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108th session
Agenda item 4

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

## Report of the Intersessional MASS Working Group


**SUMMARY**

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|---|---|
| *Executive summary:* | This document provides the report of the second session of the Intersessional MASS Working Group. |
| *Strategic direction, if applicable:* | 2 |
| *Output:* | 2.23 |
| *Action to be taken:* | Paragraph 64 |
| *Related documents:* | MSC 107/20 and MSC 107/WP.9 |


**Introduction**

1 The second meeting of the Intersessional Working Group on Maritime Autonomous Surface Ships (the Group), chaired by Mr. Henrik Tunfors (Sweden), was held at IMO Headquarters in London from 30 October to 3 November 2023.

2 The Group was attended by delegations from the following Member States:

ARGENTINA
BAHAMAS
BELGIUM
BRAZIL
CANADA
CHINA
DENMARK
ECUADOR
EGYPT
FINLAND
FRANCE
GERMANY
GREECE
INDIA
INDONESIA
IRELAND
ITALY
JAPAN
LIBERIA
MALTA
MARSHALL ISLANDS
MEXICO
MOROCCO
NEW ZEALAND
NETHERLANDS (KINGDOM OF THE)
NIGERIA
NORWAY
PANAMA
POLAND
QATAR
REPUBLIC OF KOREA
RUSSIAN FEDERATION

SAUDI ARABIA
SINGAPORE
SPAIN
SWEDEN
THAILAND
TÜRKİYE
UNITED ARAB EMIRATES
UNITED KINGDOM
UNITED STATES

a representative from the following Associate Member of IMO:

HONG KONG, CHINA

observers from the following intergovernmental organizations:

INTERNATIONAL HYDROGRAPHIC ORGANIZATION (IHO)
EUROPEAN COMMISSION (EC)
EUROPEAN SPACE AGENCY (ESA)
INTERNATIONAL MOBILE SATELLITE ORGANIZATION (IMSO)

and observers from the following non-governmental organizations:

INTERNATIONAL CHAMBER OF SHIPPING (ICS)
COMITE INTERNATIONAL RADIO-MARITIME (CIRM)
BIMCO
INTERNATIONAL ASSOCIATION OF CLASSIFICATION SOCIETIES (IACS)
OIL COMPANIES INTERNATIONAL MARINE FORUM (OCIMF)
INTERNATIONAL MARITIME PILOTS' ASSOCIATION (IMPA)
INTERNATIONAL FEDERATION OF SHIPMASTERS' ASSOCIATIONS (IFSMA)
INTERNATIONAL ASSOCIATION OF INDEPENDENT TANKER OWNERS (INTERTANKO)
EUROPEAN ASSOCIATION OF INTERNAL COMBUSTION ENGINE AND ALTERNATIVE POWERTRAIN MANUFACTURERS (EUROMOT)
THE INSTITUTE OF MARINE ENGINEERING, SCIENCE AND TECHNOLOGY (IMarEST)
INTERNATIONAL MARINE CONTRACTORS ASSOCIATION (IMCA)
INTERNATIONAL TRANSPORT WORKERS' FEDERATION (ITF)
WORLD SHIPPING COUNCIL (WSC)
THE NAUTICAL INSTITUTE (NI)
ACTIVE SHIPBUILDING EXPERTS FEDERATION (ASEF)

**Terms of reference**

3 The Group was instructed, taking into account the progress made by the intersessional Correspondence Group and comments and decisions made at MSC 107, to:

.1 continue the development of the non-mandatory goal-based MASS instrument (MASS Code), taking into account the latest draft of the Code prepared by the Correspondence Group, based on annex 1 to document MSC 107/WP.9;

.2 further consider the common potential gaps and/or themes identified during the Regulatory Scoping Exercise (MSC.1/Circ.1638, section 5), focusing on the high-priority items (MSC.1/Circ.1638, paragraphs 6.11.1 to 6.11.3);

.3 if necessary, develop positions on any common issues for submission to a Joint MSC/LEG/FAL Working Group in the future;

.4 limit the development of the non-mandatory MASS Code to cargo ships with a view to considering the feasibility for application to passenger ships at a future stage;

.5 time permitted, consider document MSC 107/5/5 and provide recommendations to the Committee on the way forward; and

.6 submit a written report to MSC 108.

**MASS Code overarching issues**

4 The Group considered first overarching or matters of principles to provide some clarity on how to proceed with the drafting of the MASS Code, as set out in the ensuing paragraphs.

***Application of the MASS Code***

5 The Group had a lengthy discussion on the application criteria for the Code, i.e. when a ship should apply the MASS Code, bearing in mind that highly automated ships were already in operation or had shipboard systems that operated at a high degree of automation or had systems on board capable of being remotely operated.

6 In this respect, the Group considered whether the MASS Code should be applied under the relevant IMO instrument, not limiting it to SOLAS. Whenever such instrument prevented MASS operation, the MASS Code should be applied. However, after some discussion, the Group agreed that the Code should be applied to SOLAS cargo ships, pending decision of the Committee with respect to including cargo high-speed craft.

7 The Group further considered whether the application provisions should include the Remote Operations Centre (ROC). Some delegations were of the view that a ROC would intrinsically be linked with a MASS and thus any explicit reference to a ROC in the application provision would be superfluous.

8 There were split views in the Group as to whether to include text in the application provision which made the application of the Code subject to an Administration's assessment of whether compliance with existing instruments was not practicable (in which case the Code would apply). While some delegations supported such proposal so that an Administration would consider each ship on a case-by-case basis in order to determine the applicability of the MASS Code, other were of the view that such approach would defeat the purpose of the Code to provide a harmonized instrument for MASS, leading to different interpretations by Administrations and thus incentivizing ship owners to seek flag States with the greatest flexibility in approving MASS.

9 Subsequently, the Group agreed to a revised application provision of the MASS Code, as set out in the annex, paragraph 5 in part 1. As currently drafted, the Code would apply to cargo ships to which SOLAS chapter I applied, including any associated ROC(s). However, square brackets remained around the text which would leave it to the Administration's assessment of whether or not compliance with other/existing instruments is not practicable.

10 While there was broad agreement to the application provision, except for the text in square brackets, the Group acknowledged that the terms "autonomous or remote operations" required definitions that would:

.1 detail the type of functions which are remotely operated or autonomous and that would trigger the MASS Code application (including, for example, ships where the bridge may be left periodically unmanned);

.2 clarify which remote or automated functions do not qualify for the application of the Code; and

.3 clarify that a ship certified under the MASS Code should not be compelled to apply all provisions of the MASS Code if the design was such that only some of the functions are autonomous or remotely operated.

11 The Group recalled that MSC 107 agreed that there was no need to amend COLREGs as it could be applied in full to any MASS. One delegation pointed out that this principle should clearly be stated somewhere in the Code, in addition to the report of MSC 107.

12 The Group agreed to defer any detailed discussion on terminology and definitions until later, but a list of terms needing clarification or definition would be retained.

***References to SOLAS***

13 In considering the draft text developed so far for the MASS Code, the Group noted some inconsistencies in referring to SOLAS and requirements therein. Recalling its agreement at MSC 107 to use the Guidance for reviewing part 3 chapters of the MASS Code, which it had developed taking into account the GBS expert's advice (MSC 107/WP.9, annex 3), the Group agreed that a review by a GBS expert should ensure consistency in the drafting of provisions with references to SOLAS.

***Expected performance***

14 Recalling its earlier agreement, the Group reconfirmed that the draft MASS Code be developed based on the *Generic guidelines for developing goal-based standards* (MSC.1/Circ.1394/Rev.2) which would comprise goals and functional requirements.

15 Notwithstanding the above, the Group agreed that the level of detail for the goals and functional requirements may differ for each chapter of the Code and that expected performances should be developed where necessary to ensure that the functional requirements are sufficiently defined.

***Editorial review by a GBS expert***

16 The Group, subsequently, agreed to request the GBS expert* to review the MASS Code with the following directions:

The GBS expert, taking into account the discussion of the MSC/ISWG/MASS Intersessional Working Group 2, should, with respect to part 3 of the draft MASS Code:

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.1 identify inconsistencies in drafting goal-based provisions of the draft MASS Code, as well as consistent referencing to SOLAS and other instruments;

.2 single out tier IV provisions which should be taken out but be preserved separately;

.3 propose editorials to the goals, functional requirements and expected performances to align it with the *Generic guidelines for developing goal-based standards* (MSC.1/Circ.1394/Rev.2); and

.4 provide the above input to the intersessional Correspondence Group.

***Network governance***

17 As part of the overarching issues to be addressed, the Group discussed the need to address network governance presented in document MSC/ISWG/MASS 2/4 (Liberia, Republic of Korea and United Arab Emirates) in order to ensure that MASS will be able to operate safely since no governance was provided so far for MASS while provided for GMDSS and LRIT.

18 In connection with the above, it was proposed to request ITU to secure frequencies and protect them for the use of MASS. In this respect one delegation explained that the common practice for application for channel allocations is for a network provider, through an Administration, to request ITU for allocation and protection of radio frequencies; however, a better approach may be to request ITU to consider developing an appendix to the Radio Regulations outlining the operation of MASS and provisions therein ensuring the safe communications for MASS, which could later include protected channels for MASS.

19 However, the Group acknowledged that ITU radio frequencies were contested among a large number of stakeholders and that MASS may have to operate within the existing bandwidth spectrum allocated to shipping. In this respect the Group noted the information provided by one delegation that the next ITU World Radiocommunication Conference (WRC) would take place in November 2023 and that it only met every four years, so any input and request from the Organization would possibly only be realistic in 2031.

20 After further discussion, the Group agreed to recommend to the Committee to consider the initiation of the process of establishing network governance for MASS as proposed in document MSC/ISWG/MASS 2/4 in order to establish a robust regime which could be initiated and followed up by the NCSR Sub-Committee in cooperation with ITU. As such exercise would require information on the data needs, the Group noted the offer from IMarEST to request its members to provide such information.

***Holistic approach***

21 Following the outcome of the Regulatory Scoping Exercise (RSE), the Group recalled that a number of IMO instruments required actions by personnel to be carried out on board and that the MASS Code may need to address instruments other than SOLAS in order to ensure that no regulatory gaps remained in existing instruments that would prevent MASS operations.

22 In respect of the above, the Group also recalled that SOLAS references other instruments, including ILLC 1966 and COLREGs, and that a number of codes are mandatory under SOLAS so that by applying SOLAS provisions in the MASS Code, such instruments would also be invoked.

23 Subsequently, the Group established that the draft chapters of the MASS Code had been developed, or had to be developed, by identifying all applicable IMO instruments, which was reflected in the goals, functional requirements and expected performances of each draft chapter. Therefore, if relevant, the different groups which developed each chapter should review their respective chapter in order to determine whether the objective of a holistic approach covering all relevant instruments has been met.

24 The Group also considered what aspects needed to be referred to other IMO bodies for further consideration and development, including training requirements for MASS and remote personnel (pertaining to HTW), documents to be carried on MASS (pertaining to FAL) and liability matters (pertaining to LEG).

25 The Group also discussed the potentially urgent need to request MEPC to review IMO instruments under its purview for any barriers that may exist preventing MASS operations. After recalling that MSC 99 had invited MEPC to consider undertaking a regulatory scoping exercise on MASS for instruments under its purview, which MEPC 73 had to defer owing to its heavy workload, the Group agreed to invite the Committee to recommend to MEPC to commence consideration of MASS for instruments under its purview.

***Matters to be referred to the Joint MSC-LEG-FAL WG on MASS***

26 In considering matters that should be referred to the Joint MSC-LEG-FAL Working Group on MASS, the Group agreed that no requests stemming from the Group needed to be considered by MASS-JWG 3.

***Surveys and certification***

27 As one of the key aspects for the safe operation of MASS, the Group considered the survey and certification requirements for both, MASS and the ROC and agreed that remote operation should be addressed. In support of this, one delegation was of the view that several tasks concerning the management of the ROC would not directly influence the safe operations of MASS and "remote operations" should be referenced rather than "ROC".

28 While there was general agreement that MASS surveys and certification should include the SOLAS survey requirements in chapter I, concern was raised with respect to SOLAS ship certificates (regulations I/8, I/9 and I/10) which may be difficult to be issued for a MASS as it may not be able to meet all SOLAS requirements. In addition, other applicable instruments, such as ILLC 1966, required the manual operation of hatch covers and thus a SOLAS certificate for a MASS would have to list all the exemptions/equivalences.

29 While the Group acknowledged that a MASS would have to deviate from some of the requirements in existing IMO instruments, it was agreed that these would remain relevant for MASS under a non-mandatory Code. The MASS Certificate would have to state the equivalences and limitations for a MASS, following the process of alternative design, as set out in MSC.1/Circ.1455.

30 In that respect the Group agreed in principle to include a new chapter on the approval process of MASS, following the principles of MSC.1/Circ.1455. Some delegations provided draft text which is included in square brackets as chapter 1.7bis of the draft Code in the annex, for consideration by the intersessional Correspondence Group.

31 However, the Group noted that a survey regime for MASS under IMO instruments and, in addition for a MASS Certificate, posed a challenge as certain SOLAS requirements may not be met by a MASS or would not be necessary (e.g. where there may be no or limited need for life-saving appliances). A satisfactory solution would be to develop an alternative survey regime for MASS, for inclusion in SOLAS under a mandatory MASS Code. However, the current work for a non-mandatory MASS Code would not be an alternative to the mandatory SOLAS survey regime and therefore should be regarded as an interim solution.

32 Given the early stage of MASS regulatory development, a proposal was made to issue an Interim MASS certificate which would be issued to a MASS undertaking trials until the operational limitations and capabilities were verified, at which point the full MASS certificate may be issued.

33 In order to minimize the survey burden to ship operators, the Group agreed that a survey under the MASS Code should be harmonized with SOLAS survey cycles, for potential inclusion under the Harmonized System of Survey and Certification (HSSC).

34 With respect to the certification of a ROC, which may operate a number of MASS flying the flags of different States, each of the flag States would have responsibility for the safe operation of its MASS. In this respect, the Group noted the presentation by Belgium introducing the concept of Remote Operation Management by which a flag State exercised oversight over an ROC, even if located outside its jurisdiction, i.e. ROCs would be subject to inspections and control by the flag Administration that have authorized the remote operation of ships flying their flag.

35 The Group considered proposal in document MSC/ISWG/MASS 2/2 on a similar principle used for the ISM Company certificate (DoC audit), which may be independent of the ISM Audit as an audit does not verify the function of each equipment.

36 In order to progress the work intersessionally, the Group agreed to summarize its proposed key principles on the survey and certification of MASS with the aim of providing guidance for the further development of the MASS Code on the matter, as set out below:

***Key principles***

- MASS certified under a non-mandatory MASS Code need to have all relevant certificates required by all existing IMO instruments;
- where a MASS Certificate is issued, it should list all the equivalences/exemptions to relevant mandatory instruments, most notably SOLAS, following the principles of MSC.1/Circ.1455;
- MASS and ROC certification should outline the specific functions for remote/autonomous ops (modes of operation of the MASS), as well as limitations of operations;
- the ISM approach should be used for ROC and MASS management certification;
- technical certification is needed for both, MASS and ROC (MSC/ISWG/MASS 2/2);
- risk assessment is the basis for MASS certification; and
- Interim Certificate for MASS trials prior to issuing MASS certificate (for management aspects only, not technical aspects).

***Flag State oversight over MASS/ROC***

37 In order to ensure the safe operation of a MASS when remotely operated from a ROC, in particular when the ROC host State was different from the flag State of the MASS, the Group considered the oversight mechanism under the ISM Code as a potential template for the MASS Code (MSC/ISWG/MASS 2/2).

38 In this connection, the Group recalled that the Legal Committee and the Joint MSC-LEG-FAL Working Group on MASS had discussed the matter and that this was work in progress. In deliberating the matter further, the Group concluded that its considerations of the flag State oversight were in the context of ensuring the safe operation of a MASS, i.e. technical requirements, training, management of the processes etc. and thus within its remit.

39 One delegation stated the legal question of the jurisdiction and responsibility of the flag State is an important one, as it derived from UNCLOS.

40 With regard to the oversight principles of the RO Code, one delegation stated that this matter should be considered in the context of MASS. While not as directly analogous as the ISM Code, the RO Code seemed to acknowledge that RO sites include locations outside the flag State.

41 Consequently the Group agreed on the concept of the ISM Code safety regime as the basis. The Group acknowledged that legal considerations on the matter of jurisdiction will be undertaken in the Legal Committee.

42 Mindful of the novelty of the approach whereby a flag State would have to oversee a ROC in another State, one delegation stated that new competencies for a flag State authorizing ROC to remotely operate MASS flying its flag were needed, as well as and for the host State's Administration, so as to ensure that ROC operate MASS safely.

