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INTERNATIONAL MARITIME ORGANIZATION

MARITIME SAFETY COMMITTEE
108th session
Agenda item 4

MSC 108/4
13 February 2024
Original: ENGLISH
Pre-session public release: ☒

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

Report of the Correspondence Group

Submitted by Marshall Islands

SUMMARY

Executive summary:	This document provides the report of the Correspondence Group on Development of a goal-based instrument for Maritime Autonomous Surface Ships (MASS).
Strategic direction, if applicable	2
Output	2.23
Action to be taken:	Paragraph 44
Related documents:	MSC 107/WP.9, MSC 107/20 and MSC/ISWG/MASS 2/WP.1

General

1 The Maritime Safety Committee (MSC), at its 107th session, established the Correspondence Group on Development of a goal-based instrument for Maritime Autonomous Surface Ships (MASS) (the Group) under the coordination of the Marshall Islands.

List of participants

2 Representatives from the following Member States participated in the Group:

ARGENTINA
AUSTRALIA
BAHAMAS
BELGIUM
BRAZIL
CANADA
CHINA
COOK ISLANDS
DENMARK
ETHIOPIA
FINLAND
FRANCE
GERMANY
GHANA
INDIA
IRELAND
ITALY
JAPAN
LIBERIA
MALTA
MARSHALL ISLANDS
MEXICO
MOROCCO
NEW ZEALAND

NORWAY
PAKISTAN
PANAMA
PAPUA NEW GUINEA
PERU
PHILLIPINES
POLAND
REPUBLIC OF KOREA
RUSSIAN FEDERATION
SAUDI ARABIA
SINGAPORE
SOMALIA
SPAIN
SWEDEN
THAILAND
TÜRKIYE
UGANDA
UNITED ARAB EMIRATES
UNITED KINGDOM
UNITED STATES OF AMERICA

representatives from the following inter-governmental organizations:

INTERNATIONAL HYDROGRAPHIC ORGANIZATION (IHO)
EUROPEAN COMISSION (EC)
INTERNATIONAL MOBILE SATELLITE ORGANIZATION (IMSO)

and observers from the following non-governmental organizations in consultative status:

INTERNATIONAL CHAMBER OF SHIPPING (ICS)
INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)
INTERNATIONAL ASSOCIATION OF MARINE AIDS TO NAVIGATION AND LIGHTHOUSE AUTHORITIES (IALA)
COMITÉ 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)
CRUISE LINES INTERNATIONAL ASSOCIATION (CLIA)
THE EUROPEAN ASSOCIATION OF INTERNAL COMBUSTION ENGINE MANUFACTURERS (EUROMOT)
THE INSTITUTE OF MARINE ENGINEERING, SCIENCE AND TECHNOLOGY (IMarEST)
INTERNATIONAL PARCEL TANKERS ASSOCIATION (IPTA)
WORLD SAILING LTD. (WORLD SAILING)
INTERNATIONAL MARINE CONTRACTORS ASSOCIATION (IMCA)
INTERNATIONAL HARBOUR MASTERS' ASSOCIATION (IHMA)
THE ROYAL INSTITUTION OF NAVAL ARCHITECTS (RINA)
INTERNATIONAL TRANSPORT WORKERS' FEDERATION (ITF)
WORLD SHIPPING COUNCIL (WSC)
THE NAUTICAL INSTITUTE (NI)
SUPERYACHT BUILDERS ASSOCIATION (SYBASS)
GLOBAL TESTNET

Terms of reference

3 Taking into account the comments and decisions made at MSC 107, the Group was instructed to:

.1 continue the development of the non-mandatory goal-based MASS instrument (MASS Code), based on annex 1 to document MSC 107/WP.9, taking into account the outcome of the GBS Working Group in document MSC 107/WP.11, as well as documents MSC 107/5/2, MSC 107/5/3, MSC 107/5/4, MSC 107/5/6, MSC 107/5/7, MSC 10/5/8, MSC 107/5/9, MSC 10/5/10, MSC 107/5/11, MSC 10/5/12, MSC 107/INF.2, MSC 107/INF.8, MSC 107/INF.11, MSC 107/INF.12, MSC 107/INF.14 and MSC 107/INF.18, and the preliminary conclusions of MASS ISWG 2;

.2 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 required, 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 of application to passenger ships at a future stage;

.5 reinstate the work procedures by which volunteering Member States and international organizations developed selected chapters of the draft non-mandatory goal-based MASS Code;

.6 provide a verbal report (by the Coordinator) to MASS-JWG 3 and MASS ISWG 2; and

.7 submit a written report to MSC 108.

4 In this regard, the Committee authorized the Correspondence Group to convene remote meetings, as necessary, using a suitable platform, in order to consider any of the terms of reference and further the development of the MASS Code.

Method of work

5 Since MSC 107, the Group has progressed its work through correspondence via email and, when considered necessary by the Coordinator, by "virtual meetings" as authorized by MSC 107.

