

ANNEX 16

RESOLUTION MSC.595(111)

**INTERNATIONAL CODE OF SAFETY FOR
MARITIME AUTONOMOUS SURFACE SHIPS (MASS CODE)**

THE MARITIME SAFETY COMMITTEE,

RECALLING Article 28(b) of the Convention on the International Maritime Organization concerning the function of the Committee,

RECOGNIZING rapid developments in technological innovation within the maritime industry that will lead to the commercial use of maritime autonomous surface ships (MASS), whether they are operated remotely or autonomously,

RECOGNIZING ALSO that instruments of the Organization currently do not adequately or fully address the safe operation of MASS, warranting the need for guidance for administrations, shipbuilders, owners, operators, insurers and other stakeholders to design, build and operate MASS safely, in particular when they are operating jointly with conventional ships,

HAVING CONSIDERED, at its 111th session, the text of the proposed Code,

1 ADOPTS the International Code of Safety for Maritime Autonomous Surface Ships (MASS Code), the text of which is set out in the annex to the present resolution;

2 INVITES all Governments concerned to take appropriate steps to give effect to the MASS Code set out in the annex, on 1 July 2026;

3 ALSO INVITES all Governments concerned to apply the MASS Code, as far as practicable, to MASS of less than 500 gross tonnage;

4 RECOMMENDS that all Governments concerned bring the MASS Code to the attention of shipowners, ship operators, ship designers, shipbuilders, ship repairers, equipment manufacturers and installers, insurers and all other parties concerned with the operation of MASS;

5 URGES Governments to facilitate the safe operation of MASS, provided that the Governments concerned are satisfied that the MASS in question comply with the provisions of this Code, together with any additional measures necessary to ensure the safe operation of such ships within their respective jurisdictions; and

6 REQUESTS the Secretary-General to bring this resolution and its annex to the attention of all stakeholders concerned.

ANNEX

**INTERNATIONAL CODE OF SAFETY
FOR MARITIME AUTONOMOUS SURFACE SHIPS
(MASS CODE)**

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PREAMBLE

1 Existing IMO instruments have historically been developed on the basis that the ship will have at least a required minimum level of manning on board to carry out the various tasks required to ensure safe, secure and environmentally sound ship operations.

2 The ever-increasing use of automation in the operation of ships, along with the anticipated increase in the use of autonomous and remote operation of key functions, will require a different approach and, therefore, some adjustment to the accepted norms regarding onboard manual intervention and control as reflected within the International Convention for the Safety of Life at Sea (SOLAS), 1974, and other IMO instruments.

3 Notwithstanding the above, enhanced automation does not qualify a ship as a MASS. The qualifier to distinguish a MASS from a conventional ship is the introduction of autonomous or remotely-operated technology augmenting or replacing functions otherwise performed by onboard crew involved in conducting or controlling these ship functions.

4 In facing these challenges it is recognized that some aspects associated with MASS are not adequately or fully addressed in SOLAS or other IMO instruments and that additional guidance is required on the design and operation of MASS to ensure a level of safety and security and environmental protection that is expected of a conventional ship.

5 This Code is intended to be supplementary to other IMO instruments, such as SOLAS, and provides a regulatory framework for autonomous and remote operation of key functions.

6 This Code, and the use of MASS, are required to conform to the relevant rules of international law, including the United Nations Convention on the Law of the Sea (UNCLOS), and generally accepted international regulations, procedures and practices developed by IMO as the competent international organization for global shipping.

7 The safety principles and objectives of this Code reflect changes in the operational risks which may result from the introduction of autonomous and remote operation of key functions. This Code addresses the management and reduction of these risks through mitigation measures and controls. This includes the human element issues which may result from the anticipated increase in human-machine interaction, cooperation or collaboration.

8 This Code has been developed based on the *Principles to be considered when drafting IMO instruments* (resolution A.1103(29)), and on the *Generic guidelines for developing IMO goal-based standards* (MSC.1/Circ.1394/Rev.2) for part III.

9 The provisions of this Code should be implemented for individual autonomous or remote functions even where persons are on board to handle other functions.

10 This Code takes into account that certain operational functions may be controlled from a location remote from the MASS and addresses necessary aspects of such Remote Operations Centres (ROCs).

PART I

INTRODUCTION

CHAPTER 1 – PURPOSE, PRINCIPLES AND OBJECTIVES

1.1 Purpose

The purpose of this Code is to provide an international regulatory framework to address autonomous or remote operation of key functions and systems, and ensure safe, secure and environmentally sound operation of Maritime Autonomous Surface Ships (MASS). The Code further aims to support the adoption and integration of new technology for ship operations, and provide for consistent approach to the design, build and operation of MASS.

1.2 Principles

This Code is developed on the principles that it be:

- .1 supplementary to any other applied instruments, and only addressing MASS operations and functions as far as they are not adequately or fully addressed in the other applied instruments;
- .2 holistic to ensure the objectives, aims and principles of the other applied instruments are maintained while also enabling the MASS operations and functions to be addressed across all instruments;
- .3 goal-based and addressing matters at the functional level;
- .4 non-mandatory although developed in such a way as to facilitate future transition to mandatory status; and
- .5 technology neutral, acknowledging industry practices and experience in the deployment of new technologies.

1.3 Objectives

In achieving its purpose, this Code is intended to:

- .1 ensure standards of an acceptable level for design, construction and operation of MASS in order to achieve levels of safety and security expected of a conventional ship;
- .2 enable all ships to safely coexist without impeding or negatively impacting each other, regardless of whether MASS operations or functions are autonomous or remotely-operated;
- .3 allow for the application of solutions that are demonstrably safe, secure and environmentally sound in performing the designated MASS operations or functions under all defined conditions;
- .4 avoid the unintended placement of regulatory barriers to new or novel application of autonomous or remotely-operated technology on ships;

- .5 require human oversight and control of MASS operations or functions while ensuring effective collaboration between human operators and autonomous systems; and
- .6 address responsibility for the operation and human oversight of a MASS.

CHAPTER 2 – APPLICATION

2.1 This Code applies to cargo ships to which SOLAS chapter I applies, including any associated Remote Operations Centre(s) (ROC(s)), which have systems and functions that enable autonomous or remote operations, when the Administration deems that compliance with other applicable instruments is impracticable or insufficient. This Code does not apply to:

- .1 cargo high-speed craft to which SOLAS chapter X applies; and
- .2 warships, naval auxiliaries, and other ships owned or operated by a Contracting Government and used only on Government non-commercial service.

2.2 Where in this Code reference is made to a "MASS", this means a ship to which this Code applies.

2.3 The provisions of this Code should be implemented for individual autonomous or remotely-operated functions even where persons are on board to handle other functions.

CHAPTER 3 – CODE STRUCTURE

The structure and intent of the parts of this Code are:

- Part I: Introduction covering overarching matters to be considered in the application of the Code.
- Part II: Principles applicable in all cases when applying the Code. These principles and the resulting provisions should be met as part of any MASS approval and certification process.
- Part III: Goals, functional requirements, and expected performances applicable to specific MASS operations and functions. Depending on the modes of operation and functionality being certified, not all chapters of part III may be applicable.

CHAPTER 4 – DEFINITIONS

For the purposes of the Code, unless expressly provided otherwise, terms used have the meanings defined in the following paragraphs. For terms used, but not defined in this Code, the definitions as given in SOLAS, should apply.

4.1 *Agent* means a human or software (computer or computer system(s)) responsible for performing or supervising control actions.

- 4.2 *Autonomous* means processes or equipment in a MASS system which are designed and verified to, under specified conditions, determine control action(s) without human intervention.
- 4.3 *Autonomous Navigation System (ANS)* means a system which, under specified conditions, is capable of the navigation of a MASS without human intervention.
- 4.4 *Concept of Operations (ConOps)* means a document describing the characteristics of a MASS.
- 4.5 *Connectivity* means capabilities that allow appropriate and applicable MASS systems and the Remote Operations Centre(s) (ROC(s)), to connect to a communication network.
- 4.6 *Control* is purposeful action on or in a process, to meet specified objectives.
- 4.7 *Control action* means the acquisition of information, analysis of information, decision-making, or implementation of actions.
- 4.8 *Control station* means a single or multiple position(s), including all equipment, such as computers and communication terminals and furniture, from which functions or operations of a MASS can be controlled or monitored.
- 4.9 *Degraded state* means a deviation in the normal operation or condition of the MASS which can potentially result in a fallback state.
- 4.10 *Failure* means the loss of the ability of an item to perform the specified function.
- 4.11 *Fallback response* means the actions and procedures to enter into, safely stay within, and eventually recover from, a predefined fallback state.
- 4.12 *Fallback state* means a predefined state entered when it is not possible for the MASS to stay within the Operational Envelope (OE).
- 4.13 *Fault* means an abnormal condition that can cause an element or an item to fail.
- 4.14 *Fault tolerant* means the ability of a functional unit to perform a required function in the presence of faults or errors.
- 4.15 *Hazards* are situations having the potential to threaten human life, health, property or the environment.
- 4.16 *Human-centred design* is an approach to system design and development that aims to make interactive systems more usable by focusing on the use of the system; applying human factors, ergonomics and usability knowledge and techniques.
- 4.17 *Human-Machine Interface (HMI)* means the part of a system with which an operator interacts. 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.
- 4.18 *Intolerable risk* means a level of risk that would neither be negligible nor tolerable.
- 4.19 *Maritime Autonomous Surface Ship (MASS)* means a ship which, to a varying degree, can operate independently of human interaction.

4.20 *MASS function* means a task or group of tasks, duties and responsibilities, as specified in the Code, necessary for the operation of the MASS.

4.21 *Mitigation* means a measure implemented to prevent unsafe conditions or modes from resulting in losses.

4.22 *Modes of operation* means the condition(s) under which the functions of a MASS are operated, i.e. autonomous or remotely-operated, with or without persons on board.

4.23 *Monitoring* means the use of measurements and analytical methods to understand the condition and any changes in the state of a MASS including its systems and components.

4.24 *Normal operation* means operations within the Operational Envelope of a MASS.

4.25 *Onboard crew* means a master, officers or operational staff physically on board.

4.26 *Operational Design Domain* (ODD) refers to the design range in which a system can operate as intended. It includes both internal events, such as component or subsystem failure or degradation; and relevant external factors, such as available resources, geographical, or environmental situations.

4.27 *Operational Envelope* (OE) means the description of the MASS's operational capabilities and limitations.

4.28 *Override* means to take over control of functions or systems that are under autonomous or remote operation.

4.29 *Quality of service* is a network's ability to maintain acceptable connectivity in the intended Operational Envelope, achieve maximum bandwidth, and deal with other network performance elements.

4.30 *Remote operation* is when functions and systems are operated from outside the MASS.

4.31 *Remote Operations Centre* (ROC) means a location remote from the MASS and from which some or all of the functions of the MASS can be operated.

4.32 *Remote operator* means a qualified person who is employed or engaged to operate some or all of the functions of a MASS from a ROC.

4.33 *Situational awareness* means the perception of surroundings and environmental elements in different modes of operation, the condition of all relevant systems and events with respect to time and space, the comprehension of their meaning, and the projection of their future status.

4.34 *Submitter* is an entity seeking approval of a MASS from the Administration, and responsible for communicating with the Administration for the submission and follow up of the approval process.

4.35 *System* means the combination of interacting elements organized to achieve one or more stated purpose.

4.36 *Systematic failure* means an event that is the consequence of inadequate work processes and may occur at any stage in the systems' lifecycle.

4.37 *Systemic failure* means an event which occurs not only by the malfunctions of a distinct component in the system but due to inherent deficiencies, flaws or oversights in the system's structure, including unforeseen interactions or dependencies among other various constitutive elements of the system.

4.38 *Task* means a set of actions taken to enable functions and the performance of operations.

4.39 *Task station* means a multifunction display with dedicated controls providing the possibility to display and operate any tasks. A task station is part of a control station.

4.40 *Third parties* means persons or entities that are not involved in the operations of the MASS or an associated ROC but are engaging with it (e.g. vessel traffic services (VTS), ports, pilots or other persons on board or in the ROC for maintenance reasons, persons in distress, etc.).

4.41 *Unsafe state* means when a system is operating outside its Operational Envelope but not within a fallback state due to degraded performance (e.g. faults or failures), or is exceeding capabilities which, if left uncorrected or unmitigated, has the potential to directly cause an accident.

4.42 *Validation* means the testing and evaluation to prove that a MASS and its systems, including hardware and software components, are effective, dependable and safe during real world operations and satisfy all the technical requirements representative of normal, abnormal and adverse operating conditions.

4.43 *Verification* means the testing and evaluation to prove MASS and its systems, including hardware and software components, meet the technical requirements at a particular stage of their development.

4.44 *Voyage phase* means the parts of the voyage typically characterized by a recognizable shift in where the MASS is located in terms of geographical surroundings, or the start and end of one or more operation.

PART II

PRINCIPLES FOR MASS AND MASS FUNCTIONS

GENERAL

Each chapter in this part consists of the principles applicable in all cases when applying the Code. These principles and the resulting provisions should be met as part of any MASS approval and certification process.

CHAPTER 5 – SURVEYS AND CERTIFICATES

5.1 MASS Safety Certificate

5.1.1 Every MASS should have on board a valid MASS Safety Certificate, issued after an initial or renewal survey confirming compliance with the relevant requirements of this Code.

5.1.2 The MASS Safety Certificate should be issued either by the Administration or an organization recognized by it, in accordance with SOLAS regulation XI-1/1.

5.1.3 The MASS Safety Certificate should be accompanied by a MASS Record, containing the following:

- .1 description of the Concept of Operations (ConOps);
- .2 survey requirements associated with the systems to which this Code applies;
- .3 task allocation summary;
- .4 regulatory gap analysis; and
- .5 list of any Remote Operations Centre(s) (ROC(s)) approved for the MASS.

5.1.4 The MASS Safety Certificate and MASS Record should be drawn up in a form corresponding to the models given in the appendix. If the language used is neither English, nor French nor Spanish, the text should include a translation into one of these languages.

5.1.5 The MASS Safety Certificate and the MASS Record should be issued in addition to other relevant certificates required in SOLAS regulation I/12.

5.1.6 Where compliance with any of the requirements of SOLAS is achieved through application of this Code, resulting exemptions or equivalent arrangements should be reflected on the appropriate SOLAS certificates.

5.2 MASS surveys

5.2.1 The MASS Safety Certificate validity, survey dates and endorsements should be harmonized with the relevant SOLAS certificates in accordance with the principles of the *Survey guidelines under the harmonized system of survey and certification (HSSC), 2025* (resolution A.1207(34), as amended), and SOLAS.