**Part 2 of the draft MASS Code on Main principles for MASS and MASS functions**

43 Having agreed that part 1 of the draft MASS Code was covered to a large extent in the discussion on the overarching principles and that further development would depend on the discussion on parts 2 and 3, the Group continued the work on part 2.

44 One delegation, supported by several other delegations, noted throughout the meeting that Part 2 was inconsistently written and requested clarification to understand how Part 2 would be used with Part 1 and 3 by industry and Administrations as this would ensure the Correspondence Group could ensure consistent drafting style. No conclusions were reached on this topic, and it was understood that the Correspondence Group would need to progress this as part of the drafting review.

***Operational context***

45 The Group considered first the operational context and agreed to the text as contained in chapter 1 of part 2 (annex).

***Concept of operation (ConOps)***

46 In considering section 1.1 of part 2 on the Concept of Operation (ConOps), the Group identified that the concept was not sufficiently clear to some of its members and that there was uncertainty about what the ConOps' purpose was and what it entailed.

47 In order to address the abovementioned uncertainty, the Russian Federation and Japan introduced the ConOps as implemented in their respective countries, highlighting the elements that were needed in order to meet their flag State's requirements in this respect.

48 The Group agreed that, in order to arrive at defining the elements for the description and characteristics of a MASS, i.e. the ConOps, a risk assessment needed to be conducted in order to ensure that the measures taken to address the risks allowed for the safe operation of a MASS as envisaged in the ConOps. Hence the Administration would require the ConOps to be part of the certification of a MASS.

49 Having modified the draft text for section 1.1 of part 2, the Group agreed to the text as set out in the annex.

***Operational Envelope***

50 The Group had a lengthy discussion on the Operational Envelope (OE) and, in discussing the elements necessary to describe the ship's operational capabilities and limitations, some delegations raised the question of how to clearly distinguish ConOps from the OE.

51 Having considered the elements to be included in the OE, the Group agreed to the text as set out in the annex, including the list of information an OE has to address (annex, part 2, paragraph 1.2).

***Fallback State***

52 Following on from the discussion on the Operational Envelope (OE), the Group considered the conditions when a MASS would operate outside its OE, the so-called Fallback State.

53 In discussing the conditions for the Fallback State, the Group considered the concept of the Operational Design Domain (ODD), described in document MSC/ISWG/MASS 2/3/7, which sets out the limitation of individual systems and functions of a MASS. While there was some support in the Group to include the concept of ODD in the MASS Code, other delegations questioned the need or appropriateness of ODD in light of the ConOps/OE context.

54 Following on from the above, some delegations concluded that a degraded state constituted a reasonably foreseeable state in which the MASS should be able to safely operate (e.g. single engine failure of a twin-engine propulsion system) while a catastrophic event in which the MASS would not be able to continue its normal operation would then invoke the Fallback State.

55 However, other delegations were of the view that Fallback States may take two levels, one which was within the OE and the other outside. Given a number of differences in the understanding of the concepts, the Group was not able to conclude draft section 1.2 of part 2. Hence a number of outstanding issues remained, including the role of human intervention in the stages during or prior to a Fallback State, as well as the consideration of additional concepts, such as degraded state, minimal risk manoeuvre (MRM) and Acceptable Risk Condition (ARC).

56 Subsequently the Group agreed that this matter needed further consideration and may be developed further by the intersessional Correspondence Group.

**Training and certification requirements for personnel operating MASS**

57 The Group considered how best to address training provisions for those personnel involved in the operation of MASS, which would include crew on board a MASS and remote operators.

58 In connection with the above, the Group considered the proposal in document MSC/ISWG/MASS 2/3/1 (IMarEST), which outlined the additional competency provisions, compared to the STCW Convention, for those involved in MASS operations.

59 After discussion, the Group acknowledged the need to develop high-level training provisions for the MASS Code whereby the detailed competency and knowledge, understanding and proficiency (KUPs) provisions may be developed by the HTW Sub-Committee at a later stage when the Code has been finalized. The Group, therefore, agreed to invite the Committee to consider requesting the HTW Sub-Committee to be aware of the potential need to develop competence tables for all MASS Code-identified personnel requiring training at its session in 2025 (HTW 11).

60 Subsequently, the Group agreed on the development of high-level training provisions in the MASS Code, which could be considered by the Correspondence Group, for inclusion in the draft MASS Code for consideration at MSC 108, taking into account documents MSC 107/5/6 (Japan), MSC 107/5/8 (Republic of Korea and ITF), MSC 107/13/2 (Russian Federation and United Arab Emirates), HTW 9/INF.4 (Russian Federation) and MSC/ISWG/MASS 2/3/1 (IMarEST).

**Further consideration of documents submitted**

61 Due to time constraints, the Group was not able to discuss all the documents submitted in detail and thus agreed to invite the Committee to consider them at its next session, i.e. documents MSC/ISWG/MASS 2/INF.2, 2/3, 2/3/2, 2/3/3, 2/3/5, 2/3/6 and 2/3/7.

**Trials under regulation I/13 of the STCW Convention in which the officer of the navigational watch acts as the sole lookout in periods of darkness in relation to MASS**

62 Due to time constraints the Group did not consider the proposal in document MSC 107/5/5 (Germany et al.), proposing a clarification of MSC/Circ.566, MSC/Circ.733 and MSC/Circ.867 concerning trials under regulation I/13 of the 1978 STCW Convention in which the officer of the navigational watch acts as the sole lookout in periods of darkness, in relation to MSC.1/Circ.1604 concerning MASS trials. The group therefore agreed to invite the Committee to consider the document at its next session, together with document MSC/ISWG/MASS 2/6 (Liberia).

**Any other business**

63 Norway expressed its intention to organize a MASS dedicated symposium one day prior to MSC 110. The symposium's objective is to share information, exchange ideas and pave the road for the implementation of MASS beyond the finalization of the draft MASS Code by presenting the latest developments on MASS in Norway. The Group noted Norway's intention to ask the Committee at MSC 108 for endorsement of such an event.

**Action requested of the Committee**

64 The Committee is invited to approve the report in general and, in particular, to:

.1 note the progress made on the development of the draft MASS Code (annex);

.2 note the draft application provision for the MASS Code, pending decision on the inclusion of high-speed craft (paragraph 9 and annex, part 1, section 5);

.3 note that the Group requested a GBS Expert to review the draft MASS Code to ensure that it is an instrument that is coherent, unambiguous and aligned in the style and format for goals and functional requirements (paragraph 16);

.4 consider the initiation of the process of establishing network governance for MASS, as proposed in document MSC/ISWG/MASS 2/4, by the NCSR Sub-Committee in cooperation with ITU (paragraph 20);

.5 note to Group's discussion on what aspects needed to be referred to other IMO bodies (HTW, FAL and LEG) (paragraph 24);

.6 recommend to MEPC to commence consideration of MASS for instruments under its purview (paragraph 25);

.7 note that the Group had no matters that needed to be referred to the third session of the Joint MSC-LEG-FAL Working Group on MASS (paragraph 26);

.8 agree to develop high-level training provisions for the MASS Code whereby the detailed competence and knowledge, understanding and proficiency (KUPs) requirements may be developed by the HTW Sub-Committee at a later stage when the Code has been finalized (paragraph 59);

.9 agree for the outstanding documents submitted to the intersessional Working Group (MSC/ISWG/MASS 2) to be considered at MSC 108 (paragraph 61);

.10 agree to consider documents MSC 107/5/5 (Germany et al.) and MSC/ISWG/MASS 2/6 (Liberia), relating to the OOW as the sole lookout in periods of darkness during MASS trials, at MSC 108 as the Group, owing to time constraints, was not able to consider the proposal (paragraph 62); and

.11 note the intention of Norway to organize a MASS dedicated symposium one day prior to MSC 110, including its endorsement by the Committee at MSC 108 (paragraph 63).

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# ANNEX[1]

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

### PREAMBLE

1 Existing IMO instruments have historically been developed on the basis that the ship will have at least a 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 remote control and autonomous operation of key functions, will require a different approach and therefore some adjustment of the accepted norms regarding on board manual intervention and control as contained within SOLAS and other IMO instruments.

3 In facing these challenges, it is recognized that some aspects associated with MASS may not be adequately or fully addressed in SOLAS or other IMO instruments and that additional guidance may be required on the design and operation of MASS to achieve a level of safety that is [~~at least~~] equivalent to that expected of a conventional ship.

4 This Code addresses the functions needed to obtain safe[,secure] and reliable operations of MASS insofar as they are not adequately or fully addressed in other applied IMO instruments, such as SOLAS, while ensuring that required safety levels are maintained [~~or enhanced~~] through the implementation of remote control, or autonomous operation, of key functions.

5 This Code is intended as a [supplementary] [complimentary] to other IMO instruments, such as SOLAS, and provides a regulatory framework for the performance of remote control and autonomous operation of key functions, as applicable.

6 The safety principles and objectives of this Code reflect changes in the operational risks (increases or reductions) which may result from the introduction of remote control and autonomous operation of key functions and address their management and reduction through mitigation measures and controls.

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

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

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

[An Administration may also apply these provisions as far as reasonable and practicable to other ships]

[1] Yellow highlighted text shows changes made at the MSC/ISWG/MASS 2 meeting against document MSC/ISWG/MASS 2/WP.2

[Advancing technology in the shipping industry leads to an ever-increasing use of automation to operate ships. Enhanced automation does not qualify a ship as a MASS. The main qualifier to distinguish a MASS from a conventional ship is the introduction of autonomous or remote operation technology augmenting or replacing functions performed by seafarers on board involved in conducting or controlling these ship functions. (*N.B. Moved text from par. 2.1 , part 2*)]

## PART 1 INTRODUCTION

### 1 Purpose

The purpose of this Code is to provide a coherent international regulatory framework to enable ~~[and ensure]~~ safe, secure, and [environmentally sound] MASS operations. The Code further aims to support the safe adoption and integration of new technology for ship operations and provide for consistency of approach to the design, build and operation of MASS.

### 2 Principles

This Code is developed on the principles that it be:

a) [supplementary] [complimentary] to any applicable base ~~IMO~~ instruments, such as SOLAS, and only address MASS issues insofar as they are not adequately or fully addressed in the applicable base instruments;

b) holistic to ensure the objectives, aims and principles of the IMO base instruments are maintained whilst also [enabling ~~ensuring that~~] the challenges of MASS functions and operations [to be ~~are~~] addressed across all instruments;
c) goal-based and addressing matters at the functional level;
d) non-mandatory [~~but~~ although] developed in such a way as to facilitate future transition to mandatory status; and
e) technology neutral and taking note of industry practices and experience in the deployment of new technologies.

### 3 [Goals] [Objectives]

In achieving its Purpose, this Code is intended to:

a) [~~ensure achievement of~~ achieve] a level of safety at least equivalent to that expected of a conventional ship;
b) enable all ships to safely coexist without impeding or negatively impacting each other, regardless of whether certain functions are remotely controlled or autonomously operated;
c) [~~ensure that there is~~ prevent] relaxation of the level of accepted standards for design, construction, or operation;
d) allow for the application of solutions that are demonstrably safe, secure, and environmentally sound in performing the designated function in all defined conditions; and
e) be cognizant of the potential for the unintended placement of regulatory barriers to new or novel application of remote control or autonomous technology on ships.

~~**[4 Verification and validation (GBS Tier III)]**~~ – *N.B. propose leaving till later when we develop the mandatory instrument.*

### 5 Application

~~The provisions contained in this Code should be applied to MASS Cargo Ships of [24 m in length] [500 gross tonnage] and over in international trade [which are not high-speed craft], as~~

~~well as any associated Remote Operations Centres (ROCs). The Administration may also apply these provisions as far as reasonable and practicable to other ships.~~

The Code applies to cargo ships to which SOLAS chapter I applies which have functions that enable autonomous or remote operations including any associated ROC(s) [when the Administration deems it that direct compliance with other/existing instruments is not practicable].

## 6 Code Structure and relationship to other IMO Instruments

As stated in the preamble, this Code addresses the functions needed to obtain safe[,secure] and reliable operations of MASS insofar as they are not adequately or fully addressed in other applied IMO instruments, such as SOLAS, and is therefore intended to be complementary to those IMO instruments.

This Code consists of:

- Part 1 – Introduction – covering overarching matters to be considered in the application of the Code.

- Part 2 – Main Principles for MASS and MASS Functions – containing those main principles that should be followed in the application, to a MASS or MASS functions, of the goals, functional requirements and provisions as laid out in part 3 of the Code.

- Part 3 – Goals, Functional Requirements and Provisions – containing, in each Chapter, the goal of the chapter, functional requirements to fulfil the goal, [and the provisions associated with those functional requirements].

## 7 Terminology and Definitions

For the purposes of the Code, unless expressly provided otherwise, terms used have the meanings defined in the following paragraphs.

7.1 Abnormal situation

*Abnormal situation* means a [divergence/deviation][~~disturbance~~] in the normal [operation][function] which can potentially result in an unsafe state ~~accidents~~. (RBAT)

7.2 Accident
*Accident* means an unintended event involving fatality, injury, ship loss or damage, other property loss or damage, or environmental damage. (IMO, 2018)

7.3 Administration
*Administration* means the Government of the State whose flag the MASS is entitled to fly.

[7.3*bis* Agent
*to be defined.]*

7.4 [Annunciated] [Announced] failure
An *annunciated failure* is one which fails 'actively', i.e. in such a manner as to inform crew of the failure by virtue of system generated cues such as visual and/or audible notifications, warnings, and alarms. (RBAT)

7.5 Anticipated event

*Anticipated event* means an event which does not force the system outside the operating envelope, and which can be handled while also maintaining normal operations. (RBAT)

7.6 Approved

*Approved* means approved by the Administration.

7.7 Automated functions

[*Automated functions* means automated processes, parts of the system that may be automated when it is not the ship being considered as one whole. [Automated systems was proposed instead of functions but consensus was on functions at this time.]

*or*

*Autonomous functions* are functions (or complete ships) that may operate in complex and open-ended environments with high levels of independence and self-determination. They perceive, learn, reason and [act with self-awareness and] respond [intelligently] [appropriately] to unforeseen changes in the environment. (*Denmark proposal from 1.2 (Application)*).]

7.8 Automatic

*Automatic* means processes or equipment that, under specified conditions, can function without human control. (RBAT)

7.9 Autonomous

*Autonomous* means processes or equipment in a MASS system which, under certain conditions, are designed and verified to be controlled by automation, without human assistance. (RBAT)

7.10 Autonomous Navigation System

[*Autonomous Navigation System (ANS)* means a system which has the functionalities of situational awareness, route planning and determination for collision and grounding risk avoidance, ship's heading, speed and track control, etc. *(MSC 107/5/10)*

or

*Autonomous Navigation System (ANS)* means a set of elements that provide functions related to autonomous navigation within a defined or higher operational envelope. It also should include the possibility of remote control. (MSC 107/5/7)]

7.11 Cargo Ship

*Cargo Ship* means any [full or semi-displacement] ship which is not a passenger ship, a ship of war and troopship, a ship which is not propelled by mechanical means, a wooden ship of primitive build, a fishing vessel or a mobile offshore drilling unit. (2008 IS Code)

[7.11 bis COLREG

*COLREG* means the Convention on the International Regulations for Preventing Collisions at Sea (COLREG), 1972.]

7.12 Company

*Company* means the owner of the MASS or any other organization or person such as the manager, or the bareboat charterer, who has assumed the responsibility for operation of the ship from the shipowner and who, on assuming such responsibility, has agreed to take over all the duties and responsibilities imposed on the Company by the MASS Code.

7.13 Concept of Operation (ConOps)
*ConOps* means a document describing the characteristics of a proposed system. The ConOps would be part of the certification of a MASS.

7.14 Control function

*Control function* means actions performed by humans or software for the accomplishment of a functional goal (adapted from IEC, 2000).

7.15 Control action

*Control action* means the acquisition of information, analysis of information, decision-making, or implementation of physical actions performed as part of a control function.

[7.15 bis Correction
*Correction* means a successful control action in avoiding the consequence of a fault without having to resort to mitigation either on board the MASS or from Remote Operations Centre.]

7.16 Degradation

*Degradation* means the reduced performance of a system or function, but it should still provide safe operations/service in the presence of hazardous events. (MSC 107/5/7)

7.17 Enabling event
*Enabling event* means the occurrence of a failure or presence of a hazard which contributes to escalating an unsafe condition/mode into an accident.