6 As instructed by the Committee, the Group reinstated the use of "'splinter groups" of volunteering Member States and international organizations for the work on development of individual chapters and chapters of the draft Code (see paragraph 3.5).

7 As further instructed by the Committee, the Coordinator of the Group gave a verbal report to MASS ISWG 2 on the status of its work and thereafter the Group took into consideration in its work the subsequent output of MASS ISWG 2.

8 The following paragraphs give more detail regarding the work of the Group on each element of its terms of reference (ToRs).

ToR 1 – continue the development of the non-mandatory goal-based mass instrument (MASS CODE), based on annex 1 to document MSC 107/WP.9

9 Taking into account the instructions of the Committee, the Group continued the development of a non-mandatory goal-based MASS Code on the basis that it should:

.1 be non-mandatory but developed such as to facilitate its eventual transfer to a mandatory code;

.2 be supplementary to existing instruments (not "standalone") and only address matters that are either not addressed in existing instruments or that require alternative approaches due to the nature of the MASS mode of operation;

.3 be goal-based and take account of 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)); and

.4 address the impact of autonomy on critical "functions" rather than attempting to address the ship as a whole.

10 In its further development of the Code, the Group used annex 1 to document MSC 107/WP.9 as a basis while taking into account the:

.1 outcome of the GBS Working Group at MSC 107 as shown in document MSC 107/WP.11;

.2 preliminary conclusions of MASS ISWG 2 as shown in document MSC/ISWG/MASS 2/WP.1; and

.3 additional documents from MSC 107 as listed in its ToRs.

11 As instructed, the Group also took into consideration the common potential gaps and/or themes identified during the Regulatory Scoping Exercise (MSC.1/Circ.1638, section 5), with focus on the high priority items.

12 The Group continued the development of chapters of part 3 of the draft Code using the " splinter groups" as directed by MSC 107, while other volunteering Member States took the lead on the development of individual chapters of parts 1 and 2 of the Code. The developed chapters of the Code were subsequently circulated to the whole Group for comment and agreement before being included in the draft shown in annex 1 to this report.

13 The Group also enlisted the services and expertise of the Chair of the MSC Goal Based Standards (GBS) Working Group, Mr. Jaideep Sirkar, to carry out a review of the chapters of part 3 of the draft Code and to advise on their further development in accordance with MSC.1/Circ.1394/Rev.2, that they were consistent with the Code being non-mandatory, and that they were editorially on the same level.

14 It should be noted that the text of the draft Code, as shown in annex 1, is the latest version prepared by the Group at the time of submission to MSC 108 and is without track changes or other markings, unless considered necessary. In addition, an editorial change has been made to subdivide all parts of the Code (not just part 3) using the term 'Chapter' with the number further updated, as necessary.

15 The following paragraphs highlight particular comments or issues that the Group agreed to highlight.

General comments

16 Following further discussion of whether the Code should be considered as 'supplementary' or 'complementary' to any applied 'base' instruments such as SOLAS, the general opinion of the Group was that the appropriate term to be used is 'supplementary', however, there were some who felt that the Code could be both supplementary and complimentary.

17 The term 'MASS' is used extensively when referring to a ship with remotely operated or autonomous functions. If the term is to be used in this way, it was felt that it should be understood that a 'MASS', in this case, is a ship to which the MASS Code is applied in part or in whole.

18 One delegation noted that it was agreed at MSC 107 that there was no need to amend COLREG as it could be applied in full to any MASS, and also noted that the working group at MSC 107 agreed that the Code needed to address how COLREG should be applied to MASS. However, this delegation felt that more consideration needed to be given to the application of COLREG in the further development of the Code.

Preamble

19 While some amendments have been agreed by the Group, the Preamble should be considered as a work in progress and subject to change as necessary until the completion of development of the Code.

Part 1 – Introduction

20 CHAPTER 1 PURPOSE, PRINCIPLES AND OBJECTIVES

Only minor editorial adjustments have been made to this chapter.

21 CHAPTER 2 APPLICATION

While the text of this chapter has been further adjusted by the Group, it is recognized that there is a need for further consideration and agreement. One delegation was of the opinion that, in order to ensure sovereign immunity for government ships to which the Code may be applied, the application provisions should not appear in the Code itself but that, for the non-mandatory Code, they should be included in the resolution, and, for the mandatory Code, directly in SOLAS.

22 CHAPTER 3 CODE STRUCTURE AND RELATIONSHIP TO OTHER IMO INSTRUMENTS

Further development should be based on the output from MASS ISWG 2 and the subsequent work of the Correspondence Group.

23 CHAPTER 4 TERMINOLOGY AND DEFINITIONS

While some minor editorial adjustments were made, the Group did not work extensively on this chapter, recognizing it will remain a work in progress and will be subject to ongoing adjustment as the Code is further developed. It was noted that, in the further development of terminology and definitions, consideration should be given to document MSC/ISWG/MASS 2/INF.2.