5.2.2 MASS surveys should be carried out as follows:

- .1 an initial survey that should include complete inspection, verification and testing of the MASS functionality and connectivity with any associated ROCs intended to be certified, to ensure compliance with the requirements of this Code;
- .2 a renewal survey that should consist of an inspection, with tests, of the MASS functionality and connectivity with any associated ROCs, to ensure compliance with the requirements of this Code, that they are in satisfactory condition, and are fit for the service for which the MASS is intended;
- .3 intermediate and annual surveys that should include, as appropriate, general inspection, verification and testing of the MASS functionality, including inspection of operational records of related systems, to ensure that they comply with the requirements of this Code, are in satisfactory condition, and are fit for the service for which the MASS is intended; and
- .4 additional surveys after repairs resulting from investigations prescribed in SOLAS regulation I/11, or after any major repairs, renewals or modifications of equipment, or systems related to autonomous or remotely-operated functions, to ensure that the MASS complies with the relevant requirements of this Code. Such major repairs, renewals or modifications of equipment and/or systems may include, inter alia, the following:
 - .1 replacements or updates that may affect the compatibility, security and stability of any software system;
 - .2 modifications to the ConOps and verification that the functionality of MASS systems and functions continues to comply;
 - .3 repairs after serious failure or defects of equipment and/or systems; and
 - .4 any change to the list of ROCs associated with the MASS.

5.2.3 The MASS Safety Certificate should be endorsed after intermediate and annual surveys referred to in II/5.2.2.

5.3 MASS ROC Certificate

5.3.1 Every ROC should, for each MASS it operates, have a valid MASS ROC Certificate issued after an initial or renewal survey.

5.3.2 The MASS ROC Certificate should be issued either by the Administration or an organization recognized by it, in accordance with SOLAS regulation XI-1/1.

5.3.3 The MASS ROC Certificate should be accompanied by a MASS ROC Record, containing the following:

- .1 a description of the ConOps;
- .2 all operational restrictions on the ROC; and

- .3 the infrastructure for connectivity, and its performance and quality of service as accepted by the Administration.

5.3.4 A copy of the MASS Safety Certificate and MASS Record should accompany the MASS ROC Certificate.

5.3.5 The MASS ROC Certificate and MASS ROC Record should be drawn up in a form corresponding to the models given in the appendix. If the language used is neither English, nor French nor Spanish, the text should include a translation into one of these languages.

5.4 MASS ROC surveys

5.4.1 MASS ROC Certificate validity, survey dates and endorsements should be harmonized with the relevant SOLAS certificates in accordance with the principles of the *Survey guidelines under the harmonized system of survey and certification (HSSC), 2025* (resolution A.1207(34), as amended), and SOLAS.

5.4.2 MASS ROC surveys should be carried out, as follows:

- .1 an initial survey that should include a complete inspection, verification and testing of the ROC and the remote operation functionality, to ensure compatibility between the MASS and ROC and that they comply with the requirements of this Code;
- .2 a renewal survey that should consist of an inspection, with tests, of the ROC and the remote operation functionality, to ensure compatibility between the MASS and ROC and that they comply with the requirements of this Code, are in satisfactory condition, and are fit for the service for which the MASS and ROC are intended;
- .3 intermediate and annual surveys that should, as considered appropriate, include general inspection, verification and testing of the ROC and the remote operation functionality, to ensure compatibility between the MASS and ROC and that they comply with the requirements of this Code, are in satisfactory condition, and are fit for the service for which the MASS and ROC are intended; and
- .4 additional surveys of equipment and/or systems related to autonomous or remotely-operated functions should be made after repairs resulting from investigations prescribed in SOLAS regulation I/11, or other major repairs, renewals or modifications, to ensure that the ROC complies with the requirements of this Code. Such major repairs, renewals or modifications of equipment and/or systems may include, inter alia, the following:
 - .1 replacements or updates that may affect the compatibility, security and stability of any software system;
 - .2 modifications to the ConOps, and verification that the ROC and MASS functionality continues to comply; and
 - .3 repairs after serious failure or defects of equipment and/or systems.

5.4.3 The MASS ROC Certificate should be endorsed after intermediate and annual surveys referred to in II/5.4.2.

5.5 Provisional Certificates

5.5.1 Provisional MASS Safety and MASS ROC Certificates may be issued to a MASS and ROC that will enable initiation of operations while they are undergoing testing during step 3 of the approval process, as described in II/6.1.

5.5.2 Provisional MASS Safety and MASS ROC Certificate(s) may be issued before performing the full-scale test of the MASS and ROC, provided that individual MASS systems have been tested and verified and results of simulation (if applicable) are reviewed and accepted, in accordance with the verification and validation plan approved at step 2 of the approval process, and all the design documents have been updated accordingly and approved according to the simulation and system testing results.

5.5.3 Provisional MASS Safety and MASS ROC Certificate(s) should be issued by the Administration to a MASS and ROC for a period and area of testing specified by the Administration, based on the arrangements proposed by the Submitter in the verification and validation plan.

5.5.4 In addition to surveys covered by the verification and validation plan, MASS and ROCs issued with Provisional MASS Safety and MASS ROC Certificate(s) should be subject to the surveys listed in II/5.2 and II/5.4, as appropriate.

5.6 Validity of certificates

5.6.1 A certificate issued under II/5.1, II/5.3 or II/5.5 should cease to be valid in any of the following cases:

- .1 if the relevant surveys and inspections are not completed within the periods specified under II/5.2 or II/5.4;
- .2 if the certificate is not endorsed in accordance with the present requirements;
or
- .3 upon transfer of the MASS to the flag of another State. A new certificate should only be issued when the Administration issuing the new certificate is fully satisfied that the MASS is in compliance with the requirements of this Code.

5.6.2 Where a MASS ROC Certificate is withdrawn or ceases to be valid, the Administration should review the effect on the associated MASS Safety Certificate as well as on other MASS ROC Certificates issued for this ROC by that Administration.

5.7 Safety management certification

5.7.1 Every International Safety Management (ISM) Company intending to operate a MASS should, in accordance with chapter 11 of this Code, develop its Safety Management System (SMS) to address autonomous and/or remote operations, as applicable.

5.7.2 The Company should ensure that the SMS is implemented and maintained on the MASS and at any ROC(s) involved in its operation. The Company should clearly identify and document the subdivision of tasks and relationship between the Company and any associated ROCs and MASS.

5.7.3 Any operational procedures specified by this Code for the autonomous or remote operations, including watchkeeping arrangements, should be included in the SMS of the MASS and ROC respectively.

5.7.4 The operation of the ROC, including the remote operation of the MASS, should be included in the ISM verification and certification process for a Company to the satisfaction of the Administration.

5.7.5 Where the alternative management described in II/11.3 is used for the operation of a ROC(s), certification should follow a similar approach as the ISM Code with:

- .1 a ROC Safety Management System (ROCSMS);
- .2 a Document of Compliance for the Remote Operation Management Company (ROM DoC); and
- .3 a ROC Management Certificate (RMC) for each ROC.

5.8 International Ship and Port Facility Security certification

A MASS and any ROC operating a MASS should be subject to the International Ship and Port Facility Security (ISPS) Code, as supplemented by this Code.

5.9 Minimum safe manning documents

5.9.1 A MASS or ROC operating a MASS should be sufficiently, effectively and efficiently manned in accordance with the principles of minimum safe manning as set out in *Principles of minimum safe manning* (resolution A.1047(27), as amended), and as supplemented by this Code.

5.9.2 A MASS should be issued with a minimum safe manning document (MSMD) according to resolution A.1047(27), as amended, and to the satisfaction of the Administration.

5.9.3 A ROC operating a MASS should be issued with a MSMD for operation of that MASS, based on the principles of resolution A.1047(27), as amended, and to the satisfaction of the Administration.

5.9.4 A ROC operating several MASS should be issued with one MSMD per MASS. For such ROCs, a MASS ROC Master Plan (MRMP) for watchkeeping and other tasks should be developed and approved by each Administration who has issued MSMDs covered by the MRMP.

5.9.5 The Company should be able to demonstrate compliance with the MSMD(s), through issuing and maintaining appropriate records.

5.9.6 The determination of safe manning should consider the specific personnel qualifications (see chapter 14), operational policy and procedures (see chapter 11), and the infrastructure/technology necessary to perform operational functions (see chapter 8). This determination should consider normal operation (including degraded states), fallback states and emergency situations.

CHAPTER 6 – APPROVAL PROCESS

6.1 Process description

6.1.1 A structured approval process should take place to enable the MASS to obtain the required approval including the necessary certificates related to requirements for the intended operation. By following this process, a Submitter and the Administration would be working in cooperation to ensure that all aspects of safety, security and environmental protection are adequately assessed. This process is intended for the MASS as a whole, while individual systems are covered in the verification and validation step.

6.1.2 The approval process for MASS should be based on and follow the main principles of the *Guidelines for the approval of alternatives and equivalents as provided for in various IMO instruments* (MSC.1/Circ.1455) taking into consideration parts II and III. The level of detail should be proportional to the complexity, level of novelty and associated risk of the MASS and on whether the Submitter is applying for preliminary or final approval. The necessary documentation may vary accordingly.

6.1.3 The Concept of Operations (ConOps) (as described in II/8.2) should be a base document in the approval process and should be the basis for the assessment in each step.

6.1.4 The steps and documentation required in this chapter (and annex 1) provide the general basis of the approval process, without prejudice to other information or documentation that may be requested by the Administration, or to an alternative process which may be followed to the satisfaction of the Administration.

6.1.5 Sufficient information should be supplied to enable the Administration to fully assess the features of the MASS. After appropriate identification of relevant stakeholders by the Submitter, discussions should commence at the earliest possible stage, so that the Administration may fully evaluate the level of safety of the MASS.

6.1.6 The following steps should be observed in the approval process:

- .1 preliminary design development;
- .2 preliminary design approval;
- .3 testing, simulation, and other verification and validation methods;
- .4 final approval; and
- .5 operation.

6.1.7 Table 1 in annex 1 provides additional guidance in relation to the approval steps that require relevant documentation.

6.2 Evaluation criteria

The basic principle for the evaluation criteria should be to ensure a level of safety, security and environmental protection that is expected of a conventional ship. The evaluation criteria should be developed through compliance with the principles of part II and goals and functional requirements of the applicable chapters of part III in combination with a risk assessment (as described in II/7.2). The evaluation criteria and an assessment plan thereof should be agreed with the Administration.

6.3 Design and documentation requirements

For each approval step, information and supporting documentation required by the Administration should be produced and submitted. The various documents required in the approval process steps are expected to be reviewed according to any possible design or operational changes and added details. The approval steps do not need to be sequential, meaning that they may also run at the same time.

6.4 Operation

6.4.1 Conditions for maintaining the safety level agreed during the design approval may be imposed on MASS operations. Any operational conditions should be determined during the approval process, and they should be clearly documented and communicated to relevant parties.

6.4.2 If, during the operational phase, the initial assumptions, systems and equipment are changed, resulting in any change in the ConOps, the part of the risk assessment with the respective changes should be repeated. The extent of work needed will be dependent on the risk-based features and the changes and the operation of the MASS, and may be decided by the Administration. For example, in the case of a Remote Operations Centre (ROC) with remote operators approved for the control of one MASS, it may be necessary to review the approval assumptions if a second MASS is added to the same ROC.

6.4.3 A MASS may initiate operations while it is being tested. During such tests, the certification of the MASS should follow the process for provisional MASS certification described in II/5.5. In addition, further mitigation layers to the system being tested should be foreseen such as different modes of operation from the ones of the final design.

CHAPTER 7 – RISK ASSESSMENT

7.1 A risk assessment should be conducted to ensure that risks arising from the use of MASS functions, including relevant functions in Remote Operations Centres (ROCs), affecting persons on board, the environment, and the safety of the MASS are addressed, taking into account identified goals and functional requirements, ensuring a level of safety expected of a conventional ship.

7.2 The risk assessment can be conducted on MASS as a whole, and/or on the MASS functions. It should also consider the Operational Envelope (OE) or Concept of Operations (ConOps) of the MASS, and address relevant mitigation measures.

7.3 Should the risk assessment be carried out on specific MASS functions, the consequences on other functions should be considered and mitigated.

7.4 Appropriate risk assessment methodologies¹ should be used for the different steps of the approval process as required in chapter 6 (Approval process). Such risk assessments, inter alia, might include:

¹ Refer to:

- MSC.1/Circ.1455 on *Guidelines for the approval of alternatives and equivalents as provided for in various IMO instruments*
- IEC/ISO 31010:2019 – Risk management — Risk assessment techniques
- IEC 61508 on *Functional safety of electrical/electronic/programmable electronic safety-related systems* - Parts 1 to 7
- STPA: http://psas.scripts.mit.edu/home/get_file.php?name=STPA_handbook.pdf
- RBAT: <https://www.emsa.europa.eu/mass/rbat.html>

- .1 MASS (including ROC(s)) and system design; and
- .2 alteration or modification of any major characteristic of the MASS or of the OE or ConOps of MASS that may impact MASS functions.

7.5 A risk assessment should be carried out by personnel with relevant expertise as required by the Administration (*Revised guidelines on alternative design and arrangements for SOLAS chapters II-1 and III* (MSC.1/Circ.1212/Rev.2), section 4 (Design team)).

7.6 The output format should be justified by the Submitter and be agreed between the Submitter and the Administration.

7.7 The risk assessment should include a comprehensive description of autonomous and remotely-operated function utilization, effectiveness and reliability by performing a hazard and mitigation analysis, evaluating the identified risks, and implementing effective risk control measures.

7.8 The risk assessment should analyse and address hazards associated with the intended OE of the MASS including any associated ROCs, as described in the ConOps. Apart from the hazards such as loss of function, cyber incidents, software application failure, component damage, fire, explosion and electric shock, it should also consider the random, systematic, and systemic hazards involved within the OE.

7.9 The adopted mitigation measures should take into consideration single failure events, but also foreseeable events within the OE of the MASS that may influence the performance of more than one system at the same time. Such features should consist mainly of independent mitigation layers, including predefined fallback states. The number of such mitigation layers should be proportional to the risk.

7.10 The assessment should ensure that hazards are eliminated wherever possible through inherently safe design and hazards that cannot be eliminated should be mitigated as needed. The effectiveness of the mitigation measures considered in the risk assessment should be verified according to the verification and validation plan stipulated in paragraph 2.7 of annex 1.

CHAPTER 8 – OPERATIONAL CONTEXT

8.1 General

8.1.1 The operational context for a MASS should, within the applicable regulatory framework, and on the understanding that it does not have any privilege over conventional ships, consider all aspects of the MASS operation and describe the autonomous or remotely-operated function(s) and the external environment that influences its operation.

8.1.2 The operational context encompasses the Concept of Operations (ConOps), the Operational Envelope (OE), the system-specific Operational Design Domain (ODD), fallback states, the modes of operation and the human control and supervision, all of which should be considered as part of the certification. Figure 1 in annex 2 illustrates the relationship between the OE, ODD, fallback state and contingency plans.

8.2 Concept of Operations

8.2.1 The ConOps should be drafted to ensure the safe, secure and environmentally sound operation of the MASS.

8.2.2 The ConOps may be drawn up in a form corresponding to the model given in annex 2, or an alternative acceptable to the Administration.

8.2.3 Risk assessments for the MASS and Remote Operations Centre (ROC) should take the ConOps into consideration. The ConOps and the associated risk assessment should ensure that all relevant risks are addressed.

8.2.4 The ConOps should include consideration of the OE and the technical design of the MASS and of the ROC(s), if applicable, including connectivity and communication lines. The ConOps should address the control, monitoring and intervention on board the MASS and at the ROC, if applicable, together with the integration of humans in the operation.

8.2.5 The ConOps should be re-evaluated when there are hardware, software, operational or management changes to the MASS or ROC.

8.3 Operational Envelope and Operational Design Domain

A MASS should have a clearly defined OE for the MASS as an integrated system, which also includes the ODDs of all relevant systems or functions.