7.18 Failure
[*Failure* means the termination of the intended behaviour of an element or item due to fault manifestations. (MSC 107/5/7)
or
*Failure* means the loss of the ability of an item to perform the required (specified) function within the limits set for its intended use. This occurs when the margin (to failure) is negative. (RBAT)]

7.19 Fallback state

*Fallback state* means a designed state that can be entered through a fallback action or process when it is not possible for the MASS with its autonomous or remote-controlled ship functions to stay within the operational envelope. (*Germany proposal MASS Code Section 2.1 (Operational Context)*)

7.20 Fault

*Fault* means an abnormal condition that can cause an element or an item to fail. (MSC 107/5/7)

7.21 Function

*Function* means a group of tasks, duties and responsibilities, as specified in the MASS [~~STCW~~] Code, necessary for MASS operation, safety of life at sea[, security of the vessel] or protection of the marine environment.

7.22 Functional allocation/ assignment

*Functional allocation/ assignment* means the distribution of functions between human and software (ISO, 2000). *Functional allocation can also be referred to functional assignment* (IEC, 2000)

7.23 Functional analysis

*Functional analysis* means the examination of the functional goals of a system with respect to available manpower, technology, and other resources, to provide the basis for determining how the function may be assigned and executed (IEC, 2009).

7.24 High-Speed Craft

*High-speed craft* (HSC) means a craft capable of a maximum speed, in metres per second (m/s), equal to or exceeding: $3.7 \cdot \nabla^{0.1667}$ where: $\nabla$ = displacement corresponding to the design waterline ($m^3$). (2008 IS Code)

7.25 Human-Automation interaction
*Human-Automation interaction* means the way a human [performs a control function or] is affected by, controls, and receives information from automation while performing a task (Sheridan & Parasuraman, 2006)

7.26 [Human Element
*Human Element* means the interaction between the autonomous systems and the human operators involved in the operation and management of MASS. [These factors should, amongst others, include cognitive workload, situational awareness, communication protocols, teamwork, decision-making processes, training requirements for human operators as well as guidelines and best practices to ensure that these factors are adequately addressed in the design and operation of MASS.]]

[7.26bis Human Machine Interface (HMI)
*to be defined.]*

7.27 In service
[(operating, under remote operation, under remote supervision; need to cover in dry dock)]
*Term to be defined.*

7.28 International Convention on Maritime Search and Rescue
International Convention on Maritime Search and Rescue (SAR), 1979, as amended.

7.29 International Safety Management (ISM) Code

*International Safety Management (ISM) Code* means the International Management Code for the Safe Operation of Ships and for Pollution Prevention as adopted by the Assembly, as may be amended by the Organization.

7.30 Intolerable risk
*Term to be defined.*

7.31 Length of ship.
*Length of Ship*. The length should be taken as 96% of the total length on a waterline at 85% of the least moulded depth measured from the top of the keel, or as the length from the fore side of the stem to the axis of the rudder stock on the waterline, if that be greater. In ships designed with a rake of keel the waterline on which this length is measured should be parallel to the designed waterline.

7.32 MARPOL
*MARPOL* means the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto as amended by the 1997 Protocol.

7.33 Maritime Autonomous Surface Ship (MASS)

*Maritime Autonomous Surface Ship (MASS)* means a ship which, to a varying degree, can operate independent of human interaction [if at least all or part of the navigation tasks are automated or remote operated].

7.34 [MASS Onboard Crew
MASS onboard crew means a master, other officers and operational staff physically on board a MASS.

7.35 MASS Remote Crew
MASS remote crew means a remote master, remote operators and responsible persons ~~controlling~~ operating MASS remotely and/or providing assistance to the crew in the MASS operation.]

7.36 Master/ Master of a MASS
*Master [of a MASS]* means the person [having command of] [being responsible for] a MASS (STCW)

Key principles agreed/requirements of a Master *(final location to be confirmed)*:

[ .1 there should be a human master responsible for a MASS, regardless of mode of operation;

.2 such master may not need to be on board, depending on the technology used on the MASS and human presence on board, if any;

.3 regardless of mode of operation, the master of a MASS should have the means to intervene when necessary; and

.4 several masters may be responsible for a MASS on a single voyage, under certain conditions, and that only one master should be responsible at any given time (further consideration of what those conditions are is required).]

[7.36bis Minimal Risk Manoeuvre (MRM)
*to be defined.]*

7.37 Mission
*Mission* means the commercial, political (e.g. defence) or public intentions which have contributed to and justifies the vessel concept development and operation.

7.38 Mission model
*Mission model* means the hierarchical breakdown of a vessel mission into a set of mission phases and operations.

7.39 Mission phase
*Mission Phase* means the subdivisions of the mission typically characterized by a recognizable shift in where the vessel is located in terms of geographical surroundings, or the start and end of one or more operations.

7.40 Mitigation
*Mitigation* means a measure implemented to prevent unsafe conditions or modes from resulting in losses (*see "Accident"*).

7.41 Mitigation layer

*Mitigation layer* means a mitigation capable of preventing a scenario from proceeding to an accident without being adversely affected by the initiating event or the action of any other mitigation layer associated with the scenario.

7.42 Modes of Operation
*Modes of Operation* means the conditions under which the functions of a MASS are controlled, i.e. remote-control or autonomous with or without persons on board.
Requirements of Modes of Operation (final location to be confirmed):
[A ship may move between modes of operation during one voyage. The use and management of Mode of Operation are defined in the ~~Operational Context~~ Concept of Operation for a given operational envelope as agreed by the Administration.]

7.43 Operational Envelope
The Operational Envelope should provide ship's operational capabilities and limitations and ship-specific capabilities and limitations.

7.44 Organization
*Organization* means the International Maritime Organization.

7.45 Process
*Process* means a set of interrelated or interacting activities that transforms inputs into outputs (IEC, 2018)
[7.45bis Quality of Service (QoS)
*to be defined*]

7.46 Remote Control:
*Remote control* is when the ship, or functions within the ship, are operated from outside the [controller area network of the] ship without interference from anyone on board the ship. Remote control may have direct control of actuators on board, or may just give functional commands to an autonomous function (system). Remote control may have varied complexity, from simple communication of setpoints to full real time control including full virtual feedback from the ship/function. (*Denmark suggestion from 1.2 (application))*

7.47 Remote Control Station
*Remote Control Station* means a system connected to MASS for its remote control. (*MASS-JWG1/WP.1)*

*Control stations* are those spaces in which the ship's radio or main navigating equipment or the emergency source of power is located or where the fire recording or fire control equipment is centralized.' *(SOLAS Chapter II – 18*)

Remote Operations Workstation" instead of "Control Station" to differentiate from "Control Station" as defined in SOLAS II-1/3.18 to avoid interpretations regarding applicability for these to be applicable onshore. (*OneSea proposal*)

*Control and monitoring equipment* means the equipment installed for the effective operation and control of the BWMS and the assessment of its effective operation. (*Ballast Water Management System (BWMS) Code*)

*Control Station* are those spaces in which the craft's radio or navigating equipment (main displays and controls for equipment specified in 13.2 to 13.7) or the emergency source of power and emergency switchboard are located, or where the fire recording or fire control equipment is centralized, or where other functions essential to the safe operation of the MASS craft such as propulsion control, public address, stabilization systems, etc., are located. *(High Speed Craft Code)*

*Operating station* means a confined area of the operating compartment equipped with necessary means for navigation, manoeuvring and communication, and from where the functions of navigating, manoeuvring, communication, commanding, conning and lookout are carried out.' (*High Speed Craft Code)*
*Control station* means a single or multiple position including all equipment such as computers and communication terminals and furniture at which control and monitoring functions are conducted. (*ISO 11064-3*)

*Remote Control Station* means a place from which MASS, or functions of a MASS can be operated. A ROC may have multiple control stations within its facilities.' (*MASS Code Remote Operation Section 3.2*)

7.48 Remote Operator
*Remote Operator* means a qualified person who is employed or engaged to operate some or all aspects of the functions of a MASS from a Remote Operations Centre.

7.49 Remote Operations Centre
*Remote Operations Centre* means a location remote from the MASS that can operate some or all aspects of the functions of the MASS.

7.50 Remote Master
*Remote Master* means a master who is in a Remote Operations Centre outside the MASS.

7.51 Remote Operations
*Term to be defined.*

7.52 Risk Assessment
*Risk Assessment* means an assessment undertaken in line with/meeting the requirements of section 2.4 of this Code.

[7.52bis Safe State
*to be defined.]*

7.54 Secure position/Location
*Term to be defined.*

7.53 Situational Awareness
*Situational Awareness* means the perception of environmental elements and events with respect to time or space, the comprehension of their meaning, and the projection of their future status (Endsley 1995). (RBAT)

*Note - the classification of situational awareness capabilities should be categorized by mode of operation because the details of situational awareness will vary depending on the subject for which it is provided (crew, remote operators, and so on) and the functionality should differ. (MSC 107/5/7).*

7.55 SOLAS
SOLAS means the International Convention for the Safety of Life at Sea, 1974, as amended.7.56

Software
*Term to be defined.*

7.57 STCW Convention
*STCW Convention* means the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978, as amended.

7.58 Support
*Term to be defined.*

7.59 System
*System* means the combination of interacting ~~elements~~ functions organized to achieve one or more stated purposes, i.e. goals (IEC, 2018).

7.60 Task
*Task* means a set of [control] actions taken to enable functions and perform operations. A task may involve interactions with several different functions or systems, but also with humans.

7.61 Third parties
*Third Parties* means persons that are not involved in the operations but engaging with the MASS, e.g. VTS, ports, pilots or other persons in the ROC for maintenance reasons, persons in distress, other vessels.

7.62 Unannunciated failures
An *unannunciated failure* is one which is latent or fails 'passively', i.e. in such a manner as to not inform the crew of the failure by virtue of system generated cues, or the provided information is misleading, incomplete, or not presented in due time.

7.63 Unsafe State
*Unsafe state* means where a system is operating outside its normal (and safe) operating envelope due to degraded performance (e.g. [faults or] failures) or exceeded capabilities which, if left [uncorrected or] unmitigated, has the potential to directly cause an accident. (*RBAT*)

7.64 Verification
*Term to be defined.*

7.65 Validation
*Term to be defined.*

7.66 Terms related to control: Control, Monitoring, Supervision (active/passive), strategic control, tactical control, supervisory control

The following submissions have been proposed on these terms so far:
<u>(MSC 107/5/3)</u>

.1 Operator control mode: This is a working mode, sometimes supported by technology or procedures, that represents the expected class of actions performed by the crew or remote-control centre operators. Modes can be changed during a voyage or operation and/or for specific functions. Four operator control modes have been defined as described in the following paragraphs.

.2 Monitoring: An operator control mode with operations which monitor a situation but do not take any action to influence necessary processes. In monitoring mode, operators may adjust non-necessary processes or equipment to facilitate gathering of information. Monitoring can, for example, be to adjust a system for exclusively human use, such as external lights or cameras, or to inspect equipment or trends in performance parameters.

.3 Strategic control: An operator control mode with operations to issue fleet-wide instructions that implement and, if appropriate, define specific functions to be used by the automatic decision-making units.

.4 Tactical control: An operator control mode with operations to influence the conclusion made by the automatic decision-making units of the autonomous ship for a particular purpose. Tactical control includes, for example, changing the required minimum closest point of approach to other ships or the port of destination and letting the autonomous ship system afterwards construct the avoidance manoeuvre or route itself. It can also be adjustment of a technical alert level, based on prevailing conditions, for example, the time delay in actuation of the bilge alarm.

.5 Direct control: An operator control mode with operations to control a specific function or parameter. Direct control means, for example, that the operator changes a waypoint that would otherwise be decided by the autonomous ship systems directly, or that the operator selects and overrides the machinery standby configuration, such as changing of generator or pump standby status.

<u>RBAT (4th report)</u>

.1 Control: Purposeful action on or in a process to meet specified objectives (IEC, 2013).

.2 Control function: Control actions performed by humans or software for the accomplishment of a functional goal (adapted from IEC, 2000).

.3 Control action: Acquisition of information, analysis of information, decision-making, or implementation of physical actions performed as part of a control function.

.4 Supervision: A role with an explicit responsibility to monitor system performance and detect abnormalities so that the desired outcome can be achieved through implementation of corrective responses.

<u>(MSC 107/INF.8)</u>

Supervisory control is a role with an explicit responsibility to monitor system performance and detect anomalies so that the desired outcome can be achieved through implementation of corrective responses. An important principle is that the supervisory agent cannot be the same as the agent performing the control action(s) being supervised. The supervisor has an overriding authority of the control action performance and is responsible for its outcome. Supervisory control can take different forms and be performed by either a software or human agent. The different categories of supervisory control defined in RBAT are:

.1 Active human supervisory control: supervisor intervenes at any stage based on continuous monitoring.

.2 Passive human supervisory control: supervisor intervenes upon requests (e.g. alarm).

.3 Software supervisory control: software intervenes on demand upon continuous monitoring of pre-defined parameters.

.4 No supervisory control.

[**1.7 bis Approval process**

1.7.1 Process description
A structured approval process should take place to enable the MASS to obtain the required approval along with the necessary certificates related to statutory requirements for their intended operation. By following this process, Submitters and Administrations would be working in cooperation to evaluate that all aspects of safety, security and environmental protection are adequately assessed.
The approval process for MASS projects 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 2 and 3 of this Code. The level of detail should be proportional to the complexity of the project and on whether the Submitter[2] is applying for preliminary or final approval.

The Submitter should accept the obligation to supply necessary information and requested documentation 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.

The approval process contains the following steps:

a) Planning and stakeholder identification

b) Development of preliminary design

c) Preliminary design approval

d) Final design definition including the requirements for testing for approval

e) Testing and other verification methods

f) Final design approval

g) Survey and Certification (as described in 1.8 of the Code)

h) Operation

1.7.2 Evaluation criteria
The basic principle for the evaluation criteria should be safety equivalence. The evaluation criteria should be developed through compliance with the goals and functional requirements

[2] Proposal for inclusion in the definitions (adapted from MSC.1/Circ.1455): Submitter is an entity seeking approval of a MASS from the Administration, responsible for communicating with the administration for the submission and followup of the approval process.

of part 3 of this Code in combination with a risk assessment (as described in [2.4] of the Code). The evaluation criteria and an assessment plan thereof should be agreed with the Administration.
The risk assessment should cover the interaction of specific systems and relevant mitigation measures (as described in 2.4). An alternative approach could be to carry out a risk assessment of the MASS and compare it to overall risk evaluation criteria.
The adopted mitigation measures should take into consideration single failure events, but also foreseeable events within the operational envelope (as described in 2.1 of the Code) of the ship that may degrade the performance of more than one system at the same time (e.g. heavy weather at night time). Such features should consist mainly of independent mitigation layers, such as predefined fallback states (as described in 2.1 of the Code). The number of such mitigation layers should be proportional to the risk.

1.7.3 Design and documentation requirements
For each approval step, the Submitter should produce and submit the documentation described below. The different documents required in the different steps are expected to be reviewed according to any possible design or operational changes and added details. This should result in updating the approval basis in later stages of the approval process.

The ConOps (as described in 2.1) should be a base document in the approval process and should be the basis for the assessment in each step.
1.7.3.1 Planning and stakeholder identification
[1.7.3.2 Preliminary design development
The following vessel-specific documentation should be compiled and submitted:

1. Preliminary concept of operations (CONOPS) (as described in 2.1 of the Code)
2. Preliminary design drawings
3. High level risk assessment report
4. Approval basis

1.7.3.3 Preliminary design approval

1. Risk assessment report
2. Preliminary design documents (including CONOPS) (as described in 2.1 of the Code)
3. Drawings & information documents (optional)
4. Task allocation summary
5. Approval basis
6. Regulatory gap analysis
7. Verification and validation definition

1.7.3.4 Final design definition
1.7.3.5 Testing and other verification methods
1.7.4.6 Final design approval
1.7.4.7 Survey and Certification
1.7.4.8 Operation]
Table 1 provides additional guidance in relation to the approval steps that require relevant documentation:

*Table 1 - Documentation for each approval step*

| | Preliminary design development | Preliminary design approval | Final design definition | Testing | Final approval | Operation** |
|---|---|---|---|---|---|---|
| Preliminary design documents | X* | X | | | | |
| Drawings and information documents | | X | X | | X | X** |
| Risk analysis | | X | X | | X | X** |
| Task allocation summary | | X | X | | X | X** |
| Approval basis | X* | X | X | X | X | X** |
| Regulatory gap analysis | | X | X | | | |
| Verification and validation definition | | X | X | | | |
| Testing and verification reports | | | | X | | |

* - High level only
** - In case of changes in the approved assumptions and conditions ]

## 8 Certificate and Survey

8.1 MASS Certificate
Every ship to which this Code applies should have a valid MASS Certificate, issued after an initial or renewal survey.

