallback space**
Existing definition(s)	Set of all fallback states
Proposed definition	Set of all fallback states
Rationale	Supportive of the ISO/TS 23860:2022 definition

Term to be defined	24. **Route planning**
Existing definition(s)	Mentioned but not explicitly defined.
Proposed definition	Process of determining the best path for a vessel to sail from one location to another, considering factors like distance, time, obstacles, and safety.
Rationale	Route planning should be defined independently of collision and grounding risk avoidance.