8.3.1 Operational Envelope

8.3.1.1 The OE of the MASS should encompass the operational capabilities and limitations of the autonomous or remote operation, and ship-specific capabilities and limitations to indicate the condition in which a MASS can operate safely in all operating conditions, including all reasonably foreseeable degraded states.

8.3.1.2 The OE should, inter alia, contain:

- .1 definition of the MASS functions and states, and its use case(s);
- .2 geographic area of operations, including coverage/connectivity and traffic conditions;
- .3 description of the environmental limitations;
- .4 description of operational limitations for different modes of operation during a single voyage;
- .5 the use and management of the modes of operation, including the division of functions and allocation of tasks between humans and systems which enable autonomous or remote operations; and
- .6 any other factors that have a significant impact on MASS operations.

8.3.2 Operational Design Domain

8.3.2.1 The ODD of individual autonomous or remotely-operated functions or systems should be based on the results of a risk assessment. The relevant design documents should include:

- .1 conditions and limitations under which any relevant individual system or function operates safely;
- .2 reasonably foreseeable system or equipment malfunctions including corresponding degraded states;
- .3 extent of human interaction;
- .4 capabilities and limitations to be accomplished before activation of the individual system or function; and
- .5 descriptions of the external and internal conditions, such as geographical boundaries within which the MASS is to operate, the maximum wind speed and wave heights, etc.

8.3.2.2 An autonomous or remotely-operated system and related equipment should operate within its ODD and should be able to detect whether its current state of operation meets the ODD.

8.3.3 Degraded state

A single autonomous or remotely-operated system or function deviating from its ODD should not necessarily result in the MASS deviating from its OE. As long as the MASS, as an integrated system, can continue to be operated within its OE, the deviation of an autonomous or remotely-operated system or function from its ODD should be considered as a degraded state.

8.4 Fallback state

8.4.1 In case of deviating from its OE, a MASS should enter a predefined fallback state, offering an additional mitigation layer. There may be more than one predefined fallback state, to address failures or conditions identified at the design stage that might lead to a MASS deviating from its OE.

8.4.2 The conditions, actions and procedure to enter into, and recover from, a fallback state should be considered as the fallback response and should be predefined and able to be tested.

8.4.3 When a MASS enters a fallback state, the predefined fallback response should avoid harm to human life, other ships, infrastructure, and the marine environment while the MASS returns into its OE and normal operation is restored.

8.4.4 Fallback states should be risk-assessed and demonstrate effectiveness in avoiding further deterioration in the status of the MASS or increases in the threat to human life, marine environment, other ships or infrastructure. Depending on the result of the risk assessment, more than one independent fallback state should be available at any time during normal operations. Being in a fallback state should not result in an intolerable risk.

8.4.5 The MASS should be capable of notifying its onboard crew and remote operators when transitioning to, and operating in, a fallback state.

8.5 Contingency plans

A deviation from an OE beyond a predefined fallback state should lead to the activation of contingency plan(s).

8.6 Mode(s) of operation

8.6.1 The mode of operation of a MASS may be changed for different phases of a voyage, and procedures to change from one mode of operation to another, along with the criteria for any such change, should be described in the ConOps.

8.6.2 The description of mode(s) of operation should also identify:

- .1 which functions are autonomous or remotely-operated;
- .2 how autonomous or remotely-operated functions are allocated to different agents (human or software);
- .3 how the affected functions are supervised, and by which agents;
- .4 where the different agents are located (on board or remote); and
- .5 which other systems and other roles (personnel) are involved in performing the control action.

8.7 Human oversight and control

8.7.1 All onboard crew and remote operators responsible for managing MASS operations should be able to exercise human oversight and control for operation of the MASS, including the ability to:

- .1 understand and interpret system outputs;
- .2 supervise the system, and verify system-initiated decisions, as appropriate; and
- .3 intervene and/or override the system, if required.

8.7.2 The allocation of functions as per II/8.6.2.2 should be based on the understanding that the operation of a MASS without any human interaction has limitations. Therefore, any onboard crew and remote operators responsible for managing MASS operations should always be able and prepared to take over the responsibilities of autonomous functions without risk to the outcome of the task.

8.7.3 There should be a human master responsible for a MASS, regardless of the mode of operation and the master should have the means to intervene when necessary.

8.7.4 The onboard crew or remote operator should be provided with ample time and sufficient information to be able to establish situational awareness, assume responsibility and exercise direct or supervisory control of all functions according to the ConOps (see II/10.7).

CHAPTER 9 – SYSTEM DESIGN

In addition to complying with relevant rules, regulations and standards, systems related to MASS functions should comply with the following high-level principles.

9.1 Safety-centric design

Systems should be designed to minimize threat to the MASS, human life, marine environment, other ships and infrastructure by incorporating inherently safe design principles. All systems used for MASS operations should include fail-safe mechanisms and emergency protocols to ensure comprehensive safety and effective risk management. Hazards should be eliminated wherever possible, and those that cannot be eliminated should be mitigated as needed by using a risk assessment as described in chapter 7 (Risk assessment).

9.2 Human-centred design

Systems should be designed, and further developed throughout their life cycle, using a human-centred approach, which takes into account the characteristics and competence of expected users, including their tasks and working environment.

9.3 Robustness

Systems should be robust and should be able to operate effectively under adverse conditions, including diverse maritime environments and operational challenges.

9.4 Reliability

It should be ensured that the systems perform their required functions effectively during the operational period specified by the manufacturer, up to predetermined maintenance intervals.

9.5 Adaptability

Systems should have the ability to adapt to changing environments, tasks, and user requirements, and allow for updates and modifications to accommodate necessary technical and regulatory updates, and future needs.

9.6 Redundancy and fault tolerance

9.6.1 Redundant sub-systems should be implemented to maintain functionality in case of component failures including systemic or systematic failures.

9.6.2 Systems should be designed to handle and recover from failures and continue operating at a reduced performance level (fallback state).

9.7 Scalability

It should be ensured that system designs are scalable, allowing for expansion or updates as technology advances or operational needs change.

9.8 Security and cybersecurity

Measures to mitigate security risks and cyber risks should be incorporated in the systems of the MASS and the Remote Operations Centre (ROC), including prevention of unauthorized access.

9.9 Data management and quality

Data management systems should be incorporated that ensure data accuracy, integrity, and quality.

9.10 Proper record-keeping (data logging)

9.10.1 Systems should support data logging for performance, failure and incident analysis.²

9.10.2 Data should be electronically stored for a predetermined period, not less than 30 days, and be made available in an appropriate format.³

9.10.3 For data stored on board, means should be available to protect data during, and retrieve data following, an incident.

9.10.4 Logged data should contain appropriate detail to restore a complete record of the MASS operations, including, where applicable, remote operations and automated decision-making processes.

9.10.5 Logged data should be made available to the Administration and other marine investigation authorities upon request.

9.10.6 The requirements of SOLAS regulation V/20 (Voyage Data Recorders) should apply to all MASS.

9.11 Interoperability

Compatibility and interoperability with systems, devices, applications, and technologies should be ensured.

9.12 Testing and validation

9.12.1 Systems should undergo comprehensive testing and validation to ensure compliance with design specifications and operational requirements. This process includes a structured procedure comprising detailed simulation, component testing, integration testing, and system testing.

9.12.2 Remote operators should be actively involved in the system validation phase in real-case scenarios to ensure practical usability and operational soundness meeting all regulatory requirements, before obtaining the necessary certifications.

² Refer to resolution MSC.333(90) on *Adoption of revised performance standards for shipborne Voyage Data Recorders (VDRs)*; IEC 61996-1:2013+A1:2021 *Maritime navigation and radiocommunication equipment and systems - Shipborne voyage data recorder (VDR) - Part 1: Performance requirements, methods of testing and required test results*.

³ Refer to MSC.1/Circ.1024 on *Guidelines on voyage data recorder (VDR) ownership and recovery*.

9.13 Transparency

Transparency should be maintained in the system design for systems operations and decision-making processes.

CHAPTER 10 – SOFTWARE PRINCIPLES

The principles in this chapter should be implemented to ensure that software on MASS or supporting MASS functions is reliable, trustworthy, safe and secure. They should be used within the context of complying with this Code, including the use of autonomous and remotely-operated functions, and should be considered as part of the approval process, and this may be done using software quality assurance standards.⁴

10.1 Proportionality

Software should have an explicit and well-defined Operational Design Domain (ODD). The use of software should not go beyond what is provided for in the Concept of Operations (ConOps). Risk assessment(s) should be used to identify and manage hazards from the software.

10.2 Reliability

The continued effectiveness of software capabilities should be subject to testing and assurance across their entire lifecycles.

10.3 Safety and security

Unwanted harm (safety risks) as well as vulnerabilities to external factors (security risks) should be avoided and addressed, as described in chapter 7 (Risk assessment). Safety and security (including cybersecurity) risks should be identified, addressed, and mitigated throughout the software's operational life to prevent and/or limit, any potential or actual harm to shipping, human life, or the marine environment.

10.4 Transparency and explainability

Software should be transparent and explainable at all stages of its operational life, and for all decision-making processes. The transparency and explainability should ensure relevant personnel possess an appropriate understanding of the technology, development processes, and operational methods applicable to autonomous capabilities, including with transparent and auditable methodologies, data sources, and design procedure and documentation.

⁴ Refer to:

- MSC.1/Circ.1512 on *Guideline on software quality assurance and human-centred design for e-navigation*
- IEC 61508 on *Functional safety of electrical/electronic/programmable electronic safety-related systems* - Parts 1 to 7
- IEC 61924-2:2021 on *Maritime navigation and radiocommunication equipment and systems - Integrated navigation systems (INS) - Part 2: Modular structure for INS - Operational and performance requirements, methods of testing and required test results*
- IEC 61162 series of standards on *Maritime navigation and radiocommunication equipment and systems - Digital interfaces*
- IACS UR E22 on *Computer-based systems Rev.3* (June 2023)
- ISO/IEC/IEEE 90003:2018 on *Software engineering - Guidelines for the application of ISO 9001 to computer software*
- ISO/IEC 25000:2014 on *Systems and software engineering - Systems and software Quality Requirements and Evaluation (SQuaRE) - Guide to SQuaRE*
- MSC-FAL.1/Circ.3/Rev.3 on *Guidelines on maritime cyber risk management*

10.5 Accountability

Entities developing, deploying or operating software should implement mechanisms to ensure accountability and proper operation of their software. Software should be auditable and traceable to such entities. There should be governance mechanisms in place for oversight, impact assessment, audit and due diligence to ensure accountability for the software's performance and reliability throughout its operational life.

10.6 Robustness

Safe and secure software should be enabled through robust frameworks. Software should perform consistently with intended objectives, in a stable and resilient manner in a variety of circumstances. The robustness of such software should be tested and assured across its entire life cycle within that domain of use.

10.7 Controllability

Software should be designed and developed to ensure that any onboard crew and remote operators responsible for managing MASS operations can exercise human oversight and control, including the means to:

- .1 interpret appropriate context by delivering accurate, timely, sufficient and unambiguous information to operators and other systems;
- .2 verify system behaviour with respect to the accuracy of system output and effectiveness of system performance at any time during operations by providing timely indicators of task status;
- .3 take over control, and adjust or override system behaviour in a time frame that minimizes risk and disruption to ongoing operations; and
- .4 provide timely input and direction as required to prevent or minimize risks to MASS operations by enabling performance of all required operator actions, providing accurate, understandable and relevant feedback and confirmation where necessary.

10.8 Unintended bias

Software should be designed and developed to prevent unintended bias.

CHAPTER 11 – MANAGEMENT OF SAFE OPERATIONS

11.1 Purpose

The purpose of this chapter is to ensure adequate management for safe operations.

11.2 Safety Management System provisions for MASS operations

11.2.1 The MASS, the Company and the Remote Operations Centre (ROC) should follow the provisions of this chapter, which are supplementary to the requirements for the management for the safe operation of ships in SOLAS and the ISM Code.

11.2.2 The Safety Management System (SMS) of the Company should provide for safe MASS operations through the establishment of procedures, plans and instructions for all foreseeable modes of operation, including for any ROC(s) involved, if applicable. In order to accomplish this, the following should be considered:

- .1 Risk control measures addressing autonomous or remotely-operated functions.
- .2 Internal processes should verify the effectiveness of procedures, plans and instructions to address autonomous or remotely-operated functions.
- .3 Human-machine interface (HMI) aspects of autonomous or remotely-operated functions.
- .4 The role and expected performance for ROC(s), where autonomous or remotely-operated functions are executed.
- .5 With respect to autonomous or remotely-operated functions:
 - .1 their interaction, capabilities and limitations;
 - .2 the complexity of systems, including software systems or data services;
 - .3 equipment and systems necessary to maintain contact with the MASS;
 - .4 lines of communication to maintain contact with the MASS;
 - .5 cyber risks; and
 - .6 fallback actions and processes to maintain their safe operation.

11.2.3 The SMS of the Company should provide for the safety and well-being of the personnel involved in the operations by identification of resources and training required and establishment of procedures, plans and instructions for all foreseeable operating conditions of the MASS, including for any ROC involved, if applicable. In order to accomplish this, the following should be considered:

- .1 Risk control measures addressing autonomous or remotely-operated functions.
- .2 Internal processes verifying the effectiveness of procedures, plans and instructions addressing autonomous or remotely-operated functions.
- .3 HMI aspects of autonomous or remotely-operated functions.
- .4 Responsibilities with regard to the interaction in MASS operations.
- .5 Maintenance of the principle of the overriding authority of the master.
- .6 Emotional pressure, specific stresses and strains to humans involved in the MASS operations.

11.2.4 The SMS of the Company should provide for the safety of the MASS under all expected emergency conditions by establishment of contingency plan(s), including emergency scenarios involving different physical locations, if applicable. In order to accomplish this, the following should be considered:

- .1 Risk control measures addressing autonomous or remotely-operated functions.
- .2 Internal processes verifying the effectiveness of procedures, plans and instructions addressing autonomous or remotely-operated functions.
- .3 HMI aspects of autonomous or remotely-operated functions.
- .4 Monitoring the performance of autonomous or remotely-operated functions, including relevant system and MASS parameters.
- .5 Assistance for emergency handling or handling of other potentially unsafe situations.
- .6 Capabilities and limitations of emergency response in the MASS operation.
- .7 Maintaining a minimum level of connectivity between the MASS and the ROC, if applicable.
- .8 Procedures for connecting to shore-based assistance during emergencies.
- .9 Cyber risks during emergencies addressing autonomous or remotely-operated functions.
- .10 Means and procedures for emergency standby arrangements and equipment addressing autonomous or remotely-operated functions.
- .11 Emergency procedures should be executed based on predefined contingency plans and adjusted appropriately as needed, considering further:
 - .1 An appropriate mode of operation should be adopted, including suspension of operations if necessary.
 - .2 Emergency response data and relevant information should be accessible at any location involved in the response.
 - .3 Resources from the MASS and the ROC should be promptly mobilized to address the emergency situations.