[Every ship to which this code applies should be subject to the surveys specified for cargo ships, other than tankers, in SOLAS, which should cover the provisions of this Code.]

8.1.1 The MASS functionality shall be subject to the following surveys:
an initial survey before the ship is put in service;

.1 a renewal survey at intervals specified by the Administration but not exceeding five years; and

.2 a periodical survey within three months before or after each anniversary date of the MASS Certificate.

8.1.2 The surveys referred to in 8.1.1~~paragraph (a)~~ should be carried out as follows:

.1 the initial survey should include a complete inspection of the MASS functionality, to ensure that they comply with the requirements of this Code;

.2 the renewal and periodical surveys should include an inspection of the MASS functionality, to ensure that they comply with the requirements of this Code.

8.1.3 The periodical should be endorsed on the MASS Certificate.
The certificates and records of equipment should be drawn up in the form corresponding to the models given in appendix [NN] to this Code. If the language used is neither English nor French, the text should include a translation into one of these languages.

SOLAS Ch. I, reg. 6, 11, 13, 17, 19, 20 and 21 applies to the MASS Certificate.

8.2 MASS ROC Certificate
Every Remote Operation Centre (ROC) to which this Code applies should have a valid MASS ROC Certificate, issued after an initial or renewal survey.

8.2.1 The MASS ROC functionality should be subject to the surveys specified below:

.1 an initial survey before the ROC is put in service;

.2 a renewal survey at intervals specified by the Administration of the host nation but not exceeding five years; and

.3 a periodical survey within three months before or after each anniversary date of the MASS ROC Certificate.

8.2.2 The surveys referred to in 8.1.1~~paragraph (a)~~ should be carried out as follows:

.1 the initial survey should include a complete inspection of the MASS functionality, to ensure that they comply with the requirements of this Code;

.2 the renewal and periodical surveys should include an inspection of the MASS functionality, to ensure that they comply with the requirements of this Code.

8.2.3 The periodical surveys referred to in 8.1.1~~paragraph (a)~~ should be endorsed on the MASS ROC Certificate.

Certificates and records of equipment should be drawn up in the form corresponding to the models given in appendix [NN] to this Code. If the language used is neither English nor French, the text shall include a translation into one of these languages.

SOLAS Ch. I, reg. 6, 11, 13, 17, 19, 20 and 21 Applies to the MASS ROC Certificate, with the condition that the Administration is to be understood as the Administration of the host nation of the ROC facility (physical location). The MASS ROC Certificate may cover national requirements of the host nation.

8.3 ISM Certification for MASS

Every Administration notified by a company of the intent to operate a MASS should make available, as it deems practical and necessary either individually or in cooperation with other Contracting Governments, its requirements, procedures and guidelines for the inclusion of the Remote Operation Centre (ROC) in the verification and certification process of the Document of Compliance (DoC) and Safety Management Certificate (SMC). Any operational procedures specified for the MASS and/or ROC by this Code, including watchkeeping arrangements, should be included in the ISM system of the MASS and /or ROC respectively.

The operation of the ROC should, to the satisfaction of the Administration, be included in the ISM verification and certification process relevant to a DoC for a company and should be carried out by, or on behalf of, the Administration in accordance with SOLAS Chapter IX, regulation 4.1 and part B, paragraphs 13, 14 and 15 of the ISM Code.

The process for the issuance of the DoC should include at least one assessment of the ROC during the period of validity of the DoC[3], conducted by the Administration, by an organization recognized by the Administration, or at the request of the Administration by another Contracting Government. The DoC should only be valid for MASS if explicitly indicated in the DoC[4], together with the indication of the ROC, if any, involved in the operation of the MASS.

The SMC for the MASS should be issued in accordance with SOLAS Chapter IX, regulation 4.3 and part B, paragraphs 13, 14 and 15 of the ISM Code. The SMC should indicate the ship type together with the indication that the ship is operated as a MASS, and the ROC, if any, involved in the operation of the MASS.

The periodical verification of the proper functioning of the Safety Management System (SMS) in accordance with SOLAS Chapter IX, regulation 6.1 should include all relevant operational aspects of the ROC as considered practical and necessary the Administration. This should include procedures for ensuring cyber security as well as procedures for physical security, including any provisions for security vetting of personnel as deemed necessary by the Administration.

8.4 ISPS Certification for MASS

Any MASS should be ISPS Certified according to the ISPS Code. The ISPS procedures may be integrated with the ISM system, as long as the required confidentiality is observed. If the ISM and ISPS systems are integrated, the approval process for ISPS [will] [should] follow the procedures in the ISM Code and not the ISPS Code procedures.

8.5 Minimum Safe Manning Documents

Both the MASS and any ROC operating a MASS shall be furnished with a Minimum Safe Manning Document (MSMD) according to IMO Resolution A.1047(27) as amended, and to the satisfaction of the Administration. ~~The watchkeeping arrangements~~

The MSMD for the MASS may carry a total manning number of 0 (zero) and may reference personnel training and certification requirements as specified in this Code.

[3] Refer to paragraph 4.4.3 of Resolution A.1118(30) – Revised Guidelines on the implementation of the ISM Code by Administrations

[4] Refer to paragraph 16.2 of part B of the ISM Code

The MSMD for the ROC should be linked to specific or a number of specific MASS. As the STCW Convention and Code does not apply to ROC, the MSMD for the ROC may include personnel outside of STCW and may reference personnel training and certification requirements as specified in this Code.

The ROC may employ a number of MSMDs dependent on the needs of the individual MASS operated by the ROC. If the ROC operates under more than one MSMD, a MASS ROC Master Plan (MRMP) for watchkeeping and other tasks has to be approved by all Administrations who has issued MSMDs covered by the MRMP. The MRMP may be part of an ISM System.

## PART 2 MAIN PRINCIPLES FOR MASS AND MASS FUNCTIONS [AND REMOTE OPERATIONS]

This part of the Code contains those main principles that should be followed in the application, to a MASS or MASS functions, of the goals, functional requirements and ~~[~~expected performances~~]~~ as laid out in part 3 of the Code.

### 1 Operational context

~~Advancing technology in the shipping industry leads to an ever-increasing use of automation to operate ships. Enhanced automation does not qualify a ship as a MASS. The main qualifier to distinguish a MASS from a conventional ship is the introduction of autonomous or remote-controlled ship functions replacing seafarers on board [who traditionally were] involved in conducting or controlling these ship functions [as humans in the loop]. To introduce MASS into the shipping industry with a level of safety of operation [, pollution prevention and security] not inferior to conventional ships, the operational context for a MASS should consider all aspects of the MASS operation and describe the autonomous or remote-controlled ship function(s) and the external environment that influences its operation.~~

~~The operational context should encompass a generic concept of operation, a MASS-specific operational envelope detailing the operational capabilities and limitations of the MASS, a fallback state to keep the MASS at a tolerable risk in case of non-performance of autonomous or remote-controlled ship functions, and the possible mode(s) of operation of the MASS during its voyage.~~

The operational context for a MASS should consider all aspects of the MASS operation and describe the autonomous or remote-controlled ship function(s) and the external environment that influences its operation. It should encompass a generic concept of operation, a MASS-specific operational envelope detailing the operational capabilities and limitations of the MASS, a fallback state to keep the MASS at a tolerable risk in case of non-performance of autonomous or remote-controlled ship functions, and the possible mode(s) of operation of the MASS during its voyage.

1.1 Concept of Operation

~~The ConOps should consider the Operational Envelope (OE) and the technical design of the MASS and of the Remote Operation Centre (ROC), if applicable, including the connectivity and communication lines. The ConOps should address the organization on board the MASS and at the ROC, together with the integration of humans in the operation [, both on board and onshore].~~

~~The ConOps as the base document should be drafted to avoid threats to maritime safety, security, and environmental protection by the operation of the MASS. Risk assessments for the safety and security of MASS and ROC should take the ConOps into consideration. The ConOps and the risk assessment should be [iterated] [repeated] until all relevant risks are managed.~~

~~The ConOps should be part of the certification as MASS.~~

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

The ConOps as the base document should be drafted to avoid threats to maritime safety, security, and environmental protection by the operation of the MASS. Risk assessments for the safety and security of MASS and ROC should take the ConOps into consideration. The ConOps and the associated risk assessment should ensure that all relevant risks are addressed.

[The ConOps should be part of the certification as MASS *(N.B. Final location to be confirmed)*.]

[The ConOps should be reviewed as and when there are hardware, software, operational and management changes to the MASS or ROC] .

1.2 Operational Envelope

~~The Operational Envelope (OE) should encompass the MASS' operational capabilities and limitations and ship-specific capabilities and limitations to indicate the condition in which an autonomous or remote-controlled ship function can work properly, in order for the MASS to achieve its ConOps. The OE should contain all tolerable events, like external forces, navigation area, the relationship between humans and autonomous navigation systems. Tolerable events might lead the MASS to a degraded condition in which it should take appropriate action, e.g. return to port.~~

~~The OE should cover all relevant voyage or operation phases as well as all relevant autonomous or remote-controlled ship function processes. The conditions should include geographic or fairway conditions, environmental conditions, [conditions of the MASS] [own ship conditions], traffic conditions, division of responsibility between human and automatic control, as well as any other factors that have a significant impact on the operation of the autonomous ship function.~~

~~The OE should contain:~~

~~.1 the definition of the MASS functions and its use case(s);~~
~~.2 the geographic area of operations, including traffic systems, traffic density and coverage/connectivity;~~
~~.3 the description of the environmental expected and acceptable conditions;~~
~~.4 the description of operations with the stages of the voyage which shall be executed;~~
~~.5 the function conditions which mean the level of automation and autonomy;~~
~~.6 the functions (processes) for the required operations; and~~
~~.7 the division of responsibilities between humans and automation.~~

The Operational Envelope (OE) should encompass the MASS' operational capabilities and limitations and ship-specific capabilities and limitations to indicate the condition in which an autonomous or remote-operation ship function can operate safely in all operating conditions, including reasonably foreseeable degraded states.

The OE should contain:

.1 the definition of the MASS functions and conditions and its use case(s);
.2 the geographic area of operations, including coverage/connectivity and traffic conditions;
.3 the description of the environmental limitations;
.4 the description of operational limitations at different voyage stages;

.5 the use and management of the modes of operations, including the division of functions and allocation of tasks between humans and automation

.6 any other factors that have an impact on operations.

1.3 Fallback state

~~In case of an autonomous or remote-controlled ship function leaving its OE a fallback state for the MASS should be established to avoid, as far as [practicable] [possible], any harm to life at sea, other ships or the marine environment. Being in a fallback state should not result in an intolerable risk.~~

~~In case the autonomous or remote-controlled ship function does not perform as expected or is forced outside its normal operation, the MASS should enter its pre-defined fallback state until the expected performance of the autonomous or remote-controlled ship function is restored.~~

In case of a MASS deviating from its OE the MASS should enter its predefined fallback state and remain there to avoid, as far as practicable, any harm to life at sea, other ships, infrastructure or the marine environment until the normal operation of the [MASS] [autonomous or remote-controlled ship] function is restored. [Being in a fallback state should not result in an intolerable risk].

1.4 Mode(s) of Operation

The use and management of Mode(s) of Operation (MoO) are defined in the OE of a MASS. MoO might change during one voyage of the MASS, the criteria for changes of MoO during the voyage should be defined.

The MoO should:

.1 Identify which ship functions are autonomous or remote-controlled;

.2 Understand how these ship functions are allocated to different agents (human or software);

.3 Check how the affected ship functions are supervised, and by which agents;

.4 Know where the different agents are located (on board or remote); and

Map which other systems and other roles (personnel) are involved in performing the control action.

**~~2 Safe states for the ship~~**
**~~3 Functions Required for MASS~~**

## 4 Risk Assessment

4.1 The overall safety of the MASS is a primary objective. The safety of MASS control system is an integral part of the overall safety of a MASS ship. A risk assessment should be conducted to ensure that risks arising from the use of MASS functions, including relevant functions in ROCs, affecting persons on board, the environment, and the safety of the ship are addressed. The risk assessment can be conducted on MASS as a whole, or on the systems and equipment covered by the goals and functional requirements in PART 3.

*Note: Explanation: rationale, purpose and objects of risk assessment.*

4.2 A risk assessment should be carried out by personnel with relevant expertise and experiences, as needed or as required by the Administration of the flag State. A Risk assessment may be performed at the following stage, including but not limited to:

.1 MASS and system design phase;

.2 during an initial survey before the MASS is put in service and a renewal survey;

.3 after a major reconstruction of the vessel that may have impacts on MASS functions.

*Note: Explanation: the personnel and timing for risk assessment.*

4.3 Following the structure and procedures, as set out in [MSC.1/Circ.1455] [MSC-MEPC.2/Circ.12/Rev.2], risks should be analysed using suitable, recognized and appropriate risk assessment techniques[5]. The risk assessment should analyze and address all hazards associated with the intended operational envelope of the MASS including the associated ROCs, as described in the CONOPS. Apart from the known hazards such as loss of function, cyber attacks, component damage, fire, explosion and electric shock, it should also consider the random, systematic, and systemic hazards involved within the operational envelope. Identification of the arising risks should include a comprehensive description of the automation systems' utilization, [effectiveness and reliability] performing a thorough hazard analysis, conducting a mitigation [corrections and] [a] analysis, evaluating the identified risks, and implementing effective risk control measures. The assessment should ensure that hazards are eliminated wherever possible and hazards that cannot be eliminated should be mitigated as needed, with the details of hazards and the means of mitigating them being documented [, identifying the ALARP conditions for the CONOPS] to the satisfaction of the Administration.
*Note: Explanation: methodology and risks to be considered.*

## 5 System design principles

*Note – there is support for both of the following options and therefore both are included and should be discussed further before choosing one.*

~~Option 1~~
~~[5.1 Goal~~
~~Automated/Autonomous systems responsible for performing and supervising specific functions of the ship must consistently comply with relevant applicable international instruments.~~
~~5.2 Design Principles~~
~~The design of ship's automated/autonomous systems and system of systems should prioritize resilience and fault tolerance. Design of automated/autonomous functions and of the ship as a whole should be capable of effectively handling system emergent properties and mitigating random, systemic, and systematic failures.~~

~~.1 Robustness and Redundancy: Automated/autonomous systems should incorporate multiple layers of failure mitigation (redundancy) to ensure robustness and safety. Such layers should be designed to address potential failures and minimize their impact on the system's functionality.~~

~~.2 Human Control: Automated/autonomous systems should allow for human [meaningful] control. Humans should have the ability to intervene, override, or assume control of the system when necessary to ensure safety and mitigate risks.~~

[5] Refer to IEC/ISO 31010:2019 – Risk assessment techniques and Risk assessment Methodologies to be used include: IEC 61508 Parts 1 to 7 - Functional safety of electrical/electronic/programmable electronic safety; STAMP (MSC 107/INF.2), RBAT (MSC 107/INF.8 - EMSA/RBAT].

~~.3 Data Quality: Robust design processes should be established with a focus on ensuring high-quality data. Accurate and reliable data should serve as the foundation for the design, development, and operation of automated/autonomous systems.~~

~~.4 Tests and Validation Protocols: Comprehensive testing protocols for verification and validation procedures should be implemented throughout the design and development phases of automated/autonomous ship's systems. Testing protocols and validation procedures should address [relevant] scenarios and failure modes to ensure the system's reliability and performance under different conditions.]~~

~~.5~~

~~Option 2~~

5.1 Automated and Autonomous systems performing and supervising any specific function of the ship should be capable of complying with relevant applicable international regulations and instruments[6] at all times.

Ship's automated/autonomous systems [(and system of systems)], should be resilient, fault tolerant, with built-in redundancy, capable of addressing system's emergent properties, able to mitigate random, systemic, and systematic failures, with humans capable of [meaningful] control. Verifiable data quality, testing and validation protocols should always be implemented. [Note: Data quality and data management is crucial for autonomous systems to accurately perform specific functions. The onboard sensors environmental sensors, and ship systems, must consistently be provided and provide high-quality data. to enable safe, secure, and efficient decision-making. Provisions should be in place to identify and mitigate issues stemming from poor data quality, as these could lead to incorrect predictions or misinterpretations, posing a significant risk to the ship, human lives, and the marine environment. Maintaining data quality and data management should be a fundamental principle for ensuring the safety, reliability, and overall performance of autonomous systems.]

## 6 Software principles

These principles promote responsible stewardship and ensure software and AI systems (referred to as software) used within remote operation or fully autonomous ships and systems are trustworthy, safe and secure. In this context, software and AI systems refer to more than Machine Learning systems.