11.3 Alternative management for the safe operation of Remote Operations Centre(s)

11.3.1 With regard to a Remote Operation Management (ROM) company operating one or multiple ROC(s), this company could, to the satisfaction of the Administration, establish an SMS for the operation of those ROCs (ROC Safety Management System (ROCSMS)) under their responsibility. This ROCSMS should supplement the MASS's SMS developed by the Company, and the MASS ROC Certificate clearly establishing the relationship between the SMS and ROCSMS, to ensure that the safety level of the MASS established through the MASS's SMS is maintained.

11.3.2 The alternative ROM certification should follow a similar approach to that of the ISM Code with:

- .1 a ROCSMS;
- .2 a Document of Compliance for ROM (ROM DoC); and
- .3 a ROC Management Certificate (RMC) for each ROC.

CHAPTER 12 – SPECIAL MEASURES TO ENHANCE MARITIME SECURITY

12.1 Purpose

The purpose of this chapter is to ensure adequate security.

12.2 General

To achieve the above-mentioned purpose, in addition to the requirements in SOLAS chapter XI-2 and the ISPS Code, the following provisions should be applied.

12.3 Implementation of security measures

12.3.1 The ship security assessment (SSA) and ship security plan (SSP) should identify and address additional security risks related to MASS operations.

12.3.2 The following should be considered in the implementation of security measures:

- .1 Measures and procedures should be in place on board a MASS to ensure a level of security not less than that of a conventional ship.
- .2 The security of the MASS should not be compromised by the use of autonomous and remotely-operated systems, considering inter alia:
 - .1 physical security;
 - .2 structural integrity;
 - .3 personnel protection systems;
 - .4 procedural policies including the SSP;
 - .5 radio and telecommunication systems including computer systems and networks; and
 - .6 that any other areas, if damaged or used for illicit observation, should not pose a risk to persons, property, or operations on board the MASS.
- .3 Systems deployed to serve security purposes should be secure, resilient to attempts to compromise them, and exchange information in such a way that it does not compromise the security of the data.

- .4 The MASS should be able to communicate and exchange security-related information, as appropriate, with a Remote Operations Centre (ROC), the Administration, Governments, port authorities, port facilities and Company upon request, taking into account the sensitivity of the information and authorization to access security-sensitive information.
- .5 Means should be provided to enable the assessment of the effectiveness of additional security measures for MASS operations.
- .6 The SSP should be stored such that duly authorized personnel required to take action are able to access it.
- .7 Record of activities addressed in the SSP should be stored such that duly authorized personnel required to access and amend them are able to do so at any time.

12.4 Remote operations

12.4.1 Ship security assessment and plans should account for the ROC(s), where appropriate, aligning as closely as possible with the concept, terminology and appropriate provisions of the ISPS Code.

12.4.2 Where responsibilities are transferred from onboard crew to remote operators, the remote operators should be subject to the requirements of the ISPS Code as supplemented by the following:

- .1 The role of remote operators and those with responsibilities that have been transferred from the MASS, should be addressed in the SSP.
- .2 Remote operators should take part in training, drills and exercises as laid out in the ISPS Code.
- .3 Records of the activities as laid out in the ISPS Code, section A/10.1, should include the involvement of remote operators.
- .4 When conducting ship security assessments, identification of weaknesses in the infrastructure, policies and procedures should consider human factors, including remote operators.

12.4.3 In the event of the security of a ROC being compromised, measures and procedures should be in the SSP and should be implemented to ensure that this does not impact the security of the MASS.

- .1 Means should be provided for early detection of a security breach.
- .2 There should be a separate mechanism for safely isolating and shutting down communications and control when the security of the ROC has been compromised
- .3 The MASS should either enter a predefined fallback state until secure communications can be established with a secure ROC or, if available, control can be assumed at a separate control location, which may include the MASS itself.

- .4 Communication with the compromised ROC should only be re-established once the security of the ROC has been ensured and validated.
- .5 Procedures should be documented in the SSP, with plans in place to state where control will be assumed, and how communications will be re-established.

12.5 Access control

Unauthorized access should be prevented to ensure the security of the MASS, its cargo and onboard personnel, and any ROCs, if appropriate.

- .1 Means should be provided to detect:
 - .1 physical intrusion by unauthorized personnel;
 - .2 physical attacks on the MASS during its voyage; and
 - .3 cyber intrusion or interference.

12.6 Communications

Communication with the MASS should be maintained during and following a security event on board, or impacting upon, a MASS.

- .1 Systems should allow for coordination between the MASS and third-party responders, and should provide sufficient information to ensure the safety and security of external responders, other ships, and the marine environment.
- .2 Means should be included in the design and implementation of communication systems such that reasonably foreseeable security incidents would not result in damage to, or compromise of, all other systems.
- .3 In the event communication is lost following a security incident, the MASS should enter an appropriate fallback state and be capable of maintaining that state during and following the event until secure communications and control can be re-established.

CHAPTER 13 – ALERT MANAGEMENT

13.1 Purpose

The purpose of alert management is to enhance the monitoring, handling, distribution and presentation of alerts for MASS and Remote Operations Centres (ROCs) thereby allowing for the prompt identification and addressing of any alert situation that arises and ensuring safe operation.

13.2 General

13.2.1 As part of the alert management system, taking into account the specificities of MASS operation, the following should be considered.

13.2.2 An alert management optimization should be performed taking into account the Concept of Operations (ConOps) so that the alert management provides:

- .1 the means to draw the attention of the onboard crew and remote operators to the existence of alert situations;
- .2 the means to enable the human operator to identify and evaluate the situation and handle alert announcements;
- .3 the means for onboard crew and remote operators and relevant third parties to assess the urgency of different alerts in cases where more than one alert should be handled;
- .4 the means to manage alerts in a distributed system structure in a consistent manner; and
- .5 support for effective supervision of autonomous and remotely-operated functions.

13.3 Principles

The alert management for MASS and ROC should be based on the following principles:

- .1 Alerting should follow the basic principles of the Bridge Alert Management (BAM) concept outlined by resolution MSC.302(87) on *Performance Standards for Bridge Alert Management (BAM)*, as may be amended.
- .2 If practicable, there should be no more than one alert for one situation that requires attention.
- .3 Alerts should provide information for the operator to sufficiently understand the consequences of the situation and determine appropriate actions.
- .4 The alert management should handle alerts from all systems or components required to support MASS and ROC operation. Furthermore, it should have the capability to handle all other alerts in a consistent manner.
- .5 The logical architecture of the alert management and the handling concept for alerts should provide the capability to minimize the number of alerts, especially those on a high priority level.
- .6 Audible alerts should guide human operators to the task stations or displays which are directly assigned to the function generating the alert and presenting upon request at least the cause of the announcement and related information for decision support, e.g. dangerous target alarms should appear and have to be acknowledged at the control station where the collision avoidance function is provided.
- .7 As alerts can be displayed at several locations and task stations, the system should be consistent as far as practicable with respect to how alerts are presented, silenced and acknowledged at any one task station. Actions taken in a task station should be visible to all other relevant task stations.

- .8 Alerts should only be presented for handling (e.g. acknowledgement or silencing) at task station(s) used by the operator in charge of the tasks related to the initiated alerts. Alerts may be presented visually for information at other task stations.
- .9 The master should receive alerts and have access to the alert management at all times.
- .10 The operator responsible for the MASS should be able to directly handle the alert management Human-Machine Interface (HMI). It should be possible to provide the central alert management HMI at the control position for the operator.

13.4 Autonomous or remote operations and functions

13.4.1 In addition to relevant alerts associated with conventional ships, specific consideration should be given to those alerts related to the operations and functions to which this Code applies, as outlined in other chapters. Examples of such alerts, inter alia, would include:

- .1 upon entering a fallback state or upon recognizing the need to enter a fallback state;
- .2 in case the MASS is not able to enter a fallback state when deviating from its Operational Envelope (OE);
- .3 in case of equipment failure affecting operations of MASS functions or significantly increasing the risk of MASS operation e.g. loss of redundancy;
- .4 in case a system, that is critical to MASS operation, exceeds or is about to exceed its Operational Design Domain (ODD); and
- .5 in case of ROC-specific alerts and conditions requiring attention (e.g. power failures, task station failures, communication system failures at ROC-level, software failures at ROC-level).

13.4.2 Task stations presenting alerts for multiple MASS should have the means to organize alerts per MASS and have the means to delegate alert handling for selected MASS to another task station.

13.4.3 When an emergency alarm is activated, dedicated human operators, including the master, should be able to take control of the MASS until the emergency is over.

13.4.4 The observation of abnormal situations and conditions concerning more than one MASS should be classified as alarms.

CHAPTER 14 – MANNING, TRAINING AND WATCHKEEPING

14.1 Purpose

14.1.1 The purpose of this chapter is to ensure that all MASS are appropriately manned and operated by trained, competent and experienced personnel.

14.1.2 For the purpose of this chapter, the training and watchkeeping standards as addressed by the 1978 STCW Convention and STCW Code may be considered by the Administration for the assigned roles in the Remote Operations Centre (ROC).

14.1.3 A ROC may be considered by the Administration as a directly associated location to the navigational bridge or part of the machinery space, as applicable, to ensure that the watchkeeping provisions of the 1978 STCW Convention and STCW Code may also apply to remote operators.

14.2 Safe manning

14.2.1 General

To ensure all MASS are manned safely as outlined in II/5.9 (Minimum safe manning documents), the following principles should be followed:

- .1 The applicable international instruments, regulations and principles of safe manning should be adhered to when structuring manning levels.
- .2 The task allocation summary (annex 1, paragraph 2.4) should be taken into account when determining the safe manning levels.
- .3 The minimum level of safe manning should ensure sufficient onboard crew and/or remote operators to operate the MASS in an effective and efficient manner:
 - .1 providing safety and security of the MASS, safe navigation and operations at sea, safe operations in port, prevention of human injury or loss of life, avoidance of damage to the marine environment and property;
 - .2 ensuring the welfare and health of onboard crew and/or remote operators through the avoidance of fatigue; and
 - .3 maintaining an effective response to emergency situations or failures of systems.
- .4 The roles of all personnel as outlined in the Minimum Safe Manning Document (MSMD), should be clearly identified, defined and allocated.
- .5 The MSMD should define whether a particular capacity is to be fulfilled by onboard crew and/or remote operators.
- .6 Clear lines of authority and responsibility between onboard crew and/or remote operators should be established to ensure the safety and security of personnel and operations.
- .7 All personnel defined by the MSMD should be qualified, competent and capable of performing their function(s) at the appropriate level(s) of responsibility, regardless of the mode of operation.

- .8 The minimum level of safe manning should take into account the impacts of fatigue on all personnel defined within the MSMD.⁵
- .9 The minimum level of safe manning should provide for sufficient hours of rest, taking into account applicable requirements, the provisions set out in the 1978 STCW Convention and STCW Code and the provisions set out in IMO's principles of safe manning.
- .10 Regardless of the mode of operation, the master is responsible for the safe operation of the MASS at all times.
- .11 The master responsible for a MASS may be located physically on board or at a ROC.
- .12 If there are crew or persons on board, the master should be physically present on board to ensure the safety of personnel and operations.
- .13 Multiple masters may be operationally responsible for a MASS on a single voyage.
- .14 Only one master should be responsible for a MASS at any given time.
- .15 Where command is transferred to or within a ROC, or between ROCs, sufficient time, resources and procedures should be provided to ensure that the master can establish situational awareness and is fully familiar with the MASS and any ROC before assuming responsibility for the MASS.

14.2.2 Safe manning for ROC(s)

Where the levels of safe manning are to be met by the inclusion of remote operators:

- .1 they should be qualified and competent to a level not less than what is required under the 1978 STCW Convention and STCW Code, to undertake their assigned tasks, duties and responsibilities from a ROC, that is certified in accordance with this Code;
- .2 remote operators should not be assigned any task, duty or responsibility, which due to the characteristics of a ROC or the MASS, cannot be discharged safely and effectively from the ROC, or has been determined by the Administration to be required to be carried out on board; and
- .3 where remote operators perform watchkeeping duties, there should be:
 - .1 a sufficient number of remote operators that meet the appropriate training and certification requirements to cover all watches, that are intended to be performed at a ROC; and
 - .2 sufficient time, resources and procedures should be provided to ensure that they can establish situational awareness and are fully familiar with the MASS and any ROC before assuming responsibility for a watch.

⁵ Refer to MSC.1/Circ.1598 on *Guidelines on fatigue*.

14.3 Watchkeeping

Watches should be carried out based on the following bridge, engine-room and ROC resource management principles:

- .1 remote operators may maintain a safe watch or watches at the ROC without being physically present on board the MASS;
- .2 an appropriate and effective watch or watches should be maintained for the purpose of safety of the MASS, which includes duties specific to a ROC;
- .3 watchkeeping may be shared between onboard crew and remote operators, provided that clear lines of authority and responsibility are established between all watchkeeping personnel to ensure the safety and security of personnel and operations; and
- .4 watchkeeping duties, tasks and functions should be designed to maintain operational attentiveness.

14.4 Training, familiarization and competence

14.4.1 Onboard crew

In addition to being qualified as required by the 1978 STCW Convention and STCW Code, onboard crew should have completed training to attain the competencies that are appropriate to the capacity to be filled and so that their duties and responsibility can be taken up, including:

- .1 where the MASS operation includes the use of a ROC certified in accordance with this Code, training and drills for emergencies and failures of systems should be conducted between onboard crew and remote operators; and
- .2 with reference to the task allocation summary, onboard crew should receive relevant additional training related to technologies and systems applied on MASS, including evidence to verify that they have the capacity to operate MASS as required for their duties and responsibilities.

14.4.2 Remote operators

Remote operators at any level of responsibility should, at a minimum, be qualified to a level not less than that required by the 1978 STCW Convention and STCW Code and have completed training to attain the competencies that are appropriate to the capacity to be filled so that their duties and responsibility can be taken up, including:

- .1 demonstration of the capacity to perform necessary functions for their assigned level(s) of responsibility;
- .2 additional training in remote operations, and the associated demonstration of knowledge, understanding, proficiency and experience, along with its evaluation;
- .3 additional training in remote operations to enable understanding of the operation of ROC and MASS systems and their associated components in order to operate them safely;

- .4 on being assigned to a MASS, familiarization with their specific duties and with all ROC and MASS operations, arrangements, installations, equipment, procedures, documentation and characteristics that are relevant to their routine or emergency duties; and
- .5 as appropriate, training or drills required of MASS should be extended to any ROC(s) and remote operators undertaking duties for that MASS, including any specialized training required to safely operate a MASS remotely and respond to emergencies.

14.4.3 Documents knowledge

All onboard crew or remote operators should be knowledgeable of the type and purpose of documentation associated with autonomous and/or remote operations.

14.5 Other matters

14.5.1 The Administration may consider evidence of remote operational experience as equivalent to approved sea-going service for those working within a ROC for revalidation of certificates.

14.5.2 The provisions on working language set out in SOLAS regulations V/14.3 and 14.4 should extend to any ROC(s) and remote operators.

CHAPTER 15 – MAINTENANCE

15.1 The purpose of this chapter is to ensure that autonomous and remotely-operated systems can be safely maintained, tested and inspected to ensure their reliability.

15.2 Maintenance of autonomous or remotely-operated systems should not result in unsafe events. This should include:

- .1 systems should be able to be safely isolated and verified prior to commencing maintenance; and
- .2 systems should be able to be restarted safely following maintenance allowing time for rebooting or reconfiguring of systems.