*Note:*
*CONTEXT: These principles are based on the UNESCO Principles for the Ethical Use of Artificial Intelligence in the United Nations System, UN System CEB (Chief Executives Board for Coordination) Principles for the Ethical Use of Artificial Intelligence in the United Nations System, OECD (Organisation for Economic Co-operation and Development) AI Principles, and national reports on AI and software principles and reflect the high-level principles presented in international guidelines and proposals made to the IMO. To ensure the principles are relevant to maritime and read well, we have amended some language but have left in references to indicate where the principle came from (e.g. (UNESCO) (CAN) etc. CONTEXT: It should be noted that some principles include trustworthiness as a principle, in its own right. We believe trustworthiness to be an outcome that can be achieved by ensuring the Software Principles are met.*

*CONTEXT: As per others section of the IMO MASS Code, we may need to include a reference to MSC.Circ.891 Guidelines for the On-Board Use and Application of Computers (Annex, section 3.3. which specifically refers to software).*

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[6] ISO/IEC/IEEE 15288:2023 Systems and software engineering — System life cycle processes
ISO/IEC/IEEE 21839:2019 Systems and software engineering — System of systems (SoS) considerations in life cycle stages of a system

6.1 Proportionality [and Do No Harm] [and Harm Prevention]
Software should have an explicit and well-defined operational envelope. (US) The use of software must not go beyond what is necessary to achieve a legitimate aim, and risk assessment(s) should be used to prevent [harms / hazards] which may result from such uses. (UNESCO)
*Note:*
*CONTEXT: We have included Do No Harm as this was proposed in some of the UN AI Principles. We believe software systems should do no harm, and it is a key principle in Laws of Robotics (an extensive summary of Robotic laws can be found here). However, it may not be appropriate for "do no harm" to be in the title; we also propose that the term "hazards" could be used instead of "harm" in the text, to align with maritime terminology.*

6.2 Safety and Security
Unwanted harms (safety risks) as well as vulnerabilities to attack (security risks) should be avoided and addressed (UNESCO). 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, humans, or the environment. (UN + CAN)

6.3 Transparency and Explainability
Software should be appropriately transparent and explainable, at all stages of its operational life and for all decision-making processes. (UK + UN) Technical explainability (and traceability) requires that the decisions made by software can be understood and traced by humans. (UN) The transparency and explainability should allow users and regulators to have sufficient information about the software, its associated inputs and outputs, and ensure that people understand when they are engaging with software and can challenge outcomes. (UN, OECD + UK Office)

*Note:*
*CONTEXT: Transparency refers to the communication of appropriate information about an AI system to relevant people (for example, information on how, when, and for which purposes an AI system is being used).*
*Explainability refers to the extent to which it is possible for relevant parties to access, interpret and understand the decision-making processes of an AI system (UK Office of AI).*

6.4 Accountability
Organisations and individuals developing, deploying or operating software should be held accountable for their proper operation (OECD). Software should be auditable and traceable. There should be oversight, impact assessment, audit and due diligence mechanisms in place to ensure accountability for the impacts of use throughout their operational life. (UNESCO + UN)

Appropriate governance structures should be established which prevent use for illegal activities, attribute the ethical and legal responsibility and accountability at any stage of the software's operational life (UN + CHINA)

*Note:*
*CONTEXT: There are links between accountability and liability, but we believe liability should not be included here yet as it will be covered elsewhere once discussed and agreed at the next Legal Committee.*

6.5 Validation and Robustness
Safe and secure software should be enabled through robust frameworks. (UN) Software should perform consistently with intended objectives, in a stable and resilient manner in a variety of circumstances. (CAN) The robustness of such systems should be tested and assured across their entire life cycle within that domain of use (US).

*Note:*
*CONTEXT: This should be checked against any principles of validation and verification that are included in the Code to ensure that software assurance is included.*

6.6 Human Oversight and Determination
Software should be designed and developed to enable people managing MASS operations ton exercise meaningful oversight. (CAN) Humans should have the ability to interpret appropriate context (CAN); prevent or minimize the risks to the safe, secure and environmental sound operation of MASS (OECD); and contest a decision or outcome that is detrimental to the safe, secure and environmental sound operation of MASS.

As a rule, life and death decisions or other decisions affecting fundamental human rights of individuals must not be ceded to AI systems, as these decisions require human intervention.~~(UN)~~
*Note:*
*CONTEXT: It should be noted that some principles include Contestability and Redress. Processes, or principles, for redress for when things go wrong will need to be considered, but we think this links to liability and should not be included here yet as it will be covered elsewhere once discussed and agreed at the next Legal Committee.*

6.7 Privacy, Data Governance and Data Protection
Privacy of individuals and their rights as data subjects must be respected, protected and promoted throughout the operational life of software (UN). International law and national sovereignty must be respected in the use of data.~~(UNESCO)~~

6.8 Fairness and Non-Discrimination
Software should be designed and developed to prevent bias, discrimination and stigmatization of any kind. (UN) Appropriate actions must be taken to mitigate discriminatory outcomes for individuals and groups to avoid unintended bias.

6.9 Inclusivity and Participation
The design, development and deployment of software should take an inclusive, interdisciplinary and participatory approach, which provides beneficial outcomes for the safe, secure and environmental sound operation of MASS, including seafarers and remote operators. ~~(UN + OECD)~~

## 7 Connectivity

7.1 MASS should establish reliable, stable and secure connectivity with ROC and other external stakeholders such as MRCC, ports, VTS, [LRIT] etc.

7.2 The connectivity between MASS and ROC should be established using redundant communication channels, including main and backup channels, preferably using different communication technologies and service providers.

7.3 The connectivity should have minimum acceptable network latency and required bandwidth for the operation of MASS.

7.4 The connectivity with the ROC should be fault-tolerant so that it operates at full capacity even in case of failure in a single component.

7.5 Traffic in the connectivity with the ROC should be prioritized according to a pre-defined prioritization policy to enable traffic with higher priority to be forwarded in case of reduced bandwidth.

7.6 The connectivity should operate according to appropriate Quality of Service (QoS) requirements and adapt with signal degradation.

7.7 The connectivity should be monitored for real-time or near real-time link quality analysis. If disconnection or performance degradation of the connectivity is detected, it should automatically switch to a backup connection.

7.8 When the conditions that cause connectivity failures or performance degradation disappear, the connectivity should be automatically reestablished.

7.9 Connectivity including computer-based system onboard MASS and ROCs should ensure the integrity of transmitted data. At the same time, measures* should be taken to protect the security of transmitted data.

* Refer to MSC.1/Circ.1639 and MSC-FAL. 1/Circ.3/Rev. 2.

**7bis Alert management**

**7.1 Goal**

The goal of alert management is to enhance the handling, distribution and presentation of alerts for a MASS during normal operation and emergency situations.

**7.2 Functional Requirements**

To achieve the above-mentioned goal, the following functional requirements which are supplementary to SOLAS requirements[7] are embodied in this section.

FR 1 An alert management optimization should be performed taking into account the ConOps so that the alert management provides:

- the means used to draw the attention of the [human operator] to the existence of abnormal situations,
- the means to enable the human operator to identify and address that condition,
- the means for the human operator and pilot to assess the urgency of different abnormal situations in cases where more than one abnormal situation has to be handled,
- the means to enable the human operator to handle alert announcements, and
- the means to manage all alert related states in a distributed system structure in consistent manner.

7.3 Expected Performance

EP 1: If practicable, there should be not more than one alert [per human operator] for one situation that requires attention.

EP 2: The alert management should be able to handle all alerts required by performance standards adopted by the Organization.

EP 3: 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 (e.g. using system knowledge from redundancy concepts inside the ANS and evaluating inherent necessities for alerts against navigational situations, operational modes or activated navigational functions).

EP 4: The master of a MASS should be able to access the alert management at all times.

EP 5: The audible announcement of alerts should enhance the guidance of the human operators to the task stations or displays which are directly assigned to the function generating

[7] Refer to the Code on Alerts and Indicators, 2009

the alert and presenting upon request 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 workstation where the collision avoidance function is provided.
EP 6: 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 displayed, silenced and acknowledged at any one task station.
EP 7: Means of direct communication between the human operator controlling the MASS and any person on board should be provided.

EP 8: In addition to conventional alerts, alerts specifically related to the operation of MASS should be considered, such as:

.1 upon entering a fallback state or upon recognizing the need to enter fallback state;

.2 in case the ANS cannot make an appropriate collision avoidance plan;

.3 in case the ANS cannot control the ship appropriately (e.g. deviation from the intended course and/or set speed range);

.4 in case the ANS itself and/or any other systems connected to the ANS (including sensors, actuators, and communication systems) have any abnormalities [and/or degradation];

.5 in case any conditions are about to deviate, or have already deviated from the predefined operating conditions of the ANS;

.6 in case the ANS detects undefined event (e.g. signal to which response is not defined);

.7 in case the communication quality is found to be reduced to a level where ROC operators cannot perform their intended operations;

.8 in case rolling accelerations or amplitudes exceed prescribed limits;

.9 in case of equipment failure during mooring at the berth for ship operating and shore personnel;

.10 in case the alert management system is not working properly; and

.11 in case a detected or suspected cybersecurity breach.

EP 9: Activated alerts should only be audible and visible to human operators operating the MASS emitting the alert.
EP 10: When an emergency alarm is activated, [at least [2]] [a sufficient number of] dedicated human operators including the master of the MASS should be [operating][controlling] the MASS until the emergency is over.

**8 Human element**
8.1 Roles and responsibilities
8.2 Manning
8.3 Training
8.4 Human-Machine Interface (including transfer of responsibility)

## PART 3 GOALS, FUNCTIONAL REQUIREMENTS AND PROVISIONS

*Note: Some Chapters in this Part of the Code include Expected Performance (EP) for each Functional Requirement (FR). It is proposed that EPs are not Tier IV and are in fact a 'fine tuning' of the FRs, therefore, they should not be seen as a replacement for 'Provisions' or 'Regulations' that may be included in the non-mandatory and mandatory versions of the MASS Code respectively.*

Each chapter in this part consists of the goal of the chapter, functional requirements to fulfil the goal, and the [expected performance] [provisions] associated with those functional requirements. A [ship] [MASS] should be considered to meet a functional requirement set out in this part when either:

a) the ship's design and arrangements [comply with all] [meet all] the [expected performance] [provisions] associated with that functional requirement; or

b) part(s) or all of the ship's relevant design and arrangements have been reviewed and [approved] [confirmed to be] in accordance with regulation [X] of SOLAS chapter [Y], and any remaining parts of the ship meet the relevant [expected performance] [provisions].

## CHAPTER 1 – NAVIGATION

1.1 Goal
The goal of this chapter is to provide for safe navigation of MASS for any mission phase, taking into account the modes of operation and the number of persons on board.

1.2 Functional Requirements (FRs)
In order to achieve the goal set out in paragraph 1.1 above, the following functional requirements are embodied in the provisions of this chapter.

1.3 General
A MASS should achieve the following functional requirements for navigation in general.

FR1.3.1 A MASS should comply with all relevant SOLAS Navigation Requirements [except where modified by the 2nd Tier Functional Requirements below].

FR1.3.2 A MASS should meet all relevant STCW and COLREG requirements by the collaboration with crew, operator, and/or Autonomous Navigation System (ANS).

FR1.3.3 Responsibility for the safety of navigation should be clearly defined at all times.

FR1.3.4 The use of ANS should not endanger the safety of persons onboard, the vessel or [the traffic environment including] other vessels.

FR1.3.5 The navigation equipment and systems on MASS should be designed, constructed, and installed to maintain their functionality under the [intended/expected] conditions in the [Operational Envelope (ODD) of MASS]/[Operational Design Domain (ODD) of ANS].

.1 The use of autonomous systems which are delegated control of function(s) or task(s) other than navigation functions should not endanger the safe operation of navigation system during autonomous navigation.; and

.2 [ANS should not affect the [existing]/[other installed] navigation systems. Even in the event of failure, [existing]/[other installed] navigation system should continue to be operable.]/[Even in the event of failure on ANS, the ship should be controlled safely by operating the [existing]/[other installed] navigation system without any effects of ANS.]

FR1.3.6 For autonomous or remotely controlled navigation, ODD of ANS should be [described][clarified], in accordance with the following requirements:

.1 The ODD should include information on the ship-specific capabilities and limitations in relation to the assessment required for activation of the ANS; and

.2 ANS should operate within its ODD as specified in the manual.

FR1.3.7 Functions related to [ensuring the safety of]/[safe] navigation should be maintained at all times and in such a way as to conform to the ODD, in accordance with the following requirements:

.1 The operation status of navigation hardware and software should be available at all times;

.2 ANS should be [approved]/[certified] by the Administration and/or recognized organization to evaluate performance in executing common operating tasks and to assess performance under [all operating conditions defined by ODD]/[defined conditions representative];

.3 [While] all reasonable steps should be taken to maintain ANS and related equipment in efficient working order [and must be seaworthy], malfunction of that equipment should not be considered as making the ship unseaworthy or as a reason for delaying the ship in ports where repair facilities are not readily available, provided suitable arrangements are made by the master to take the inoperative equipment or unavailable information into account in planning and executing a safe voyage to a port where repairs can take place;

.4 Task stations for the ANS should be located where crew/operator usually [exist (i.e. not necessarily in the bridge)]/[works place]. [Depending on the degree of autonomy, the control centre/station does not need to be located in the bridge];

.5 Manuals for the use of ANS should be readily accessible at the ANS itself and in all the task stations. Maintenance status of ANS (including system renewals, etc.) should also be accessible; and

.6 ANS should be designed to ensure that it can recover properly in case of an unexpected shutdown.

FR1.3.8 Redundancy design of ANS should be considered as necessary based on a result of risk assessment taking into account the mode of operation.

FR1.3.9 HMI should be designed appropriately for all the [possible] [expected] interactions between the crew/operator and MASS.

FR1.3.10 In the case of remotely controlled MASS with crew on board, all the displayed information should be consistent both on board the ship and in the remote operations centre. Interactions between onboard crew and remote operator should be considered for HMI design.

FR1.3.11 Hardware interface for autonomous control are appropriately connected. Performance checks and tests to ANS comply with ANS provider's documentations, e.g. safety manuals and recommendations.

1.4 Voyage plan[8]

A MASS should fulfil the following functional requirements for an appropriate voyage plan that establishes safe routes.

FR1.4.1

[<option1> Voyage plan from [departure to arrival]/[berth/port to berth/port] should be [planned]/[approved by the responsible person] to ensure safe navigation of MASS.

<option2> A detailed voyage or passage plan should be prepared which should cover the entire voyage or passage from berth to berth.]

FR1.4.2 Voyage plan should be developed taking into account the following issues:

.1 [The voyage plan should ensure that the operators are provided with sufficient information to enable operations to be conducted with due consideration to the safety of the ship and persons [on board];]

.2 [All potential navigational hazards [and hydro-meteorological] are [accurately] identified;]

.3 [Charts and publications[9] are corrected [updated] in accordance with the latest information available;]

.4 Comprehensive information including OE and mode of operation should be provided;

.5 [The voyage plan describing the full voyage from departure to arrival should be definable and updatable at any time; and]

.6 [A voyage plan is an indication of preferred actions based on information available at the time the plan is prepared; therefore departure from the plan may be necessary based actual circumstances at the time the plan is executed.]

FR1.4.3 Crew, operator and/or supervisor should verify that the voyage plan input into ANS is correct.

[FR1.4.4 An ANS may not be activated without an appropriately approved voyage plan.]

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[8] *Voyage plan* is to plan and conduct a route, determine position, and then input them in ANS before departure.

[9] Charts and publications are considered to include electronic versions.

1.5 Situational awareness

Situational awareness is the perception of the navigational and technical information provided and the comprehension of their meaning, as required for timely reaction to the situation.

FR1.5.1 When MASS is underway, MASS should be able to continuously monitor the following items:

.1 static and dynamic objects of its surroundings on the surface of the sea in the vicinity relevant to the safety of navigation such as sea marks, other vessels and wreckage; Lookout function which is a measure to realise the perception is to continuously monitor the ship's surroundings, when the ship is underway, to detect, recognize and identify any objects and lights on the surface of the sea in the ship's vicinity relevant to the safety of persons and the ship as well as other ships and vessels;

a. The detection function should provide discovery of an object and provide this information for the recognition function;

b. The recognition function should categorize the detected object and provide this information to the identification function;

c. The identification function should specify a unique identity of a recognized object needed to decide whether and how to react to the identified object; and

d. [The lookout function should inform of degradation of performance.]

.2 its own status such as heading, velocity, position and condition of each subsystem; and

.3 geographic information related to safety of navigation such as nautical chart information and environment condition.

FR1.5.2 The distress or emergency signal should be immediately detected and the type and scale of the emergency is promptly identified.