15.3 Qualified and authorized persons should be available on board or remotely to monitor the system and equipment faults and abnormal conditions to verify their cause and implement corrective actions.

15.4 Technical, operating and maintenance manuals or information should be made accessible to authorized operating and maintenance personnel.

PART III

GOALS, FUNCTIONAL REQUIREMENTS AND EXPECTED PERFORMANCES APPLICABLE TO SPECIFIC MASS OPERATIONS AND FUNCTIONS

GENERAL

Each chapter in this part consists of the Goal of the chapter and related Functional Requirements to fulfil the goal. Also included are, where appropriate, Expected Performances (EPs) associated with those functional requirements.

Chapters should be applied in full, but application of chapters in this part of the Code may be waived in agreement with the Administration as part of the approval process depending on the Concept of Operations and/or MASS functions implemented.

A MASS should be considered to meet a functional requirement set out in this part when either:

- .1 the MASS's design and arrangements meet all the expected performances associated with that functional requirement; or
- .2 part(s) or all of the MASS's relevant design and arrangements have been reviewed and confirmed to be in accordance with applicable provisions of IMO instruments, and any remaining parts of the MASS meet the relevant expected performance as outlined in this Code.

The functional requirements and associated expected performances should take into account the modes of operation of the MASS and any human presence on board.

CHAPTER 16 – SAFETY OF NAVIGATION

16.1 Goal

The goal of this chapter is to provide for safe navigation.

16.2 Functional requirements

To achieve the above-mentioned goal, a MASS should comply with all relevant requirements for safety of navigation in SOLAS, as supplemented by the functional requirements of this chapter, and the Convention on the International Regulations for Preventing Collisions at Sea, 1972, as amended (COLREG).

16.3 General

16.3.1 A MASS should comply with the following functional requirements for navigation in general.

16.3.2 Autonomous and remote navigation systems for MASS operations should be designed, constructed and installed to maintain their functionality under the expected conditions in the Operational Envelope (OE).

- EP 1 An Autonomous Navigation System (ANS) or system for remote navigation should be installed enabling the functionalities described in the Concept of Operations (ConOps), other design documents and the task allocation summary.

- EP 2 The use of autonomous or remotely-operated systems for non-navigation functions or tasks should not endanger the safe operation of an ANS or system for remote navigation.
- EP 3 An ANS or system for remote navigation should effectively integrate and coordinate with other MASS systems to prevent conflicting operational commands.
- EP 4 In the event of a failure of an ANS or system for remote navigation, the MASS should be able to be operated safely by alternative means.

16.3.3 All data necessary for safe navigation should be available, in an appropriate format.

- EP 1 A MASS should meet the requirements of SOLAS regulations V/19.2.1.4 and 19.2.1.5 by electronic means.
- EP 2 Data used by, or for input into, an ANS or system for remote navigation should be in a machine-readable format.
- EP 3 The voyage plan should be accessible, at all locations where navigation tasks are executed.

16.4 Sub-functions for MASS navigation

Any or all of the navigation sub-functions below could be autonomous or remotely-operated, while having different modes of operation according to the ConOps:

- .1 Voyage planning: 16.4.1;
- .2 Situational awareness: 16.4.2;
- .3 Collision and grounding avoidance: 16.4.3; and
- .4 Route execution and monitoring: 16.4.4.

As such, a MASS should comply with the relevant sub-function related requirements only when that sub-function is planned to be autonomous or remotely-operated.

16.4.1 Voyage planning

16.4.1.1 An ANS or system for remote navigation that is provided with the voyage plan should have a means to ensure that the voyage plan is safe for navigation.

- EP 1 An ANS or system for remote navigation should provide a means to review and as necessary modify the voyage plan.
- EP 2 An ANS or system for remote navigation should be capable of confirming to the master that the voyage plan has been correctly received and is able to validate and implement the voyage plan received.
- EP 3 The use of the voyage plan, and any modification of the voyage plan, by the ANS or system for remote navigation should not be possible without an approval, including verification of its correctness, by the master.

16.4.1.2 An ANS or system for remote navigation that is capable of developing the voyage plan should have a means to ensure that the voyage plan is safe for navigation, taking into account the Guidance developed by the Organization.⁶

- EP 1 An ANS or system for remote navigation should be provided with access to all nautical and hydrographic data necessary to appraise and plan a voyage.
- EP 2 The voyage plan developed by an ANS or system for remote navigation should be presented in a form that allows the master to approve the plan.
- EP 3 The voyage plan should provide an ANS and/or system for remote navigation and the master with all information necessary to execute and monitor a voyage.
- EP 4 An ANS or system for remote navigation should provide a means to review and as necessary modify the voyage plan.

16.4.2 *Situational awareness*

An ANS or system for remote navigation should maintain adequate situational awareness for the purpose of ensuring safe navigation.

- EP 1 An ANS or system for remote navigation should continuously monitor all information necessary for safe navigation, based on the OE.
- EP 2 An ANS or system for remote navigation should continuously analyse the current situation in order to perceive and process navigational and environmental elements and project or predict future statuses. This should be done while considering the operation goals and objectives, the system's capability, and the modes of operation.
- EP 3 An ANS or system for remote navigation should provide a means to make the information obtained and all analysis accessible as necessary.

16.4.3 *Collision and grounding avoidance*

An ANS or system for remote navigation should ensure there is a means to take action in accordance with COLREG to prevent collisions, as well as allisions and groundings.

- EP 1 Planning and decisions to alter course and/or speed should be both timely and in accordance with safe operating limits.
- EP 2 Any action to avoid collisions, allisions or groundings should be based on an assessment of the risk and the action necessary to avoid the risk of a collision, allision or grounding.
- EP 3 Action to avoid collisions, allisions or groundings should not result in another situation which presents intolerable risk to the MASS, other ships or the marine environment.

⁶ Refer to the *Guidelines for voyage planning* (resolution A.893(21)).

16.4.4 Route execution and monitoring

An ANS or system for remote navigation should safely execute the voyage plan and appropriate monitoring should be provided.

- EP 1 An ANS or system for remote navigation should execute the planned route within the predefined limits of allowable deviation taking into account the factors listed in the Guidance developed by the Organization.⁷
- EP 2 An ANS or system for remote navigation should alert the master if the prevailing circumstances and conditions necessitate a deviation from the voyage plan.
- EP 3 An ANS or system for remote navigation should continuously monitor the progress of the MASS against the voyage plan and make the information available, as necessary.

16.5 Override

An ANS or system for remote navigation should be capable of being overridden from location(s) where control of navigation can be exercised.

- EP 1 Means for overriding operation of an ANS or system for remote navigation should be simple to operate, independent of the systems that they control and allow for control to be taken immediately.

CHAPTER 17 – CONNECTIVITY

17.1 Goal

The goal of this chapter is to ensure that connectivity is maintained between the MASS and the Remote Operations Centre(s) (ROC(s)), and that it is sufficient for the effective monitoring and/or control of MASS functions.

17.2 Functional requirements

17.2.1 To achieve the above-mentioned goal, a MASS and ROC should meet the functional requirements of this chapter.

17.2.2 Connectivity between the MASS and ROC is essential for remote monitoring or control and should be ensured as described in the Concept of Operations (ConOps).

17.2.3 The infrastructure for connectivity should cover the operational context of a MASS and provide a quality of service and connectivity, adequate to ensure the safe operation of MASS, taking into account factors such as bandwidth, data integrity, reliability, resilience and network latency.

17.2.4 Connectivity should be such as to operate the MASS safely, considering operational limitations of connectivity, such as meteorological and oceanographic conditions.

⁷ Refer to the *Guidelines for voyage planning* (resolution A.893(21)).

17.2.5 Connectivity should be maintained at capacity in the case of a single failure in the system.

17.2.6 Redundancy measures should be implemented based on the risk assessment.

17.2.7 The data exchanged should be categorized and prioritized according to a predefined prioritization scheme to enable data with higher priority to prevail over lower prioritized data in case of decrease in communication capacity. The predefined categorization and prioritization of exchange of data should be included in the ConOps.

17.2.8 Connectivity requirements of the MASS should be established for the different voyage phases and modes of operation.

17.2.9 Connectivity performance should be monitored against stated requirements and measures should be in place to address disconnection or performance degradation and to implement necessary actions including entering a fallback state when necessary.

17.2.10 Connectivity including Computer Based System (CBS)⁸ on board MASS and ROCs should ensure the integrity of transmitted data, and that they are sent from authorized authenticated sources. At the same time, measures⁹ should be taken to protect the security of transmitted data.

CHAPTER 18 – REMOTE OPERATIONS

18.1 Goal

The goal of this chapter is to ensure the safe and secure remote operation of MASS systems or functions, when duties and responsibilities for safe operation are assigned to a Remote Operations Centre (ROC).

18.2 Functional Requirements

18.2.1 To achieve the above-mentioned goal, a MASS and ROC should meet the functional requirements of this chapter.

18.2.2 A ROC should be at a suitable location to enable the safe and secure remote operation.

EP 1 A ROC should have:

- .1 facilities that are secure and protected from unauthorized access;
- .2 means to enable reliable connectivity and communication between ROC(s) and the MASS, third parties and persons on board;
- .3 facilities to allow access to, and sharing of, certificates and other documents required to demonstrate that the MASS is compliant with applicable international, national and regional requirements;

⁸ Refer to IACS UR E22 on *Computer-based systems*, UR E26 on *Cyber resilience of ships* and UR E27 on *Cyber resilience of on-board systems and equipment*.

⁹ Refer to MSC.1/Circ.1639 on *The guidelines on cyber security onboard ships* and MSC-FAL.1/Circ.3/Rev.3, as may be amended on *Guidelines on maritime cyber risk management*.

- .4 arrangements, such that the failure and subsequent recovery of the ROC would not result in an unsafe state or intolerable risk on or around the MASS in service;
- .5 verified and validated systems to support its operation;
- .6 sufficient and relevant qualified personnel to enable safe MASS operations; and
- .7 facilities to ensure data and information used, produced, sent or received is retained in reliable and tamper-proof storage, and at a suitable standard of data quality, and considering the SOLAS requirements for voyage data recorders.

18.2.3 A remote control station should be provided to ensure the safe and secure remote operation.

EP 1 A remote control station should:

- .1 have appropriate verified and validated systems;
- .2 have means to monitor the communication and information received, or transmitted, by the MASS and to communicate through the MASS in accordance with relevant communication requirements;
- .3 provide sufficient and accurate data and information to enable the remote operators to carry out their role(s) effectively;
- .4 be fully compatible with the MASS systems assigned to it;
- .5 be tested to ensure that when installing and updating system(s) that the related onboard equipment and devices have appropriate compatibility and interoperability;
- .6 ensure failure and recovery of the control station(s) would not result in an unsafe state or intolerable risk, on or around the MASS in service; and
- .7 be designed and operated in such a way that its location does not impact on its ability to control the MASS.

18.2.4 Verified and validated systems and interfaces between remote control station(s) and the MASS should be provided to ensure the remote operators can operate the MASS safely and securely.

EP 1 This should be accomplished by ensuring the remote operators are able to:

- .1 maintain a watch, as appropriate and applicable, and in a manner conforming to the principles of watchkeeping (as described in chapter 14 (Manning, training and watchkeeping));
- .2 send and receive sufficient, timely and accurate information/commands effectively and securely between the ROC, the MASS, third parties, and persons on board;

- .3 take all decisions necessary to ensure the safe remote operation of the MASS, including support for abandonment of the MASS;
- .4 know the status of the connectivity at the remote control station(s) with the MASS and, where relevant, with third parties;
- .5 know which systems can be controlled, and from where control is being exercised;
- .6 know when conditions on the MASS or at the ROC deviate from the Operational Envelope (OE); and
- .7 monitor the condition and operation of equipment and systems and take measures to mitigate risks.

18.2.5 The transfer of operation should be safe and secure.

EP 1 Safe transfer of operation of the MASS will be accomplished by ensuring that:

- .1 transfer and synchronization of all necessary information is possible between remote control station(s), ROC(s) and the MASS;
- .2 operation can be transferred safely and securely during failure and/or recovery or an emergency situation at the ROC or remote control station(s);
- .3 control cannot be exercised at multiple locations at the same time;
- .4 the present control location is clearly indicated both in ROC and on board the MASS; and
- .5 there is no loss of control of the MASS when the operation is transferred.

18.2.6 The software used for remote operation should be appropriately designed, managed and maintained to ensure the safe and secure operation.

EP 1 The software used should be:

- .1 designed in accordance with chapter 10 (Software principles), taking into account chapter 13 (Alert management);
- .2 integrated, managed, maintained and supported throughout its operational life;
- .3 able to receive, recognize and assist with the prioritization of emergency and non-emergency situations occurring on board the MASS, to enable the remote operators to carry out their role(s) effectively; and
- .4 presented in a form that allows the remote operators to be able to understand the information transmitted to the ROC.

CHAPTER 19 – STRUCTURE, SUBDIVISION, STABILITY AND WATERTIGHT INTEGRITY

19.1 Goal

The goal of this chapter is to ensure that the structure, subdivision, stability, and watertight integrity are within acceptable limits.

19.2 Functional requirements

19.2.1 To achieve the above-mentioned goal, a MASS should comply with all relevant SOLAS structural, stability, subdivision and watertight integrity requirements, as well as the International Convention on Load Lines, 1966 as amended by the 1988 Protocol, and the 2008 Intact Stability Code, as supplemented by the functional requirements of this chapter.

19.2.2 A stability control system (SCS) should be in place, capable of continuously assessing the intact stability of the MASS during its operation as well as supporting the assessment of the survivability of the MASS in case of damage.

- EP 1 To enable timely mitigation, the SCS should, including during fallback states, be able to:
 - .1 continuously assess the intact stability of the MASS; and
 - .2 identify when the stability of the MASS is outside the Operational Envelope (OE).
- EP 2 The SCS should be able to continuously monitor the loading conditions towards the longitudinal strength.
- EP 3 The SCS should be able to support the assessment of survivability of the MASS in case of damage by providing information on any internal flooding, compartments and spaces affected, draughts and attitude.
- EP 4 The SCS should have resilience to single points of failure.
- EP 5 The SCS should be able to detect existing or predictable stability failures and raise alerts.
- EP 6 The SCS should be able to suggest mitigation actions when the system has detected non-compliance with intact stability criteria.
- EP 7 The SCS should be able to transmit data to relevant systems and onboard crew or remote operators in an appropriate format.
- EP 8 The SCS should be able to be continuously supervised by an independent/supervising function, or human operator, capable of detecting failures or degraded performance.

19.2.3 Accurate and reliable data should be acquired to ensure that the stability, subdivision, weathertight and watertight integrity of the MASS can be maintained under all foreseeable conditions.

19.2.4 Means should be provided for the SCS to reduce the risk of excessive motions of the MASS in adverse sea conditions.

- EP 1 The SCS should be able to continuously measure amplitudes and accelerations of MASS motions.
- EP 2 The SCS should be able to detect when the motions of the MASS exceed predefined thresholds based on its OE, and trigger relevant alerts.
- EP 3 The SCS should be able to suggest adjusting speed and course, in response to the wave direction to ensure compliance with predefined limits for the MASS's motions.
- EP 4 The SCS should be able to suggest appropriate mitigation actions if the approved voyage plan may cause the MASS to exceed its stability thresholds.

CHAPTER 20 – FIRE PROTECTION, FIRE DETECTION AND FIRE EXTINGUISHMENT

20.1 Goal

The goal of this chapter is to ensure that fire-safety systems and equipment are effective.

20.2 Functional requirements

20.2.1 To achieve the above-mentioned goal, a MASS should comply with all relevant SOLAS fire-safety objectives and requirements, as supplemented by the functional requirements of this chapter.

20.2.2 A MASS should remain under control or enter a fallback state during and following a fire event in any single compartment that is directly linked to the control of the MASS.

20.2.3 A fire which is limited to a single compartment that does not have a direct link to the control of the MASS, should not cause a loss of control or lead to a fallback state.

20.2.4 Means should be provided to detect, confirm and locate a fire incident.

- EP 1 The detection, confirmation and location of fire incidents should be routed to control station(s).
- EP 2 Means for timely detection of a fire should be provided in all spaces with a fire risk.
- EP 3 Onboard crew and remote operators should be made aware of the detection and location of a fire along with the status of, and any actions taken by, fire protection systems.
- EP 4 Means for detection and confirmation should be independent.
- EP 5 If alarm signals are not acknowledged, a secondary alarm should be automatically activated at control station(s) and throughout the MASS.

- EP 6 After detection and confirmation of the fire, means should be provided to locate the seat of fire, so that the most appropriate fire-extinguishing means may be activated.

20.2.5 Means should be provided to enable the appropriate use of fire-extinguishing systems, taking into account possible human presence.

- EP 1 Information and instructions in relation to fire safety should be provided to any personnel boarding the MASS.
- EP 2 Fire-extinguishing systems should be able to be safely isolated and verified prior to compartment access.
- EP 3 Fire-extinguishing systems should provide onboard indication and warning prior to, and during, activation.
- EP 4 The stability of the MASS should be monitored during any fire-fighting operation.

20.2.6 Means should be provided to monitor and assess fire growth and fire-fighting effectiveness during and after fire.

- EP 1 Means should be provided to assess any smoke development.
- EP 2 Means should be provided to assess the temperature development in spaces adjacent to the compartment affected by the fire.

20.2.7 Means should be provided to enable the remote and onboard control of all active fire protection measures, including containment measures.

- EP 1 All active fire protection measures should be individually controllable, allowing activation, deactivation, and status monitoring at control station(s).
- EP 2 Means should be available to detect fire protection systems-related faults and provide indication at control station(s).

20.2.8 Means should be provided to facilitate an intervention from external fire responders.

- EP 1 Procedures should be in place to transmit any relevant information and data to external fire responders during and following a fire incident.
- EP 2 Means of communication between the external fire responders and the MASS and Remote Operations Centre (ROC) should be ensured during and following a fire incident.

CHAPTER 21 – SEARCH AND RESCUE

21.1 Goal

The goal of this chapter is to ensure that the duties and tasks regarding search and rescue are fulfilled.

21.2 Functional requirements

21.2.1 To achieve the above-mentioned goal, the master should comply with all relevant requirements in SOLAS for providing assistance to persons in distress, and as provided in the functional requirements of this chapter and applicable international law.

21.2.2 A MASS and its associated Remote Operations Centre(s) (ROC(s)) should be provided with a ship-specific plan and procedures which enable the master to provide assistance to persons in distress when obligated to do so.

21.2.3 Rescue equipment provided on board should be able to be safely used independently of the presence of crew.¹⁰

21.2.4 Persons retrieved on board should be able to be safely accommodated until such time as they can be delivered to a place of safety.

EP 1 Persons retrieved on board should be provided with information and arrangements to communicate with a ROC.

EP 2 Persons retrieved on board should be provided with access to any arrangements provided for their safety.

CHAPTER 22 – CARRIAGE OF CARGOES

22.1 Goal

The goal of this chapter is to provide for the carriage of cargoes in a manner that ensures that the MASS, persons on board and the environment are safe.

22.2 Functional requirements

22.2.1 To achieve the above-mentioned goal, the MASS should comply with the requirements of SOLAS chapters VI and VII and relevant regulations relating to the carriage of cargoes, as supplemented by the functional requirements of this chapter.

22.2.2 Means should be provided to enable for the safe carriage of cargo involving autonomous or remotely-operated systems and functions.

EP 1 Consideration should be given to the need for any special arrangements regarding:

- .1 transfer of cargo information;
- .2 cargo handling, stowing and securing;
- .3 cargo monitoring; and
- .4 emergency response.

¹⁰ According to SOLAS regulation III/17-1, MSC.1/Circ.1447 on *Guidelines for the development of plans and procedures for the recovery of persons from the water*, MSC.1/Circ.1182/Rev.1 on *Guide to recovery techniques* and MSC.1/Circ.1185/Rev.1 on *Guide for cold water survival*.

CHAPTER 23 – ANCHORING, TOWING AND MOORING

23.1 Goal

The goal of this chapter is to ensure safe and secure anchoring, towing and mooring operations.

23.2 Functional requirements

23.2.1 To achieve the above-mentioned goal, the MASS should comply with the functional requirements of this chapter. It should be noted that these functions may be treated independently from each other.

23.2.2 Autonomous or remotely-operated anchoring, towing and mooring arrangements should allow the safe conduct of these operations.

23.2.3 Where anchoring, towing and mooring operations involve a Remote Operations Centre (ROC), the remote operators should have sufficient information, oversight and control to enable safe and effective operations with due consideration to interactions with any third parties, infrastructure and/or involved personnel.

23.2.4 The emergency towing arrangements in SOLAS regulation II-1/3-4 should apply to all MASS, and means should be provided to enable remote or autonomous activation where no alternative means of rapid deployment are available.

23.2.5 Anchoring arrangements should be able to be activated autonomously or remotely during fallback states and in emergency situations.

CHAPTER 24 – MACHINERY AND ELECTRICAL INSTALLATIONS

24.1 Goal

The goal of this chapter is to provide for safe and reliable machinery and electrical installations.

24.2 Functional requirements

24.2.1 To achieve the above-mentioned goal, the MASS should comply with the SOLAS requirements for machinery and electrical installations, as supplemented by the functional requirements of this chapter.

24.2.2 Machinery and electrical installations should ensure their availability, including backup functions.

24.2.3 Machinery and electrical installations should be sufficient for the autonomous and remotely-operated functions to be maintained during normal operation, fallback states and emergency situations.

24.2.4 Electrical power production and distribution should be capable of maintaining the MASS in normal operation and fallback states, and ensuring that essential systems remain operational in emergency situations for the period(s) specified by SOLAS.

24.2.5 Machinery and electrical installations should be able to support predefined fallback states, and be fault tolerant to connectivity being lost or below an acceptable threshold.

24.2.6 Monitoring should be provided to assess system robustness, reliability and effectiveness.

24.2.7 Measures should be provided to prevent machinery or electrical systems being autonomously or remotely-activated when operated or serviced by authorized persons on board, and to ensure the safe reactivation upon completion.

24.2.8 Measures should be provided to detect machinery or electrical system malfunctions or failures to maintain safe operation in normal and emergency situations.

24.2.9 Measures should be provided to ensure availability and resilience according to the mode of operation to respond to machinery or electrical system malfunctions and failures.

APPENDIX

FORMAT FOR CERTIFICATES AND RECORDS

The objective of this appendix is to offer guidance for the development of the MASS and ROC certificates and records as required in chapter 5 (Surveys and certificates) of this Code.

Depending on the Concept of Operations (ConOps) of the respective MASS and associated ROC(s), not all of the elements in the templates proposed in this appendix need to be addressed by the Administration.

Form of certificate for maritime autonomous surface ships

MARITIME AUTONOMOUS SURFACE SHIP SAFETY CERTIFICATE

This Certificate should be supplemented by a Record of MASS for the Maritime Autonomous Surface Ship Safety Certificate (Form MASS).¹

(official seal)

(State)

Issued under the provisions of the INTERNATIONAL CODE OF SAFETY FOR MARITIME AUTONOMOUS SURFACE SHIPS (MASS CODE), 2026, as adopted by RESOLUTION MSC.595(111)

under the authority of the Government of

(name of the State)

by

(person or organization authorized)

Particulars of MASS²

Name of MASS _____

Distinctive number or letters _____

Port of registry _____

Gross tonnage _____

IMO Number³ _____

Date of application of the MASS Code⁴ _____

Date of any major repairs, renewals or modifications of equipment, or systems related to autonomous or remotely-operated functions _____

THIS IS TO CERTIFY:

- 1 That the MASS has been surveyed in accordance with the provision of II/5.2 of the International Code of Safety for Maritime Autonomous Surface Ships.
- 2 That it has been shown that:
 - 2.1 the inspection, verification and testing of MASS functionality and connectivity with any associated ROCs were satisfactory;
 - 2.2 the autonomous and/or remotely-operated functions of the MASS have been demonstrated to be safe and their condition is in all respects satisfactory and that the MASS complied with the relevant provisions of the Code; and

¹ Please insert the version of the Record of MASS: Document no.[...], version no.[...], and issue date [dd/mm/yyyy].

² Alternatively, the particulars of the MASS may be placed horizontally in boxes.

³ In accordance with the *Integrated IMO Identification Number Scheme* (resolution A.1215(34)).

⁴ Administrations may request the history of the application of the MASS Code.

2.3 the MASS complied with goals, functional requirements and expected performances in following chapters of the Code where the Administration deems that compliance with other applied instruments is impracticable or insufficient:

check box, if applicable:

- III/16 Safety of Navigation
- III/17 Connectivity
- III/18 Remote Operations
- III/19 Structure, Subdivision, Stability and Watertight Integrity
- III/20 Fire Protection, Fire Detection and Fire Extinction
- III/21 Search and Rescue
- III/22 Carriage of Cargoes
- III/23 Anchoring, Towing and Mooring
- III/24 Machinery and Electrical Installations

This certificate is valid until _____ subject
to the annual/ intermediate surveys in accordance with II/5.2 of the Code.

Completion date of the survey on which this certificate is based
_____ (dd/mm/yyyy)

Issued at _____
(place of issue of the certificate)

_____ (date of issue) _____ (signature of authorized official issuing the certificate)

(seal or stamp of the issuing authority, as appropriate)

Endorsement for annual and intermediate surveys

THIS IS TO CERTIFY that, at a survey required by II/5.2 of the Code, the MASS was found to comply with the relevant requirements of the Code.

Annual survey
Signed _____
(signature of authorized official)
Place _____
Date _____

(seal or stamp of the authority, as appropriate)

Annual/Intermediate⁵ survey

Signed _____
(signature of authorized official)
Place _____
Date _____

(seal or stamp of the authority, as appropriate)

Annual/Intermediate⁵ survey

Signed _____
(signature of authorized official)
Place _____
Date _____

(seal or stamp of the authority, as appropriate)

Annual survey
Signed _____
(signature of authorized official)
Place _____
Date _____

(seal or stamp of the authority, as appropriate)

⁵ Delete as appropriate.

Endorsement to extend the certificate if valid for less than five years in alignment with the provisions of regulation I/14(c) of the SOLAS Convention

The MASS complies with the provisions of II/5.2 of the Code, and this certificate should, in alignment with the provisions of regulation I/14(c) of the SOLAS Convention, be accepted as valid until _____

Signed _____
(signature of authorized official)
Place _____
Date _____

(seal or stamp of the authority, as appropriate)

Endorsement for renewal surveys years in alignment with the provisions of regulation I/14(d) of the SOLAS Convention

THIS IS TO CERTIFY that, at a survey required by II/5.2.2.2 of the Code, the MASS was found to comply with the relevant provisions of the Code.

Renewal survey:

Signed _____
(signature of authorized official)
Place _____
Date _____

Endorsement to extend the validity of the certificate until the MASS reaches the port of survey or for a period of grace in alignment with the provisions of regulations I/14(e) or I/14(f) of the SOLAS Convention

The certificate should, in alignment with the provisions of regulation I/14(e)/I/14(f)⁶ of the SOLAS Convention, be accepted as valid until _____

Signed _____
(signature of authorized official)
Place _____
Date _____

(seal or stamp of the authority, as appropriate)

Endorsement for advancement of anniversary date in alignment with the provisions of regulation I/14(h) of the SOLAS Convention

In alignment with the provisions of regulation I/14(h) of the SOLAS Convention, the new anniversary date is _____

Signed _____
(signature of authorized official)
Place _____
Date _____

(seal or stamp of the authority, as appropriate)

In alignment with the provisions of regulation I/14(h) of the SOLAS Convention, the new anniversary date is _____

Signed _____
(signature of authorized official)
Place _____
Date _____

(seal or stamp of the authority, as appropriate)

⁶ Delete as appropriate.

Form of certificate for maritime autonomous surface ships Remote Operations Centre

MARITIME AUTONOMOUS SURFACE SHIPS
REMOTE OPERATIONS CENTRE CERTIFICATE

This Certificate should be supplemented by a Record of MASS Remote Operations Centre (ROC) for the MASS Remote Operations Centre Certificate (Form MASS-ROC).¹

(official seal)

(State)

Issued under the provisions of the INTERNATIONAL CODE OF SAFETY FOR MARITIME
AUTONOMOUS SURFACE SHIPS (MASS CODE), 2026, as adopted by
RESOLUTION MSC.595(111)

under the authority of the Government of

_____ *(name of the State)*

by _____

(person or organization authorized)

Particulars of ROC²

ROC identifier _____
ROC Company Name _____
ROC Company Address _____
ROC location (Physical address or other) _____

Provide the above information as applicable.

Particulars of the MASS operated by ROC³

Name of MASS _____
Distinctive number or letters _____
Port of registry _____
Gross tonnage _____
IMO Number⁴ _____

THIS IS TO CERTIFY:

¹ Please insert the version of the Record of MASS ROC: Document no.[...], version no. [...], and issue date [dd/mm/yyyy].

² Alternatively, the particulars of the ROC may be placed horizontally in boxes.

³ Alternatively, the particulars of the MASS may be placed horizontally in boxes.

⁴ In accordance with the *Integrated IMO Identification Number Scheme* (resolution A.1215(34)).

- 1 That the ROC has been surveyed in accordance with the provisions of II/5.4 of the International Code of Safety for Maritime Autonomous Surface Ships.
- 2 That it has been shown that:
 - 2.1 the inspection, verification and testing of the ROC and MASS remote operation functionality were satisfactory;
 - 2.2 the ROC is demonstrated to have the ability to support the autonomous and/or remotely-operated functions of the MASS in compliance with the relevant provisions of the Code.
 - 2.3 the ROC complied with the requirements of III/17 and III/18 of the Code;
 - 2.4 the ROC complied with goals, functional requirements and expected performances in following chapters of the Code where the Administration deems that compliance with other applied instruments is impracticable or insufficient:

check box, if applicable:

- III/16 Safety of Navigation
- III/19 Structure, Subdivision, Stability and Watertight Integrity
- III/20 Fire Protection, Fire Detection and Fire Extinction
- III/21 Search and Rescue
- III/22 Carriage of Cargoes
- III/23 Anchoring, Towing and Mooring
- III/24 Machinery and Electrical Installations

This certificate is valid until _____ subject to the annual/ intermediate surveys in accordance with II/5.4 of the Code.