FR1.5.3 MASS[ANS] should integrate all information obtained from [1.2.3] to interpret and analyze MASS's condition with taking into account the limitations of the equipment and prevailing circumstances and conditions.

FR1.5.4 [Appropriate] [ Accurate] understanding of current and predicted vessel state, navigation path, and external environment should be shared with [crew/remote operator].

1.6 Route planning and determination for collision and grounding risk avoidance

A MASS should achieve the following functional requirements in order to ensure that decisions for collision and grounding avoidance are made appropriately.

FR1.6.1 ANS should plan an appropriate route to avoid collisions and groundings [according to changing/in all] conditions and notify other system and/or [the necessary personnel [such as the Master, crew, operator and/or supervisor]] based on the results of the situational awareness, taking into account the following items:

.1 Action taken to avoid a close quarter situation or collision with other vessels is in accordance with COLREG;

.2 Decisions and planning to amend course and/or speed are both timely and in accordance with safe operating limits of ship propulsion, steering and power systems; and

.3 [The route should be updated as required based on the latest inputs and conditions.]

1.7 FRs for heading, speed and track control

A MASS should achieve the following functional requirements in order to ensure appropriate control and actuation based on situational awareness and decision.

FR1.7.1 ANS should track with pre-defined accuracy based on its manoeuverability over the planned route including collision avoidance, berthing, un-berthing [and anchoring].

FR1.7.2 [Safe operating limits of ship propulsion, steering and power systems controlled by ANS are not exceeded in normal manoeuvres. ANS should be capable of adjustments made to the ship's course and speed to maintain safety of navigation.]/[ANS should be able to control the ship's capabilities such as propulsion, steering, powering to ensure safe navigation, taking into account current stability based on the ship’s loading conditions.]

1.8 Alert management

An ANS should achieve the following functional requirements in order to enhance the handling, distribution and presentation of alerts within the ANS and to ensure that onboard crew and/or the remote operator can override any autonomous functions and/or take over the control of the ship when necessary.

FR1.8.1 The alert management should support the proper application of SOLAS regulation V/15. The alert management of ANS should handle the [reasonably foreseeable] abnormal situations including those specific to MASS operations, such as the following situations that:

.1 the ANS cannot make an appropriate collision avoidance plan;

.2 the ANS cannot control the ship appropriately (e.g. deviation from the intended course and/or set speed range);

.3 the ANS itself and/or any other systems connected to the ANS (including sensors, actuators, and communication systems) have any abnormalities [and/or degradation];

.4 any conditions are about to deviate, or have already deviated from the ODD of the ANS; and

.5 the ANS detects undefined event (e.g. signal to which response is not defined).

FR1.8.2 In case of remotely controlled MASS with crew on board, all the alerts and the alert management status (e.g. acknowledgement of alarms and warnings) should be presented in the task stations both on board the ship and in the remote operations centre, with consistency among those task stations. Any abnormalities of the equipment in the remote operations centre should also be presented in the task stations both on board the ship and in the remote operations centre.

FR1.8.3 In case of MASS without crew on board, all the alerts and the alert management status (e.g. acknowledgement of alarms and warnings) should be presented in the task stations in the remote operations centre. If alert management is conducted [by onboard automatic back-up system], all the alert information including the abnormalities of the equipment in the remote operations centre should also be transferred to the back-up system.

1.9 Data record

A MASS should achieve the following functional requirements in order to adequately store data that contributes to safety navigation and casualty investigations.

FR1.9.1 Proper records of the movements, activities and time relating to ANS should be maintained at the same level as voyage data recorders.

FR1.9.2 In the case of remotely controlled MASS, the audio of conversations and communication logs at the remote operations centre should be stored.

FR1.9.3 In the case of MASS without crew on board, records of navigational activities and daily reports should be stored automatically or remotely.

1.10 Services for navigation

A MASS should achieve the following functional requirements in order to safely navigate by utilizing the services described in SOLAS Chapter V.

FR1.10.1 [MASS should use a mandatory ship's routeing system. If MASS decides not to follow the route for compelling reasons, any such reason should be recorded.]

FR1.10.2 Safe embarkation of necessary and expected external personnel [(e.g. pilots)] should be ensured regardless of the [concept of operations][nature] of the MASS [taking into account security issues].

FR1.10.3 In case of MASS without crew on board, information on navigation warnings, meteorological services, ice patrol service, vessel traffic services, aids to navigation[, port operation services] and danger messages should be available [for crew, operator and/or ANS].

FR1.10.4 In case of MASS without crew on board, observed meteorological data, information relating to ship reporting systems, reports to VTS and danger messages should be reported automatically or remotely, as required.

1.11 Override and safe fallback response

An ANS should be capable of the override and safe fallback response set out in the following functional requirements.

FR1.11.1 A Crew/operator should be able to override ANS at any time of their own choice, in accordance with the following requirements:

.1 Mode switching to override should be an easy operation; and

.2 In case of MASS allowing override remotely, the means should be provided, taking into account cyber security and connectivity.

FR1.11.2 Fallback response should be promptly performed in case of deviation from the ODD (including internal ANS conditions and external environment). The crew/operator should be notified when an ODD deviation occurs or is predicted and ANS should be maintained in an appropriate status until the fallback response is completed.

FR1.11.3 In case where it is difficult for MASS to continue normal operations, e.g. the crew/operator cannot respond promptly to a fallback request, Minimal Risk Manoeuvre (MRM), i.e. the action of moving MASS to pre-defined Minimal Risk Condition (MRC), should be carried out, in accordance with the following requirements:

.1 The condition for transition to MRM and the content of MRC should be designed, taking into account the ConOps and mode of operation of MASS; and

.2 MASS should notify the crew/operator and surrounding vessels promptly when it transitions to MRM.

## CHAPTER 2 – REMOTE OPERATIONS

### 2.1 GOAL

The goal of this chapter is to ensure the safe remote operation of a MASS [, or automated functions thereof,] from a location which is not onboard the ship[10], taking into account the modes of operation* and the number of persons on board.

### 2.2 FUNCTIONAL REQUIREMENTS

In order to achieve the goal, set out in paragraph xx above, the following functional requirements are embodied in this chapter:

FR 2.2.1: A MASS [, or the automated functions thereof,] should be able to be operated from a ROC at a secure location to ensure the safe, secure and effective operation of MASS at any time when they are in service.

The location should provide the ROC with:

EP.1: facilities that are secure and protected from unauthorized access.
EP.2: means to enable reliable connectivity and communication between the ROC and the MASS, third parties[11] and any shipboard personnel.
EP.3: facilities to authorize access to, and sharing of, certificates and other mandatory documents required to demonstrate MASS are compliant with international, national and regional requirements.
EP.4: mechanism(s) by which failure and recovery of the ROC would not result in an unsafe state or intolerable risk on or around the MASS in service, including the use of redundancy or back up measures. [OR, mechanisms by which the ROC can enter a fallback state]

The ROC should be equipped with:

EP.5: validated and verified systems to support the execution of effective remote operation of MASS.
EP.6: sufficient and relevant qualified personnel [in accordance with Management of Safe Operations requirements] to enable safe operation of MASS, taking into consideration the total number of MASS that are operated from the same ROC.

[10] Note this position could be on land or on board another ship.

[11] Third parties include persons that are not involved in the operations but engaging with the MASS, e.g. VTS, ports, pilots or other persons in the ROC for maintenance reasons, persons in distress, other vessels.

FR 2.2.2: MASS[, or the automated functions thereof,] should be operated from control station(s) to ensure the safe, secure and effective operation.[12]
A control station located within a ROC should:

- EP 1: have appropriate validated and verified systems to enable effective operation of MASS.
- EP 2: provide sufficient and accurate data and information to enable the remote operator to carry out their role(s) effectively.
- EP 3: be fully compatible throughout its operational life with MASS [or the automated functions] under its control.
- EP 4: be tested to ensure that when installing and updating system(s) on MASS, it should be confirmed that the related on-board equipment and devices have appropriate compatibility and interoperability with those in the ROC.
- EP 5 ensure failure and recovery of the control station(s) would not result in an unsafe state or intolerable risk, on or around the MASS, including the use of redundancy and back up measures. [OR have mechanisms by which the control station can enter a fallback]
- EP 6 be designed and operated in such a way that its location does not result in loss of control or negatively affect the MASS performance.

FR 2.2.3: The control station(s) and MASS[, or the automated functions thereof,] to be operated remotely should have validated and verified systems and interfaces that enable the remote operator to ensure the safe, secure and effective operation.
This will be accomplished by ensuring:

- EP 1: The ability to keep a watch at sea or in port in a manner conforming to the principles of watchkeeping, [~~such~~ as ~~those~~ described in Parts 3, 4 and 5 of Section A-VIII/2 of the STCW Code[13]].
- EP 2: the ability to send and receive sufficient and accurate information/commands effectively and securely between the ROC, MASS, third parties, and any shipboard personnel.
- EP 3: the ability to make all decisions necessary to ensure the safe operation of MASS.
- EP 4: the status of the connectivity is known at the control station(s) and MASS and where relevant by third parties.
- EP 5: it is known at all times which systems can be controlled, have the location which is in control clearly visible, and know whether this is in accordance with the operational envelope.
- EP 6: awareness of when conditions on the MASS in service or at the ROC deviate from the operational envelope.
- EP 7: ability to monitor the condition and mode of operation of MASS equipment and systems and, take measures to prevent and/or rectify deficiencies when emergency warnings actuate.

FR 2.2.4: The transfer of operation of MASS [, or the automated functions thereof] should be safe and secure.

This will be accomplished by ensuring:

- EP 1: transfer of all necessary information is possible between control station(s), ROC and the MASS.

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12 A ROC may have multiple control stations within its facilities.

13 We note reference to STCW sections may be premature ahead of any decision regarding remote operator status, but the principles of watchkeeping as described in STCW should apply.

EP 2: operation can be transferred safely and securely during failure and/or recovery or an emergency situation at the ROC or control station(s).
EP 3: the control is not provided by multiple positions at the same time and the present control station is clearly indicated both in ROC and on-board the MASS.
EP 4: when the operation is transferred there is no loss of control of the MASS and it does not negatively affect performance of the MASS or the ROC.

FR 2.2.5: Software used in the control station(s), ROC and/or on-board the MASS should be appropriately managed and remain within the defined operational envelope.

This will be accomplished by [ensuring] [having] software:
EP 1: is designed, integrated, managed, maintained and supported throughout its operational life to ensure safe and secure operation of MASS.
EP 2: is able to receive, recognize and assist with the prioritization of emergency and non-emergency situations, such as out-of-the-loop loss of situational awareness, occurring on board the MASS to enable the remote operator to carry out their role(s) effectively.
EP 3: [is designed to ensure that the remote operator is able to read and understand the information transmitted to the ROC, in order to support safe decisions by the remote operator.]

FR 2.2.6: Data and information used, produced, sent or received by a ROC should be retained in reliable and tamper proof storage and at a suitable standard of data quality, considering the information necessary for operation of MASS, the total number of MASS that are operated from that ROC, and referring to the SOLAS requirements for Voyage Data Recorders.

## CHAPTER 3 – COMMUNICATIONS

### 3.1 GOAL

The goal of this chapter is to [ensure] [provide] stable, reliable, and secure communication with other ships in the vicinity and external communication including connection with the ROC and external systems under normal and emergency operation of MASS.

### 3.2 FUNCTIONAL REQUIREMENTS

To achieve the above-mentioned goal, the following functional requirements are embodied in this chapter.

3.2.1 General

FR 3.2.1Measures should be taken to [ensure] [establish] that the communication between the MASS and its communication objects is achieved.

*Note:*
*Explanation: In order to achieve communication in the current situation, there is no limit to the methods and means used.*

FR 3.2.2 The communication between the MASS ship and its communication objects should meet the operation needs of MASS.
*Note:*
*Explanation: The essential requirement of communication is to meet the needs of the ship, including but not limited to bandwidth, speed, time-delay, redundancy, etc.*

FR 3.2.3 MASS should meet the functions required by Regulation IV/4 of the SOLAS Convention.

*Note:*
*Explanation: MASS ships should have the same communication function as convention ships.*

3.2.2 Communication between MASS and ROC
FR 3.2.4 MASS should establish reliable and secure connectivity with one or more designated ROCs throughout their entire voyage.
Additional requirements for remote operated ships and fully autonomous ships

FR 3.2.5 The remote operator should be able to seamlessly switch and distribute different vessel data between the different communication channels without a negative effect on the operations.

FR 3.2.6 For remote operated ships, communication with external stakeholders is able to be executed by personnel in ROC.

FR 3.2.7For full autonomous ships, communication with external stakeholders is able to be executed by automated system on the MASS itself.

## CHAPTER 4 – SUBDIVISION, STABILITY AND WATERTIGHT INTEGRITY

### 4.1 Goals

The ship should, owing to the varying conditions of service, e.g. the loading condition(s), sailing conditions and the weather conditions, not be vulnerable to stability failures, regardless of whether in intact or damaged conditions.

### 4.2 Functional Requirements

Onboard systems
FR 4.2.1A stability control [system] [function] should be in place, capable of continuously determine by calculations and/or measurements the ship intact stability during its operation as well as to assess the survivability of the ship in case of damage, to maintain that the ship, at all times is operating within the stability envelope as prescribed in the stability booklet.

FR 4.2.2 The stability control system should be resilient to single failure.
FR 4.2.3 The stability control system should be supervised by an independent control system. The action of the supervising independent control system shall be triggered by failures/events[14] of the stability control system.

FR 4.2.4 Any automated/autonomous system performing and supervising intact stability of the ship should be capable of restoring ship's compliance with relevant applicable intact stability requirements [15]if the system has detected that these requirements are not met.

FR 4.2.5 The control system supervising the stability control system should rely on an independent measuring system and sensors.

Remote [Control] [Operations] Centre
FR 4.2.6 The Remote Control Centre (RCC) should be supplied with real-time information as is necessary to control the ship draughts and stability at all times, including ship movements in 6 degrees of freedom.

14 Events such as but not limited to, alarms from ballast systems, malfunction of any stability control system component, loading not according to loading plan, lost communication with the stability control system and/or with the RCC.

15 List of all relevant applicable stability regulations, see cover notes associated to the chapter 3.4

FR 4.2.7 The stability control system and/or the supervising control system should be able to detect existing or predictable intact stability failures, as well as damaged stability failures if in damaged condition, and alarm the ship and the [RCC] [ROC] if, for example, the rolling accelerations or amplitudes exceed prescribed limits.

FR 4.2.8 The stability control system, the supervising control system and the [RCC] [ROC] should be able to bring the ship to the [Minimum Risk Condition (MRC)] [Fallback State] upon an alarm.

FR 4.2.9 The stability control system, the supervising control system and the [RCC] [ROC] should be able to monitor, control and operate any systems[16] onboard that may affect the stability of the ship.

## CHAPTER 5 – FIRE PROTECTION/SAFETY

### 5.1 GOAL

The goal of this chapter is to fulfil the fire-safety objectives of SOLAS chapter II-2, taking into account the modes of operation and the number of persons on board.

### 5.2 Functional Requirements

To achieve the above-mentioned goal, the following functional requirements which are [supplementary] [complementary] to SOLAS chapter II-2 are [to be complied with] [embodied in this chapter]:

FR5.2.1: A MASS should remain under control or enter a fallback state during and following a fire event. This will be accomplished by ensuring ~~xxxx~~:

[EP 1: The ship should be able to enter an approved fallback state following a fire in any single fire compartment.

EP 2: A fire limited to a single compartment not directly linked to the control of the ship should not cause a loss of [navigational] control or lead to a fallback state.

FR 5.2.2: Means should be provided to enable detection, confirmation and localization of a fire incident. ~~This will be accomplished by ensuring xxxx:~~

[EP 1: All alarms related to the fire safety systems should be routed to the control station.

EP 2: Means for timely detection of a fire must be provided in all compartments with a fire risk.

EP 3: A human operator should be made aware of the detection and localization of a fire along with the status of any actions taken by the fire protection systems.

EP 4: After a fire detection alarm is activated, means should be provided to confirm a fire which are different from the original detection source.

EP 5: If alarm signals are not acknowledged, a secondary alarm should be automatically activated at the control station and throughout the ship.

EP 6: After detection and confirmation of the fire, means should be provided to localize the fire accurately, so that the most appropriate fire extinguishing means may be activated.]~~EP 2: After a fire detection alarm is activated, means should be provided to confirm a fire which are different from the original detection source.EP 3: If the signals have not been acknowledged within 2 min, an audible fire alarm shall be automatically sounded at the control station.~~

[16] Systems like e.g. watertight doors (if any), valves, cross-flooding systems, ballast water and anti-heel tanks.

~~EP 4: After detection and confirmation of the fire, means should be provided to localize the fire so that the most appropriate fire extinguishing means may be activated.]~~

FR 5.2.3: Means should be provided to enable the proper use of fire [extinguishing] [protection] systems, taking into account the possible presence of people~~. This will be accomplished by ensuring xxxx:~~

EP 1: If a fixed fire extinguishing system is present and its activation poses risks to onboard humans, safeguards must account for human presence before activation.

EP 2: The operation of the fire extinguishing system should not impede the possibility of escape.

EP 3: Fire extinguishing systems should be able to be safely isolated for compartment access or maintenance and should provide onboard indication and warning of activation.

EP 4: While operating fire extinguishing systems, the stability of the vessel should be actively monitored.

EP 5: Information and instructions in relation to fire safety should be provided to any personnel boarding the ship.~~[EP 1: If the ship has a fixed fire extinguishing system, the activation of which might be harmful to humans, and humans are onboard the ship, they should be accounted for before activating the system.]~~

~~[EP 2: The operation of the fire protection system should not impede the possibility of escape.]~~

~~[EP 3: Fire-fighting systems shall be able to be safely isolated for compartment access or maintenance and shall provide onboard indication and warning of activation.]~~

~~[EP 4: While operating fire extinguishing systems, the stability of the vessel should be actively monitored.]~~

~~[EP 5: Information and instructions in relation to fire safety should be provided to any external personnel boarding the ship.]~~

FR 5.2.4: Means should be provided to assess the fire-fighting effectiveness during and after fire. ~~This will be accomplished by ensuring xxxx:~~

[EP 1: Means should be provided to assess any smoke development in spaces adjacent to the compartment affected by the fire during and after the fire.

EP 2: Means should be provided to assess the temperature development in spaces adjacent to the compartment affected by the fire during and after the fire.]

FR 5.2.5: Means should be provided to enable the control of all active fire protection measures. ~~This will be accomplished by ensuring xxxx:~~

EP 1: All active fire protection measures should be individually controllable, allowing activation, deactivation, and status monitoring.

EP 2: Drills involving all relevant personnel should take place on regular intervals including the intended activation of fire protection measures. All active protection measures should be tested on regular intervals.

EP 3: Means should be available to automatically detect faults of systems related to fire protection.

~~[EP 1: Means should be provided to enable the individual activation, deactivation and status monitoring of all active fire protection measures.~~

~~EP 2: Drills should take place every X weeks including the intended activation of fire protection measures. Within a period of Y months, all active protection measures should be tested.~~

~~EP 3: Means should be available to automatically detect faults of systems related to fire protection.]~~

FR 5.2.6: Means should be provided to facilitate an intervention from external fire responders. ~~This will be accomplished by ensuring xxxx:~~

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 MASS ~~control station~~ and the external fire responders should be ensured during and following a fire incident.

EP 3: Access to the ship for external fire responders should be possible when any single compartment is on fire.]

## CHAPTER 6 – LIFE SAVING APPLIANCES AND EQUIPMENT

### 6.1 Goal

The goal of this chapter is to save and maintain human life during and after an emergency situation taking into account the mode of operation of the ship and the number of persons on board.To achieve the above-mentioned goal, the following functional requirements are embodied in this chapter.

### 6.2 Functional requirements

FR 6.2.1All life-saving appliances should be in a state of readiness for immediate use.

FR 6.2.2In the event of an emergency, human safety should be the priority.

FR 6.2.3All ships should provide means for a safe abandonment for all persons.

FR 6.2.4All personnel involved in the operation of MASS should be trained to take appropriate measures in case abandonment of personnel is required.

FR 6.2.5All ships should provide means for the safety and survivability of all persons after abandonment for the time until expected rescue.

FR 6.2.6All ships should have an effective emergency management system.

FR 6.2.7The use of [automated and/or remotely controlled] lifesaving appliances should not endanger the safety of any persons on board or of the ship.

FR 6.2.8Proper instructions and information to be provided in relation to all lifesaving appliances and their use.

FR 6.2.9All survival craft and lifesaving appliances should be capable being deployed [automatically] [autonomously] to enable the safe abandonment of personnel from the MASS.

FR 6.2.10 Sequence of abandonment of survival craft and lifesaving appliances with the necessary equipment's must be pre-established.

FR 6.2.11 Provision should be made to enable the deployment of lifesaving appliances and response to be undertaken on board by an external responder. This should include provisions for establishing communications with the remote operating center and a response to an abandonment of personnel.

FR 6.2.12 The lifesaving appliances media and by-products of any [automated] [autonomous or remotely controlled] lifesaving appliances should be managed so that they do not present a [an increased] risk to the safety of persons on board or of the ship.

FR 6.2.13 Management of an abandonment of personnel using lifesaving appliances shall be possible from the remote operating center and the operator shall be provided with sufficient information to understand the scale, impact, response, and success of the survival of personnel.

FR 6.2.14 An appropriate level of communication between the MASS and the remote operating center should be maintained during and following an abandonment of personnel.

## CHAPTER 7 – MANAGEMENT OF SAFE OPERATIONS

### 7.1 Goal

The goal of this chapter is to fulfil the safety objectives for management of safe operation of SOLAS Chapter IX and the ISM Code taking into account the mode(s) of operation and the number of persons on board.

### 7.2 Functional Requirements

In order to achieve the goal set out in paragraph 7.1 above, the following functional requirement and expected performances (EP), which are [supplementary] [complimentary] to SOLAS chapter IX and the ISM Code, are embodied in the provisions of this chapter.

FR7.2.1 Additional operational hazards from autonomous or remote-controlled ship functions should be addressed in the Safety Management System (SMS) of the company.

This will be accomplished by ensuring the following Expected Performance (EP):

- EP 1: Consideration of role and expected performance of all physical location(s) involved in the MASS operation.
- EP 2: Consideration of interaction of autonomous or remote-controlled ship functions.
- EP 3: Consideration of capabilities and limitations of autonomous or remote-controlled ship functions.
- EP 4: Consideration of complexity of systems, including software systems or data services.
- EP 5: Consideration of risk control measures addressing all identified hazards.
- EP 6: Consideration of equipment and systems necessary to maintain contact to the MASS.
- EP 7: Consideration of lines of communication to maintain contact to the MASS.
- EP 8: Consideration of cyber-threats.
- EP 9: Consideration of fall-back system to maintain safe navigation.

FR7.2.2 Additional hazards to humans involved in MASS operations should be addressed in the Safety Management System (SMS) of the company.

This will be accomplished by ensuring the following Expected Performance (EP):

EP 1: Consideration of human resources and training requirements.

EP 2: Consideration of responsibilities with regard to the intersection and interaction to operate a MASS.

EP 3: Consideration how to maintain function of overriding authority.

EP 4: Consideration of emotional pressure, specific stresses and strains to humans in the operation of a MASS.

EP 5: Consideration of risk control measures addressing all identified hazards.

FR7.2.3 Additional emergency hazards from autonomous or remote-controlled ship functions should be addressed in the Safety Management System (SMS) of the company.
This will be accomplished by ensuring the following Expected Performance (EP):

EP 1: Consideration of monitoring autonomous or remote-controlled ship functions performance including relevant system and ship parameters.

EP 2: Consideration of assistance for emergency handling, or handling of other potentially unsafe conditions.

EP 3: Consideration of capabilities and limitations of emergency response in the MASS operation.

EP 4: Consideration of internal audit processes addressing autonomous or remote controlled ship functions.

EP 5: Consideration of risk control measures addressing all identified hazards.

## ~~CHAPTER 8 - CONTROLLING THE OPERATION OF A SHIP~~

*Agreed previously to delete.*

## CHAPTER 9 – SECURITY

### 9.1 Goal

The goal of this chapter is to fulfil the security objectives of SOLAS Chapter XI-2 and the ISPS Code, taking into account the number of persons, [and the property] on board and [the level of autonomy] [mode of operation].

### 9.2 High Level Functional Requirements

FR 9.2.1 A MASS should comply with all relevant SOLAS security requirements for all security levels as modified by the specific functional requirements below.

.1 to detect security threats and take preventive measures against security incidents affecting ships; and

.2 to ensure confidence that adequate and proportionate maritime security measures are in place.

FR 9.2.2 The use of [automated and/or remotely controlled] security systems should not endanger the security of any persons or property on board or of the ship.

FR 9.2.3 Onboard [and remote] management of automated [autonomous] systems should be provided to enable control of the systems.

FR 9.2.4 Means should be provided to enable the assessment of security effectiveness.

FR 9.2.5 A MASS should remain under control during and following a security event.

FR 9.2.6 The use of [automated] [autonomous] security systems should not prevent the effective physical security; structural integrity; personnel protection systems; procedural policies; radio and telecommunication systems including computer systems and networks; and other areas that may, if damaged or used for illicit observation, pose a risk to persons, property, or operations on board the ship.
FR 9.2.7 There should be a mechanism for safely shutting MASS communications down when the security of the remote operation centre has been compromised.

**9.3 Specific Functional Requirements**

FR 9.3.1 Means should be provided for the effective coordination on security level between port and MASS.

FR 9.3.2 Critical systems for maintaining appropriate control of the vessel should be protected from foreseeable security events.

FR 9.3.3 Boundaries where a security event can occur should be fitted with a suitable control system.

FR 9.3.4 Effective security measures are to be provided in all compartments/open deck areas where there is a security [hazard/risk]. [These may be active or passive to prevent unauthorized access to ships and their restricted areas and to prevent the introduction of unauthorized weapons, incendiary devices, or explosives to ships or port facilities].

FR 9.3.5 Provision should be made to enable security control and response to be undertaken on board by an external responder. This should include provisions for establishing communications with the remote operating centre and a response to a security event on board. Information concerning onboard control systems should be readily available to the responders.

FR 9.3.6 The security system should be managed so that they do not present a [an increased] risk to the safety of persons on board or of the ship.

FR 9.3.7 Communication systems for ships should be maintained.

FR 9.3.8 Management of a security event should be possible from the remote operation centre and the operator shall be provided with sufficient information to understand the scale and impact of an event and the response and success of the security measures on board the ship.

FR 9.3.9An appropriate level of communication between the MASS and the remote operating centre should be maintained during and following a security event.

FR 9.3.10 Upon identification of a security event the MASS should enter an appropriate fallback state and be capable of maintaining that state during and following the event to the degree necessary to prevent it becoming a hazard.

FR 9.3.11 Means should be provided for controlling access to the ship, as well as the embarkation of persons and their effects automatically. (Conventionally by seafarers.)

FR 9.3.12 Means should be provided for monitoring and recording restricted areas, deck areas, areas surrounding the ship.

## CHAPTER 10 – SEARCH AND RESCUE

10.1 GENERAL

### 10.1.1 Goal

The goal of this part is to ensure that MASS fulfill the duties and tasks of any vessel under the International Law regarding distress situations, taking into account the mode of operation of the MASS [and the number of persons on board]. These duties and tasks can be summed up to three: duty to render assistance and to proceed to rescue persons in distress at all possible speed, duty to coordinate with the SAR services of the coastal State, and to render assistance requested by the coastal State. This chapter deals also with the duties of a MASS in distress. Master's authority regarding distress situation should be in line with regulations that deals with master's authority . In particular, the vessels to which SOLAS Chapter V applies should satisfy the following functional requirements.

### 10.1.2 Functional requirements:

In order to achieve the above mentioned goal ~~set out in paragraph 3.10.1 above~~, the following functional requirements are embodied in the provisions of this chapter:

FR 10.1.1 Every MASS in position to be able to provide assistance and receiving information from any source of persons in distress at sea, is bound to render assistance in so far as such action may reasonably be expected ~~of him~~ and it~~he~~ can do so without serious danger to the ship or the crew ~~or the passengers~~.

FR 10.1.2 Having account of the previous FR, every MASS should proceed with all possible speed to the rescue of persons in distress.

FR 10.1.3 Keeping in mind its operational limitations, every MASS will be at the disposal of the search and rescue service responsible for the SAR operation the MASS is involved in, except if its participation is deemed not necessary.

FR 10.1.4 After a collision, every MASS should render assistance to the other ship, its crew and its passengers, and provide the other vessel with the name of the vessel, its port of registry and the next port of call.

FR 10.1.5 A MASS master should lead SAR activities ~~onboard~~ in case of distress.

FR 10.1.6 A MASS master should have, according to international Law, the authority and responsibility to make decisions concerning safety and security of the ship, including to cooperate with SAR services of the coastal state concerned.

10.1.[3] Provisions

In order to comply with the functional requirements stated above, regardless of the mode of operation or the presence of persons on board, the MASS should comply as required to ships of the same tonnage and type. No matter if the MASS has crew on board, compliance with the tasks specified should be assured.

**10.2 Distress signals and communications**

**10.2.1 Goal**

The goal of this part is to ensure that the MASS fulfill the duties and tasks regarding the use of distress signals and communications related to a distress situation. This chapter should be read in conjunction with the Communications chapter of this Code.

**10.2.2 Functional requirements**

In order to achieve the goal set out in paragraph above, the following functional requirements are embodied in the provisions of this chapter. In particular, the vessels to whom SOLAS Chapter IV applies should be able of the following:

FR 10.2.1 MASS should be able to emit, receive, identify, locate and relay distress signals.

FR 10.2.2 Personnel in charge of the MASS should be able to emit and identify distress signals. The distress or emergency signal should be immediately detected, and the type and scale of the emergency should be promptly identified.

FR 10.2.3 MASS should be able to transmit, receive, identify and relay distress communications. A MASS without crews onboard, should be able to automatically generate ship to shore distress alerts. The alerting process must ensure that alerts are transmitted when required and that false alerts are avoided.

FR 10.2.4 MASS should be able to keep an operation watch at the distress frequencies.

FR 10.2.5 Personnel in charge of the MASS should be able to transmit, receive, identify and relay distress messages.

FR 10.2.6 Personnel in charge of the MASS should have training on distress incidents communications and the applicable certification.

FR 10.2.7 Personnel in charge of the MASS should be able to coordinate SAR communications.
FR 10.2.8 MASS sensors should be able to collect environmental data and share them with the Remote Operations Center (ROC).

10.2.[3] Provisions
In order to comply with the functional requirements stated above, regardless of the mode of operation or the presence of persons on board, the MASS should be equipped with the devices and systems that are required to ships of the same tonnage and type. No matter if the ship has crew on board, effective Distress communications and identification of Distress signals should be assured.

**10.3 SAR Actions**

**10.3.1 Goal**

The goal of this part is to fulfill the duties and tasks of every MASS receiving a distress alert, apart to those related with distress signals and communications. In particular, the vessels to whom SOLAS Chapter III applies should be able of the following:

### 10.3.2 Functional requirements

In order to achieve the goal, set out in paragraph above, the following functional requirements are embodied in the provisions of this chapter.

FR 10.3.1 If applicable, every MASS should be fitted with, at least, one rescue boat.

FR 10.3.2 If applicable, rescue boat manuals should be available to the personnel in charge of the MASS.

FR 10.3.3 Vol. III of IAMSAR Manual should be available to the personnel in charge of the MASS.

FR 10.3.4 The MASS should have specific plans and procedures for the rescue of persons in Distress.

FR 10.3.5 A MASS should detect, recognize, and identify objects and lights according to FR 3.1.3.1 (NAV chapter).

FR 10.3.6 A MASS should be able to establish relative bearing to detected objects.

FR 10.3.7 A MASS should be able to launch, recover and stow the rescue boat.

FR 10.3.8 A MASS and the rescue boat should have means to ease the boarding of persons in distress.

FR 10.3.9 A MASS should have a sheltered space on board to accommodate persons in distress.

FR 10.3.10 A MASS should be able to use a line-throwing appliance.

FR 10.3.11 A MASS should have a training and drills plan related to the rescue of persons in distress.

FR 10.3.12 A MASS should have a rescue boat maintenance plan.

FR 10.3.13 A MASS should have specific plans and procedures, including responsibilities, for its own distress situations.

~~10.3.3 Provisions~~

~~In order to comply with the functional requirements stated above, regardless of the mode of operation or the presence of persons on board, the MASS should be equipped with the devices and systems that are required to ships of the same tonnage and type . No matter if the ship has crew on board, effective Search and Rescue actions should be assured.~~

## CHAPTER 11 – CARGO HANDLING

### 11.1 Goal

The goal of this chapter is guidance in relation to the safety objectives contained in SOLAS Chapter VI, VII and XII for the care of cargoes during loading, unloading and voyage as well as keeping the ship, human life, and the environment safe from events caused by cargoes under voyage taking into account the mode(s) of operation and the number of persons on board.

### 11.2 Functional requirements

FR 11.2.1 Provide necessary connectivity for transferring relevant cargo information irrespective of the level of manning or means of control of the ship and its cargo.