Completion date of the survey on which this certificate is based _____
(dd/mm/yyyy)

Issued at _____
(place of issue of the certificate)

(date of issue)

(signature of authorized official issuing the certificate)

(seal or stamp of the issuing authority, as appropriate)

Endorsement for annual and intermediate surveys

THIS IS TO CERTIFY that, at a survey required by II/5.4 of the Code, the ROC was found to comply with the relevant requirements of the Code.

Annual survey
Signed _____
(signature of authorized official)
Place _____
Date _____

(seal or stamp of the authority, as appropriate)

Annual/Intermediate⁵ survey
Signed _____
(signature of authorized official)
Place _____
Date _____

(seal or stamp of the authority, as appropriate)

Annual/Intermediate⁵ survey
Signed _____
(signature of authorized official)
Place _____
Date _____

(seal or stamp of the authority, as appropriate)

Annual survey
Signed _____
(signature of authorized official)
Place _____
Date _____

(seal or stamp of the authority, as appropriate)

⁵ Delete as appropriate.

Endorsement to extend the certificate if valid for less than five years in alignment with the provisions of regulation I/14(c) of the SOLAS Convention

The ROC complies with the provisions of II/5.4 of the Code, and this certificate should, in alignment with the provisions of regulation I/14(c) of the SOLAS Convention, be accepted as valid until _____

Signed _____
(signature of authorized official)
Place _____
Date _____

(seal or stamp of the authority, as appropriate)

Endorsement for renewal surveys years in alignment with the provisions of regulation I/14(d) of the SOLAS Convention

THIS IS TO CERTIFY that, at a survey required by II/5.4.2.2 of the Code, the ROC was found to comply with the relevant provisions of the Code.

Signed _____
(signature of authorized official)
Place _____
Date _____

(seal or stamp of the authority, as appropriate)

Endorsement to extend the validity of the certificate until the MASS reaches the port of survey or for a period of grace in alignment with the provisions of regulations I/14(e) or I/14(f) of the SOLAS Convention

The certificate should, in alignment with the provisions of regulation I/14(e)/I/14(f)⁶ of the SOLAS Convention, be accepted as valid until _____

Signed _____
(signature of authorized official)
Place _____
Date _____

(seal or stamp of the authority, as appropriate)

Endorsement for advancement of anniversary date in alignment with the provisions of regulation I/14(h) of the SOLAS Convention

In alignment with the provisions of regulation I/14(h) of the SOLAS Convention, the new anniversary date is _____

Signed _____
(signature of authorized official)
Place _____
Date _____

(seal or stamp of the authority, as appropriate)

In alignment with the provisions of regulation I/14(h) of the SOLAS Convention, the new anniversary date is _____

Signed _____
(signature of authorized official)
Place _____
Date _____

(seal or stamp of the authority, as appropriate)

⁶ Delete as appropriate.

Form of provisional certificate for maritime autonomous surface ships

PROVISIONAL MARITIME AUTONOMOUS SURFACE SHIP SAFETY CERTIFICATE

This provisional Certificate should be supplemented by a Record of MASS for the Maritime Autonomous Surface Ships Safety Certificate (Form MASS).¹

(official seal)

(State)

Issued under the provisions of the INTERNATIONAL CODE OF SAFETY FOR MARITIME AUTONOMOUS SURFACE SHIPS (MASS CODE), 2026, as adopted by RESOLUTION MSC.595(111)

under the authority of the Government of

_____ *(name of the State)*

by _____

(person or organization authorized)

Particulars of MASS²

Name of MASS _____

Distinctive number or letters _____

Port of registry _____

Gross tonnage _____

IMO Number³ _____

Date of application of the MASS Code⁴ _____

Date of any major repairs, renewals or modifications of equipment, or systems related to autonomous or remotely-operated functions _____

¹ Please insert the version of the Record of MASS: Document no.[...], version no.[...], and issue date [dd/mm/yyyy].

² Alternatively, the particulars of the MASS may be placed horizontally in boxes.

³ In accordance with the *Integrated IMO Identification Number Scheme* (resolution A.1215(34)).

⁴ Administrations may request the history of the application of the MASS Code.

THIS IS TO CERTIFY:

- 1 That the MASS complied with the provision of II/5.5 of the International Code of Safety for Maritime Autonomous Surface Ships which enables initiation of operations during testing and verification stage.
- 2 That individual MASS systems have been tested and verified and results of ship simulation (if applicable) have been reviewed and accepted.
- 3 That all the design documents have been updated accordingly and approved according to the simulation and system testing results.
- 4 That the MASS period of testing is limited to (dd/mm/yyyy)_____
- 5 That the MASS area of testing is limited to_____
- 6 That an approved verification and validation plan is in place covering the management of safety and scope of testing to be completed.

This provisional certificate is valid until _____, subject to the annual/intermediate surveys listed in II/5.2 of the Code, and any additional surveys covered by the verification and validation plan.

Completion date of the survey on which this certificate is based
_____ (dd/mm/yyyy)

Issued at _____
(place of issue of the certificate)

(date of issue)

(signature of authorized official issuing the certificate)

(seal or stamp of the issuing authority, as appropriate)

Endorsement for annual and intermediate surveys

THIS IS TO CERTIFY that, at a survey required by II/5.2 of the Code, the MASS was found to comply with the relevant requirements of the Code.

Annual survey
Signed _____
(signature of authorized official)
Place _____
Date _____

(seal or stamp of the authority, as appropriate)

Annual/Intermediate⁵ survey

Signed _____
(signature of authorized official)
Place _____
Date _____

(seal or stamp of the authority, as appropriate)

Annual/Intermediate⁵ survey

Signed _____
(signature of authorized official)
Place _____
Date _____

(seal or stamp of the authority, as appropriate)

Annual survey
Signed _____
(signature of authorized official)
Place _____
Date _____

(seal or stamp of the authority, as appropriate)

⁵ Delete as appropriate.

**Form of provisional certificate for maritime autonomous surface ships Remote
Operations Centre**

PROVISIONAL MARITIME AUTONOMOUS SURFACE SHIPS
REMOTE OPERATIONS CENTRE CERTIFICATE

This provisional Certificate should be supplemented by a Record of MASS Remote
Operations Centre (ROC) for the MASS Remote Operations Centre Certificate
(Form MASS-ROC).¹

(official seal)

(State)

Issued under the provisions of the INTERNATIONAL CODE OF SAFETY FOR MARITIME
AUTONOMOUS SURFACE SHIPS (MASS CODE), 2026, as adopted by
RESOLUTION MSC.595(111)

under the authority of the Government of

_____ *(name of the State)*

by _____

(person or organization authorized)

Particulars of ROC²

ROC Identifier _____

ROC Company Name _____

ROC Company Address _____

ROC Location (Physical address or other) _____

Particulars of the MASS operated by ROC³

Name of MASS _____

Distinctive number or letters _____

Port of registry _____

Gross tonnage _____

IMO Number⁴ _____

¹ Please insert the version of the Record of MASS ROC: Document no.[...], version no.[...], and issue date [dd/mm/yyyy].

² Alternatively, the particulars of the ROC may be placed horizontally in boxes.

³ Alternatively, the particulars of the MASS may be placed horizontally in boxes.

⁴ In accordance with the *Integrated IMO Identification Number Scheme* (resolution A.1215(34)).

THIS IS TO CERTIFY:

- 1 That the ROC complied with the provision of II/5.5 of the International Code of Safety for Maritime Autonomous Surface Ships, which enables initiation of operations during testing and verification stage.
- 2 That individual systems related to MASS remote operation functionality have been tested and verified and results of simulation (if applicable) have been reviewed and accepted.
- 3 That all the design documents have been updated accordingly and approved according to the simulation and system testing results.
- 4 That the MASS period of testing is limited to (dd/mm/yyyy)_____
- 5 That the MASS area of testing is limited to_____
- 6 That an approved verification and validation plan is in place covering the management of safety and scope of testing to be completed.

This provisional certificate is valid until _____, subject to the annual/intermediate surveys listed in II/5.4 of the Code, and any additional surveys covered by the verification and validation plan.

Completion date of the survey on which this certificate is based
_____ (dd/mm/yyyy)

Issued at _____
(place of issue of the certificate)

(date of issue)

(signature of authorized official issuing the certificate)

(seal or stamp of the issuing authority, as appropriate)

Endorsement for annual and intermediate surveys

THIS IS TO CERTIFY that, at a survey required by II/5.4 of the Code, the ROC was found to comply with the relevant requirements of the Code.

Annual survey
Signed _____
(signature of authorized official)
Place _____
Date _____

(seal or stamp of the authority, as appropriate)

Annual/Intermediate⁵ survey

Signed _____
(signature of authorized official)
Place _____
Date _____

(seal or stamp of the authority, as appropriate)

Annual/Intermediate⁵ survey

Signed _____
(signature of authorized official)
Place _____
Date _____

(seal or stamp of the authority, as appropriate)

Annual survey
Signed _____
(signature of authorized official)
Place _____
Date _____

(seal or stamp of the authority, as appropriate)

⁵ Delete as appropriate.

**Record of MASS for the Maritime Autonomous Surface Ship Safety Certificate
(Form MASS)**

This Record should be permanently attached to the Maritime Autonomous
Surface Ship Safety Certificate

RECORD OF MASS FOR COMPLIANCE WITH THE INTERNATIONAL CODE OF SAFETY
FOR MARITIME AUTONOMOUS SURFACE SHIPS

1 DESCRIPTION OF THE CONCEPT OF OPERATIONS (CONOPS)

1.1 Particulars of MASS

Name of MASS	
Name of Company	
Distinctive number or letters	
Port of registry	
Gross tonnage	
IMO Number*	

1.2 Overview of MASS and MASS functions

General description of the scope of operations the MASS is authorized to perform	
Brief description of autonomous functions	
Brief description of remote operation functions	
Other descriptions of MASS functions	

1.3 Key systems

Description and list of key systems related to autonomous and/or remotely-operated functions.
(Consistent function/system identifiers should be used throughout this Record)

ID	Function	System	Description
Systems essential to the safe and secure operation of ship as required in Part II of the MASS Code: (for example, alert management, maintenance, etc)			
1			
2			

* In accordance with the *Integrated IMO Identification Number Scheme* (resolution A.1215(34)).

Systems required as described in Part III of the MASS Code : (for example, navigation, stability, cargo handling, etc)			
1			
2			

1.4 Operational Envelope

1.4.1 Modes of operation

Overview of configuration(s), as applicable, for the allocation of MASS functions and their supervision, taking into account different modes of operation during different voyage phases. Note that the Minimum Safe Manning Document (MSMD) should address each mode of operation. (Consistent mode of operation identifiers should be used throughout this Record).

Voyage Phase A:			
MASS Function	Mode of Operation	Function Allocation & Location	Supervision & Location
Function 1	1:		
	2:		
	3:		
Function 2	1:		
	2:		
	3:		
Function 3	1:		
	2:		
	3:		
Voyage Phase B:			
MASS Function	Mode of Operation	Function Allocation & Location	Supervision & Location
Function 1	1:		
	2:		
	3:		
Function 2	1:		
	2:		
	3:		
Function 3	1:		
	2:		
	3:		

1.4.2 Limitations of autonomous and/or remote operation

Limitations under which the MASS can operate safely in all operating conditions, including all reasonably foreseeable degraded states.

Category	Description of limitation(s) <i>(Variances applicable in different modes of operation and/or normal/degraded states should be clearly stated)</i>
Environmental limitations	
Geographical limitations	
Operational limitations	
Other limitations, if applicable	

1.5 Fallback State(s) and Contingency Plans

Fallback states and contingency plans for the MASS (as a whole, not individual functions or systems). *(Variances applicable in different modes of operation/voyage phase should be clearly stated. Where multiple fallback states are available, the application of any hierarchy to activation sequencing should also be clearly stated).*

Fallback state(s)		
ID	Conditions of entry	Predefined fallback response
1		
2		

Contingency Plans		
ID	Conditions of activation	Predefined actions
1		
2		

2 SURVEY REQUIREMENTS ASSOCIATED WITH THE SYSTEMS TO WHICH THE MASS CODE IS APPLIED

	Systems (as in 1.3)	Survey Requirements
1		
2		

3 TASK ALLOCATION SUMMARY

The document describing the distribution of functions and tasks between human and machine/systems in normal, abnormal and emergency situations, as approved by the Administration, should accompany this Record.

4 REGULATORY GAP ANALYSIS

Authorized MASS-related deviations from applicable rules and regulations.

	Affected rule or regulation	Description of deviation/alternative solutions
1		
2		

5 LIST OF ROC(S) APPROVED FOR WORKING WITH THE MASS

Number of approved Remote Operations Centres: _____

ID	ROC identifier	ROC location (Physical address or other)	ROC Company Name	Description (including, for example, scope of remote operation, redundancy arrangements, communication configurations, transfer of control conditions)
1				
2				

Provide the above information as applicable.

THIS IS TO CERTIFY that this Record is correct in all respects.

Issued at _____
(place of issue of the Record)

(date of issue) _____
(signature of authorized official issuing the Record)

(seal or stamp of the issuing authority, as appropriate)

**Record of MASS ROC for MASS Remote Operations Centre Certificate
(Form MASS-ROC)**

This Record should be permanently attached to MASS Remote Operations Centre Certificate

RECORD OF MASS ROC FOR COMPLIANCE WITH THE INTERNATIONAL CODE OF
SAFETY FOR MARITIME AUTONOMOUS SURFACE SHIPS

1 PARTICULARS OF ROC

ROC Identifier	
ROC Company Name	
ROC Location (Physical address or other)	
Description	

2 DESCRIPTION OF MASS CONCEPT OF OPERATIONS (CONOPS)

A copy of the MASS Safety Certificate and MASS Record should accompany this document. A description of the Concept of Operations (ConOps) for the MASS can be found in its MASS Record.

3 ROC OPERATIONAL LIMITATIONS

Category	Description of limitation(s) <i>(for example, geographical, human element, operational, number of control stations, etc.) (Variances applicable in different modes of operation and/or normal/degraded states should be clearly stated)</i>

4 INFRASTRUCTURE FOR CONNECTIVITY

Description and list of infrastructure for connectivity <i>(for example, communications devices authorized for use to communicate with MASS)</i>	
1	
2	
Description of quality of service and performance <i>(for example, bandwidth, network latency, data integrity, reliability, etc.)</i>	

5 OTHER SYSTEMS

Other systems at the ROC supporting remote operation (<i>for example, uninterruptable power supply</i>)

THIS IS TO CERTIFY that this Record is correct in all respects.

Issued at _____
(place of issue of the Record)

(date of issue)

(signature of authorized official issuing the Record)

(seal or stamp of the issuing authority, as appropriate)

Annex 1

APPROVAL PROCESS

Table 1 provides additional guidance in relation to the approval steps that require relevant documentation.

1 Preliminary design development

The following MASS specific documentation should be compiled and submitted:

- .1 Concept of Operations (ConOps); as described in II/8.2 of the Code.
- .2 Preliminary design documents; the initial set of preliminary documents should be submitted as deemed necessary to illustrate the main characteristics of the MASS and system arrangements, especially related to autonomous and remotely controlled functions.
- .3 High-level risk assessment report; the objective of the high-level risk assessment is to identify safety critical areas and functions at an early stage and to assist as far as practicable to the drafting of the initial approval basis.
- .4 Approval basis; should be submitted for approval by the Administration at the end of the preliminary design development. It should be highlighted that within the context of an iterative approval process, it is expected that this document will be modified significantly throughout the process.
- .5 Preliminary actions register; the necessary actions for the completion of the process should be drafted, while the early involvement of key stakeholders should be ensured for a clear understanding of roles and responsibilities in the approval process.

2 Preliminary design approval

- .1 *Risk assessment report*; a risk assessment, as described in chapter 7 (Risk assessment) of the Code should be performed for all the functions affected by autonomous or remote operations. The level of detail of the risk assessment should be proportional to the complexity of the project.
- .2 *Preliminary design documents*; as the approval process is an iterative one, the purpose of the preliminary design documents is to further describe and illustrate the key elements of the project that prove the equivalence justification. At the end of this step and possibly after more than one iteration, the design parameters of the systems and system interaction in question should be clear enough to be able to determine appropriate performance criteria that could be verified through testing and other verification methods.

At the end of the step, there should be an alignment between the submitted documents and the risk assessment in terms of assumptions and philosophy, especially regarding mitigation measures. The preliminary design documents could be the following:

- .1 Safety philosophy;
 - .2 Design philosophy;
 - .3 Operation and maintenance philosophy;
 - .4 Emergency response philosophy;
 - .5 General arrangement;
 - .6 Systems and equipment matrix; and
 - .7 ConOps including Operational Envelope (OE) (updated).
- .3 *Drawings and information documents* (optional): while the iteration process of the project advances, it might be necessary for the approval process to also submit relevant drawings and information documents to clarify certain aspects of the design, especially on issues that are found to be safety critical (i.e. implying very high risk according to the risk analysis). It is expected that such issues that need to be demonstrated at a more detailed level are issues where redundancy, fault tolerance or fail-safe mechanisms need to be further explained.
- .4 *Task allocation summary*: a task and function allocation summary should be submitted describing the distribution of functions and tasks between human and machine/systems in both normal, abnormal and emergency situations. The task allocation summary should be aligned with the other design documents. There should be particular focus on the expected control actions performed, while especially in the case of human operators it should be made possible to evaluate their expected workload but also their cognitive support.
- .5 *Approval basis*: it is expected to be updated with each iteration especially when design details and assumptions are decided and documented. At the end of this step the approval basis should be a significantly more detailed document than the one presented in paragraph 1.2 of the present annex.
- .6 *Regulatory gap analysis*: a regulatory gap analysis should be submitted to document any deviations from the applicable regulatory framework. At the end of the preliminary approval step, it is not expected that this document will cover all the applicable prescriptive provisions, however it would be beneficial for the detailed design approval to already introduce as much detail as possible. This should be demonstrated through a link between the risk analysis and justification on why design or operational solutions are justified as being equivalent.
- .7 *Verification and validation (V&V) plan*: the final step to the preliminary design approval is the detailed definition of how it is intended to perform V&V of the systems and the MASS as a whole. The objective of the V&V plan should be to describe how functionalities regarding autonomous and remote operations will be verified. A V&V plan should be submitted for approval considering the following:
- .1 high risk functions and system components as they stem from the risk assessment;

- .2 boundary conditions and system safety requirements and constraints;
- .3 cybersecurity related features upon which the protection of the safety critical components is based;
- .4 incorrect and unexpected inputs and input sequences and timing;
- .5 reaction of the system-to-system faults and failures;
- .6 fail-safe modes and fallback states;
- .7 operational procedures for V&V; and
- .8 ensure that no additional hazards are introduced during V&V.

The V&V plan should also include a detailed time frame including intermediate deliverables and reports as deemed necessary. A periodic progress review by the Administration and any organization performing third-party verification should be considered. If the complexity of the project does not allow for a complete time frame to be set at this stage, an initial time frame may be accepted for a specific period to be agreed upon.

- .8 *Actions register*: the actions register, as described in paragraph 1.5 of the present annex, should be updated accordingly.

3 Testing, simulation and other verification methods

3.1 Testing and verification should be conducted according to the defined V&V plan and the relevant reports submitted for information. According to the testing results, the design documents, as well as the approval basis, the actions register and the V&V plan may need to be updated accordingly. In the case that the V&V plan is reflecting an outdated time frame, it should be updated accordingly.

3.2 A high degree of transparency with the Administration and any organization conducting third-party verification is strongly recommended to facilitate this approval step.

3.3 Different testing and verification methods might be used upon request and should be approved by the Administration. Model tests or simulations are recommended to verify the control system before a full-scale test of the MASS is performed.

3.4 For tests to be conducted, the relevant procedure(s) should be submitted to the Administration in due time before testing. The test report should be submitted after testing, where a summary or test log should include how the test and its results are linked to the design documents and the V&V plan.

3.5 The testing of certain systems or parts of systems may include an element of simulation-based testing. Such testing should not replace full-scale testing.

4 Final approval

4.1 This approval step should follow the approach from the *Guidelines for the approval of alternatives and equivalents as provided for in various IMO instruments* (MSC.1/Circ.1455). It is particularly important to correlate the different components and systems that constitute the MASS under consideration. In addition, this step should be used as a verification that the different steps leading to the final approval are consistent and can be easily verified.

4.2 Before the initial survey of the MASS, testing needs to have been completed to demonstrate the requirements in the approval basis have been met. This evidence would typically include the final design documents and the reports of activities undertaken including a link to the related item of the V&V plan.

4.3 A summary of the equivalence justifications should be submitted. This summary should articulate the approach taken to demonstrating compliance with the approval basis and include the Submitter statement that compliance with the approval basis has been demonstrated.

4.4 The Submitter should propose any survey or inspection requirements associated with the system(s) in question. The operational requirements (e.g. training, maintenance) to address the innovative technology aspects should also be included in the in-service documentation. Focus should be put on any operational restrictions.

Table 1 – Relevant documentation for approval steps

	Preliminary design development	Preliminary design approval	Testing, simulation and other verification methods	Final approval	Operation
Preliminary design documents	X*	X			
Drawings and information documents		X		X	X**
Risk Assessment	X*	X		X	X**
Task allocation summary		X		X	X**
Approval basis and Actions register	X*	X	X	X	X**
Regulatory gap analysis		X			
Verification and validation plan		X			
Testing and verification reports			X		

* Preliminary and high-level only.

** In case of changes in the approved concept, assumptions and conditions.

Annex 2

FRAMEWORK FOR CONCEPT OF OPERATIONS

The objective of this framework is to offer clear guidance during the development of the Concept of Operations (ConOps) as required in chapter 8 (Operational context) of the MASS Code.

1 INTRODUCTION

ConOps is a high-level document that, in conjunction with other design documents, serves as a key source of information for the design, approval, and operation of a MASS. In this section, it should be clearly indicated which step in the approval process this document pertains to. The appropriate degree of detail within ConOps will depend on the development process and should be to the satisfaction of the Administration. Additionally, it should offer a high-level overview of the modifications made to the previous version, along with the reasons for these changes.

2 OVERVIEW OF MASS FUNCTIONS

This section provides an overall picture of the objective of the target MASS, including a general description of the scope and intent of autonomous and/or remotely-operated functions, its use cases and corresponding operation and voyage phases, etc.

3 TECHNICAL CHARACTERISTICS OF MASS

This section provides a general description of particulars and systems related to autonomous and/or remotely-operated functions.

3.1 Particulars of the MASS

This section provides general information on the MASS, including main dimensions, design/service speed, manoeuvrability, cargo type and deadweight, ballast/full load draft, ballast/full load displacement, steering capability, propulsion capacity, fuel/water storage (if applicable), energy storage, self-sustaining capacity, etc. These factors should be considered when designing/aligning autonomous and/or remotely-operated systems/functions.

3.2 Key systems

This section describes systems related to functions which are essential to the safe and secure operation of MASS as described in part II of the MASS Code, including security, alert management, maintenance, etc.

3.3 Systems related to autonomous and/or remotely-operated functions

This section describes systems related to autonomous and/or remotely-operated functions as described in part III of the MASS Code, including navigation, connectivity, remote operations, structure, subdivision, stability and watertight integrity, fire protection, fire detection and fire extinction, search and rescue, carriage of cargoes, anchoring, towing and mooring, and machinery and electrical installations. The inclusion of these systems depends on the specific modes of operation and the functionality being certified.

4 OPERATIONAL ENVELOPE

This section describes MASS functions, conditions, limitations, modes of operation, as well as any other factors that significantly affect MASS operations.

4.1 Modes of operation

This section describes how autonomous and/or remotely-operated functions are used and managed during different phases of voyage, including function overview and corresponding voyage phases, function allocation (human or software), function supervision (human and/or software), function and supervision location (on board or remote), conditions and procedures for mode switch, and other systems and other roles (personnel) involved in performing the control actions.

4.2 Limitations of autonomous and/or remote operation

This section describes environmental, geographical, and operational limitations under which the MASS can operate safely in all operating conditions, including all reasonably foreseeable degraded states. The environmental limitations may include weather conditions (acceptable wind speed, sea state, visibility, water depth, adverse weather, day/night, etc.) and current conditions (acceptable current speed, direction, etc.). The geographical limitations may include coverage/connectivity (areas requiring connectivity, effective coverage of communication systems, redundancy and automatic switching, latency and bandwidth requirements, security, communication with other ships, Vessel Traffic Service, Marine Rescue Service, etc.) and traffic conditions (acceptable traffic density: e.g. no more than "X" ships within six nautical miles in certain scenarios). The operational limitations may indicate ship-specific limitations such as speed and range, and mode of operation.

5 FALLBACK STATE AND CONTINGENCY PLANS

This section defines the conditions under which the MASS should enter a predefined fallback state across different voyage phases, as well as the conditions leading to the activation of contingency plans when the MASS deviates from the Operational Envelope (OE) beyond a predefined fallback state. Predefined fallback states and contingency plans should also be included.

6 REMOTE OPERATIONS CENTRE (IF APPLICABLE)

6.1 Technical characteristics of a Remote Operations Centre

This section describes essential systems installed in a Remote Operations Centre (ROC) that support remote operations.

6.2 Number and location of Remote Operations Centres, provision of redundancy

This section describes the number and locations of ROCs and outlines redundancy provisions required to ensure continuous and reliable remote operations.

6.3 Means of communication and conditions for transferring control between different Remote Operations Centres

This section establishes the conditions and procedures for transferring control between different ROCs to ensure safe and seamless operations.

7 HUMAN INVOLVEMENT

This section describes how humans are involved in MASS functions, including on board and at the ROC. This includes the expected role of the person, the broader context in which they will work and how they will interact with third parties.

7.1 Minimum safe manning levels

This section identifies the minimum safe manning levels for MASS operations, taking into account the principles as outlined in chapter 14 (Manning, training and watchkeeping) and II/5.9 (Minimum safe manning documents).

7.2 Task allocation

This section describes which tasks are automated, and which tasks and responsibilities are allocated to onboard crew or remote operators.

8 RULES AND REGULATIONS

8.1 Applicable rules and regulations

This section identifies the applicable rules and regulations, including special and local rules, such as international, national or industry-specific rules, and technical, safety and operational requirements and constraints in specific areas or regions, that the MASS should comply with, taking into account its operational area.

8.2 Regulatory gap

This section identifies possible deviations from the applicable rules and regulations and provides justification of alternative solutions based on risk assessment.

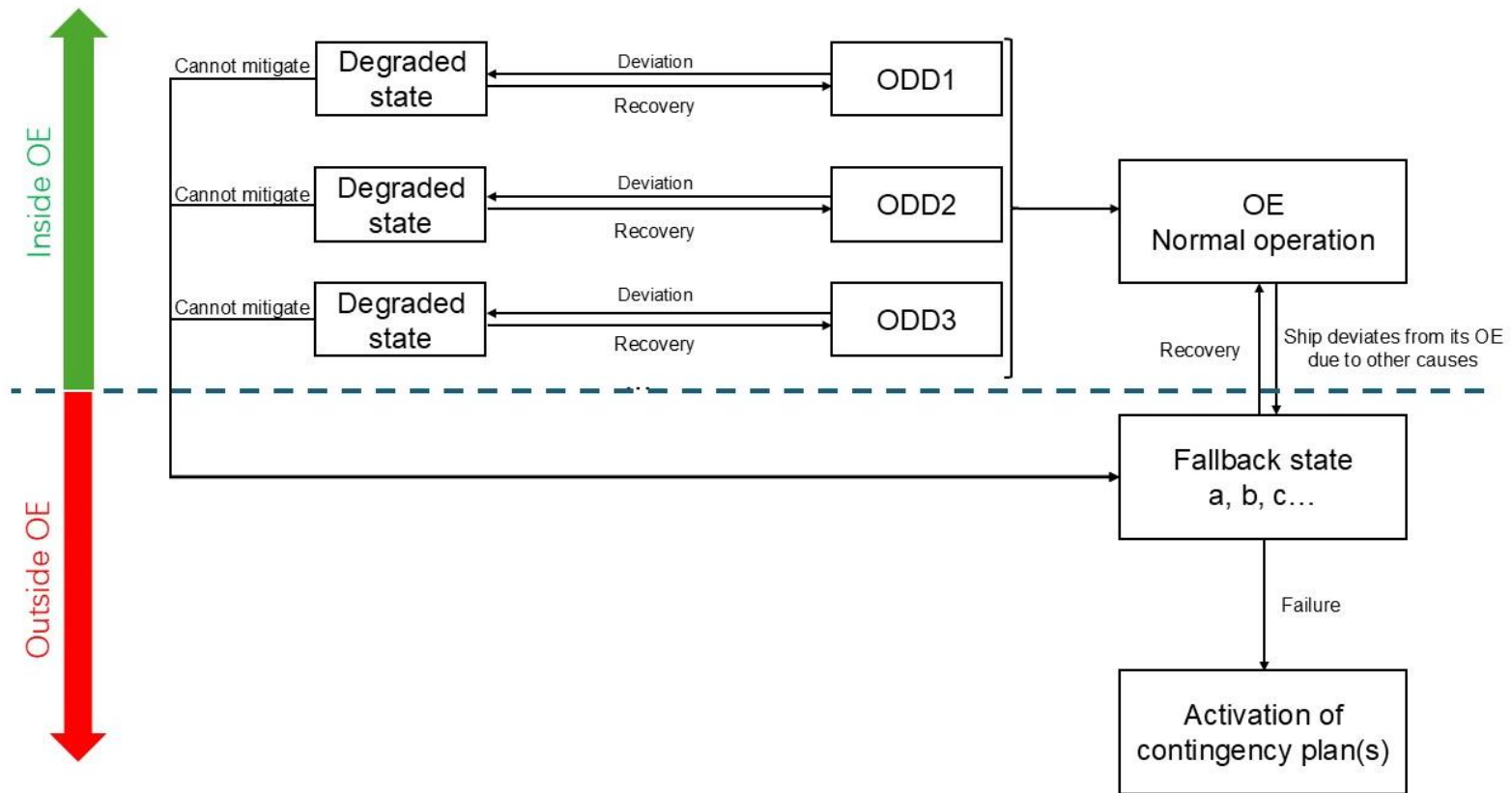


Figure 1: Illustration of the relationship between Operational Envelope, Operational Design Domain, Fallback State and Contingency Plans to support the application of chapter 8 (Operational context)