FR 11.2.2 All relevant cargo information should be provided irrespective of the level of manning or means of control of the ship and its cargo.

FR 11.2.3 Handling of cargo required by IMO instruments should be provided irrespective of the level of manning or means of control of the ship and its cargo.

FR 11.2.4 The Cargo emergency response should be provided irrespective of the level of manning or means of control of the ship and its cargo.

## [CHAPTER 12 – PERSONNEL SAFETY AND COMFORT]

### 12.1 Goal

The goal of this chapter is to ensure the health, safety, and comfort of any personnel on board a MASS or at a Remote Operation Centre.

### 12.2 Functional Requirements

In order to achieve the goal, set out in paragraph 3.12 above, the following functional requirements are embodied in the provisions of this chapter.

FR 12.2.1 Where a MASS can be boarded, or operates with persons on board, it should meet all applicable existing regulations for personnel safety and comfort.

FR 12.2.2 Personnel should have safe means of embarkation and disembarkation to and from a MASS.

FR 12.2.3 Remote Operation Centres and workstations should be developed using Human Centred Design (add footnote defining Human Centred Design as per MSC.1/Circ.1512 "where systems are designed to suit the characteristics of intended users and the tasks they perform, rather than requiring users to adapt to a system").
*(Note: *may overlap with Part 3 chapter 2)*

FR12.2.4 Remote Operation Centres and workstations should be ergonomically designed [including visual ergonomics]
*(Note: *may overlap with Part 3 chapter 2)*

FR 12.2.5 Use of wearable technologies should adhere to health and safety requirements.

FR 12.2.6 Personnel working at a Remote Operation Centre should have suitable hours of work and rest *(Note: *may overlap with Part 3 chapter 2)*.

FR 12.2.7 Personnel should not be exposed to levels of noise that exceed safe working conditions.

FR 12.2.8 Human Machine Interfaces should be designed to meet the capabilities of all intended users *(Note: *may overlap with Part 3 chapter 2)*.

FR 12.2.9 Personnel should not be exposed to levels of vibration that exceed safe working conditions.

FR 12.2.10 Risks to personnel from hazardous circumstances should be minimized.

FR 12.2.11 Personnel should be provided with appropriate medical care or aid.

FR 12.2.12 The facilities and working conditions of a Remote Operation Centre or MASS should [promote] [support] the health and well-being of all personnel.

FR 12.2.13: There should be sufficient and suitable ventilation, natural or artificial or both, supplying fresh or purified air.

FR 12.2.14: The best possible conditions of temperature, humidity and movement of air should be maintained, and larger fluctuations avoided.

FR 12.2.15: There should be sufficient and suitable lighting, natural or artificial, or both.

FR 12.2.16: Sufficient and suitable sanitary conveniences should be provided for in suitable places and be properly maintained.

FR 12.2.17: Sanitary conveniences should be adequately ventilated and so located as to prevent nuisances. They should not communicate directly with workplaces.

FR 12.2.18: Control room should have sufficient space to comfortably accommodate all necessary equipment and allow operator to move freely.

## CHAPTER 13 – TOWING AND MOORING

### 13.1 Goal

The goal of this chapter is to fulfill the safety objective of the SOLAS regulations II-1/3-4 and II-1/3-8 for safely and securely towing and mooring operations, having regard the modes of operation and the number of persons on board.

To achieve the above-mentioned goal, the following functional requirements, which are [supplementary] [complementary] to SOLAS chapter II-1 Reg. 3-4 and Reg. 3-8, are embodied in this chapter:

### 13.2 Functional Requirements

FR 13.2.1 Shipboard mooring and towing arrangements should enable the ship to conduct berthing, un-berthing and towing functions in all mode(s) of operation and conditions, regardless of the level of manning of the ship or means of control.

FR 13.2.2 Means should be provided for effective coordination and conduct of mooring and towing operations in all mode(s) of operation for which the ship is certified to operate, [regardless of the manning of the ship or means of control] [regardless of how or from where control of maneuvering of the ship is exercised]

FR 13.2.3 Means should be provided to ensure the continuous monitoring/control capability for towing and mooring arrangements and automatic dissemination of audible and visible alarm/indication in the event of failure, malfunctions and overload during operations, [regardless of the level of manning of the ship or means of control] [regardless of how or from where control of manoeuvring of the ship is exercised].

FR 13.2.4 Means should be provided to ensure that sufficient information about mooring and towing arrangements at marine facilities, terminals, and berths is available to enable the operations to be planned and conducted with due consideration to safety of property and personnel, and as appropriate, environmental protection.

## CHAPTER 14 – MARINE ENGINEERING/MACHINERY INSTALLATIONS

### 14.1 Goal

The goal of this chapter is to provide for machinery installations capable of delivering the required functionality to ensure safe navigation and the safe carriage of cargo and persons on board both during normal operation and in any emergency situation, taking into account the mode of operation of the ship and the number of persons on board.

### 14.2 Functional Requirements

To achieve the above goal, the following functional requirements are embodied in this chapter.

[FR 14.2.1 A reliable and secure connection between the remote control station(s) and the ship should be provided in normal and emergency situations.]

FR 14.2.2 Taking into account that connectivity might be lost [or be below an acceptable threshold], ensure that machinery systems are able to support any [fallback states].

FR 14.2.3 Condition-based monitoring should be provided to assess to system reliability.

FR 14.2.4 Local means of isolation with visual indication should be provided to ensure remote control or autonomous systems cannot start machinery if being worked on by [authorized] persons on board.

FR 14.2.5 Monitoring and control capability should be provided to ensure machinery system failures or malfunctions are [immediately] detected and operation in normal and emergency situations is maintained.

FR 14.2.6 Redundancy should be provided taking into account the number of [authorized] persons onboard available to respond to machinery system failures and malfunctions.

## CHAPTER 15 – ELECTRICAL AND ELECTRONIC ENGINEERING

### 15.1 Goal

The goal of this chapter is to provide for:

.1 All electrical auxiliary services necessary for maintaining the ship in normal operational and habitable conditions will be ensured without recourse to the emergency source of electrical power, taking into account the mode of operation of the ship and the number of persons on board.

.2 Emergency sources of power capable of delivering the required functionality of essential systems in emergency situations, taking into account the mode of operation of the ship and the number of persons on board.

.3 Protection of all persons on board the ship from electrical hazards.

### 15.2 Functional Requirements

To achieve the above goal, the following functional requirements are embodied in this chapter:

[FR 15.2.1 A reliable and secure connection between the remote-control station(s) and the ship should be provided in normal and emergency situations.]

FR 15.2.2 Taking into account that connectivity might be lost [or be below an acceptable threshold], ensure that electrical systems are able to support any [fallback states].

FR 15.2.3 Condition-based monitoring should be provided to assess to system reliability.

FR 15.2.4 Local means of isolation with visual indication should be provided to ensure remote control or autonomous systems cannot start machinery or energize the electrical system while work is in progress by [authorized] persons onboard.

FR 15.2.5 Monitoring and control capability should be provided to ensure electrical system failures or malfunctions are [immediately] detected and operation in normal and emergency situations is maintained.

FR 15.2.6 Redundancy should be provided taking into account the number of [authorized] persons onboard available to respond to electrical system failures and malfunctions.

## CHAPTER 16 – MAINTENANCE AND REPAIR

### 16.1 Goal

The goal of this chapter is to provide the maintenance and repair objectives of SOLAS, to ensure that the maintenance and repair requirements are not compromised during normal operation and emergency situations, taking into account the mode of operation of the ship and number of qualified [authorized] persons on board.

### 16.2 Functional requirements

To achieve the above-mentioned goal the following functional requirements are embodied in this chapter.

FR 16.2.1 Computer-based integrated system maintenance should be done in accordance with the manufacturer's recommendation and conducted when the ship is operating in a practical mode of operation to maintain safe operations in normal and emergency situations.

FR 16.2.2 Suitable monitoring and control capability should be provided at the remote-control operations centre, or by autonomous technology to ensure system and machinery faults are detected during autonomous modes of operation in normal and emergency conditions and can maintain any [fallback states]
FR 16.2.3 Suitable redundancy actions should be provided taking into account the number of qualified persons onboard that are available to respond to system and machinery faults.

FR 16.2.4 Maintenance requirements for the equipment and systems used on board should not be compromised by ships mode of operation.

FR 16.2.5 Qualified [authorised] persons should be available to remotely monitor system and equipment faults and abnormal conditions to verify their cause and confirm that the designed redundancy has been effective in maintaining the intended performance.

## CHAPTER 17 – EMERGENCY RESPONSE

### 17.1 Goal

The goal of this chapter is to provide measures for adequate responses in emergency situations[17][in a reasonable time] [in a sufficient time], taking into account the modes of operation in order to ensure the safety of human lives, property, and the environment.

### 17.2 Functional requirements

To achieve the abovementioned goal, the following functional requirements are embodied in this section.

#### 17.2.1. High Level Functional Requirements

FR 17.1.1: Measures should be in place for emergency prevention, preparedness, identification, response, and recovery activities[18].
FR 17.1.2: An effective emergency response plan and command structure should be established to sufficiently respond to any hazards that may arise from the ship or ROC and to ensure that they do not result in intolerable risk.

FR 17.1.3: Emergency response should prioritize the protection of human lives, environment, ship(s) and ROC(s), eliminating or mitigating the impact of the incident and preventing the escalation of the emergency.

FR17.1.4: Emergency response should be provided to enable the person or system to timely evaluate and decide on the emergency scale and subsequent response level in the event of an emergency.

FR 17.1.5: The relevant [information][data] of emergency [situations][incidents] should be automatically recorded from the start of the occurrence to the resolving of the situation and kept stored for investigation purposes.

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17 Emergency situations should include, but not limited to, the following main groups of emergency (A28/Res.1072):
.1 fire;
.2 damage to the ship;
.3 pollution;
.4 unlawful acts threatening the safety of the ship and the security of its passengers and crew;
.5 personnel accidents;
.6 cargo-related accidents; and
.7 emergency assistance to other ships.

18 The scope of the Emergency Response section of the MASS Code should include "Prevention", "Preparedness", "Response" and "Recovery". In emergency situation, "notification" and "evaluation" [shall] [should] be immediately made, and "follow-up" [shall] [should] be included as necessary.

| Stage | Definition |
|---|---|
| Prevention/Mitigation | Prevent future potential disasters and minimize damage |
| Preparedness | Activities to carry out plans or preparations to protect property |
| Response | Activities to protect lives in disaster situations and prevent future property damage |
| Recovery | All activities that return to normal or safer conditions |

* Reference: Guidelines for a structure of an integrated system of contingency planning for shipboard emergencies. (A 28/Res.1072)

[FR 17.1.5: With reference to SOLAS requirements for VDRs, response command locations, including ships, ROC and ashore, should be equipped for recording and storing emergency response related information.]

FR 17.1.6: A~~n adequate~~ communication system with external notification points, including ships in the vicinity, ROC, and ashore, should be maintained [during] [in the event of] an emergency.

**17.2.2. Specific Level Requirements**

FR 17.2.1: Emergency response plan should cover all steps from the detection to the termination of the emergency and the vessel and personnel are in a safe state.

FR 17.2.2: For an effective emergency response, an emergency response plan should cover the following;

.1 response process for both the ship and the ROC, including procedures for each type of emergencies.
.2 system that supports the entire process from detection to the end of response [resolving of the emergency].
.3 information including sensor information and simulation results of the incident evolution process based on incident scenarios.
.4 resource management
.5 training and education
.6 interface between ship and ROC, including standardized incident response indicators.
.7 independent, systematic interface between the human and machine
[.7bis interface between the human and autonomous system of MASS considering Modes of operation and emergency situation]
.8 roles and responsibilities
.9 other measures, etc.

FR 17.2.3: Sufficient information, including the nature, location, and scale of the emergency, should be provided to the detection/analysis functions of ~~the emergency response system~~ the autonomous system of MASS to enable effective emergency response.

FR 17.2.4: The method and response speed of the system used to determine the need for emergency response should be based on the ~~simulation~~ study results of the event evolution by the type of incident and the rate at which the incident may escalate.

FR 17.2.5: The timely handover of command-and-control functions between people and machines, between vessels and ROC, as required by the emergency response situation, should [occur as appropriate and record] [be available according to established] procedures.

FR 17.2.6: For crewless MASS, the autonomous system should be capable of assessing risk situations to identify additional risks and [refine][support] response strategies during emergencies.

FR 17.2.7: During crewless autonomous operation, the reliability of the onboard detection system should be ensured at an appropriate level, taking into account potential sensor failures and spurious actions.

FR 17.2.8: To respond to the emergency situations, any responsible person[19] should be notified that an emergency has occurred and issue commands to activate ~~the vessel's emergency response system~~ autonomous system of MASS to ensure appropriate response.

19 'Any responsible person' in the above context, include the crew on board and remote operators in ROC.

FR 17.2.9: The emergency response system should have reasonably and practicable level of capability for identifying and responding to emergency situations, considering resilience in case of failure of the system.

[FR 17.2.9: The vessel should be equipped with the capability and back-up facilities to respond autonomously in case the identification or response to an emergency is not successful.

| | | |
|---|---|---|
| Resilience | Resilience is the ability of a system to detect and compensate external and internal disturbances, malfunction and breakdowns in parts of the system. This should be achieved without loss of functionalities and preferably without degradation of their performance. | *NCSR 1/9 (Annex 1); NAV58/6/1* |

FR 17.2.10: Response command locations, including the ship and ROC, should be equipped with recording and storing functions for emergency response-related [information[data].

FR 17.2.11: In the event of an emergency, the functions to report relevant information are required [in a reasonable time] [in a sufficient time], and updated situational [information][data] should be provided to external notification points after the emergency ~~response~~ situation has ~~activated~~ occurred.

FR 17.2.12: [Measures][Means] for emergency communication including both within the ship and with external stations, should be prioritized over routine communications.

FR 17.2.13: Functions are required to evaluate the effectiveness of emergency response and the resolving of the situation, utilizing all relevant [data][information] of the event, and the result of the judgement should be notified to the person in charge of the ship.

~~FR17.2.14~~: The evaluation function should provide warning to the operator or the person in charge [in a reasonable time] [in a sufficient time] when the situation is progressing out of the Operational Envelope.

FR 17.2.15: The effectiveness of the emergency response plan should be reviewed periodically and updated whenever there is a change in the installation of the system or external circumstances that could significantly affect the content of the plan.

FR 17.2.16: Emergency response ~~systems~~ functions of autonomous systems of MASS should be operated/inspected/tested and maintained in accordance with appropriate procedures to ensure that their functional requirements are maintained.

~~17.1 Goal~~
~~[The goal of the chapter is to ensure safe, effective, and efficient handling of onboard fire emergencies on MASS.]~~

~~Regarding the case of fire or flooding accidents, the key components to consider in the accident response system for MASS and their associated functional requirements are:~~

~~FR17.1 Sensor system Various sensor systems with different methods according to compartment characteristics (engine room, battery room, etc.), potential fire types (oil, gas, and metal, electrical or chemical) must be installed to detect fire and flooding and to prevent sensor malfunctions.~~

~~FR17.2 Data communication Data communication between ships and remote-control centers onshore in real-time is essential for the operator to recognize the operational situation to~~

~~ensure safe navigation, especially in high-density traffic areas, narrow routes, night, and bad weather conditions.~~

~~FR17.3 Redundancy As redundancy is claimed to be a primary means of reducing accidents, sensor networks must be implemented with redundancy because some sensors may malfunction from fire and flooding accidents.~~

~~FR17.4 Engineering calculation and simulation database Engineering calculation and simulation database can provide predictive information on what will happen to a ship by the accident and support to make informed decisions within minutes.~~

~~FR17.5 The operation of MASS with 3 or 4 degrees of autonomy (DoA) should consider the following approaches and requirements for optimal accident response or damage control:~~

~~.1 Accident confirmation: In the case of an accident, the data transmission system to the remote operation center must be designed to consider the limitation of data capacity, speed, and reliability.~~

~~.2 Troubleshooting for accident responses: When the initial accident response fails, the self-decision-making facility of an accident response system should be designed as a backup.~~

~~.3 Verification of accident response results: In order to verify the accident result, unless there is a crew on board, the accident response system of the ship must equip the ability to assess the result and take additional action when required.~~

~~.4 Configuration and requirements: The major elements and suggested requirements for DoA 3 MASS include sensors, image sensor processing, communication ability, redundancy, response procedure, confirming accident response results, engineering analysis, self-adaptation, and user interface.~~

~~17.2 Provisions [XXXXXXXX]~~

**ANNEX**

MSC.1/Circ.1604 – "Interim Guidelines for MASS Trials"

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