24 CHAPTER 5 APPROVAL PROCESS

This is a new chapter, which was added in recognition of the need for a structured approval process to enable the MASS to obtain the required approval, along with the necessary certificates related to statutory requirements for its intended operation. By following the proposed process it is felt that those seeking approval, and Administrations, will be able to work in cooperation to ensure that all aspects of safety, security and environmental protection are adequately addressed.

25 CHAPTER 6 CERTIFICATE AND SURVEY

The Group noted the existing text in the report of MASS ISWG 2 and the inclusion of the new chapter 7 on Approval Process. The Group was informed that Belgium et al. may submit a proposal to MSC 108 on 'Concepts on the Management of Remote Operations'. Considering that there may be potential overlaps and interactions between chapters 7 and 8, and the potential proposal from Belgium et al, the Group decided not to progress its work on chapter 8 at this time and proposes further discussion at MSC 108.

Part 2 – Main principles for MASS And MASS functions

26 CHAPTER 1 OPERATIONAL CONTEXT

This chapter has been subject to further development in order to structure it in a way appropriate to a chapter in this part of the Code and introduces terms such as Operational Envelope, Acceptable Risk Condition, Degraded State, and Fallback State along with a figure illustrating the relationship and interaction between them.

27 CHAPTER 2 RISK ASSESSMENT

Further development should be based on the output from MASS ISWG 2 and the subsequent work of the Correspondence Group.

29 CHAPTER 3 SYSTEM DESIGN PRINCIPLES

This chapter has been further developed and divided into 12 subsections covering Safety-Centric Design, User-Centric and Intuitive Interface, Robustness and Reliability, Adaptability and Flexibility, Redundancy and Fault Tolerance, Scalability, Security and Cybersecurity, Energy Efficiency and Environmental Consideration, Data Management and Quality, Interoperability, Testing and Validation, and Ethical and Transparent Design.

29 CHAPTER 4 SOFTWARE PRINCIPLES

Further development should be based on the output from MASS ISWG 2 and the subsequent work of the Correspondence Group.

30 CHAPTER 5 CONNECTIVITY

This chapter has been developed together with the chapter on Communication in part 3, and by the same splinter group. Given that the distinction between the terms 'Connectivity' and 'Communications' is not clear enough, this chapter is structured more in line with the chapters in part 3. Consideration should be given to whether these two chapters should be merged and, if so, whether such merged chapter would belong in part 2 or part 3 of the Code.

31 CHAPTER 6 ALERT MANAGEMENT

Further development should be based on the output from MASS ISWG 2 and the subsequent work of the Correspondence Group.

32 CHAPTER 7 HUMAN ELEMENT

Development of this chapter, and the associated chapter 12 in part 3 of the Code, has not progressed significantly since MSC 107, however it is anticipated that at MSC 108, and in the re-established Correspondence Group, if agreed, more progress could be made.

Part 3 – Goals, functional requirements, and expected performance

33 The chapters in part 3 of the Code have undergone considerable revision through the work of the 'splinter groups' and with the additional support of the Chair of the MSC GBS Working Group, but the individual chapters of part 3 of the Code should be seen as being at different stages in their development with some being very advanced while some are in a less developed state.

34 The further development of part 3 and its chapters will include consideration and comparison of chapters regarding links and overlaps, consistency of level, use of terminology, layout, etc. No specific comments are made here on individual chapters and the drafted text can be seen in annex 1 to this report.

ToR 2 – 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)

35 As indicated above, during the work of the Group, and the work of the groups of volunteering Member States and international organizations developing selected chapters of the Code, the common potential gaps and/or themes (MSC.1/Circ.1638, section 5) were taken into consideration, as necessary.

ToR 3 – if required, develop positions on any common issues for submission to a Joint MSC/LEG/FAL Working Group in the future

36 As instructed, the Group considered whether it could identify any common issues for submission to a Joint MSC/LEG/FAL Working Group in the future and with a view to developing positions on any identified issues. During its work, the Group did not identify any such common issues that were not already being taken into consideration by the Joint MSC/LEG/FAL Working Group.

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

37 Some delegations expressed the opinion that the Committee should consider extending the application of the MASS Code to passenger ships immediately after the non-mandatory MASS Code is approved and that, given the functionally-oriented nature of the MASS Code, it should be possible to use the regulation developed for cargo ships to regulate autonomous passenger ships in terms of the same functions.

38 However, as instructed, the Group limited its development of the non-mandatory MASS Code to cargo ships, while taking into account, only as far as seen appropriate at this stage, its potential future application to passenger ships.

ToR 5 – reinstate the work procedures by which volunteering Member States and international organizations developed selected chapters of the draft non-mandatory goal-based MASS Code

39 As requested by MSC 107, the Group reinstated the so called "splinter groups" of volunteering Member States and international organizations for the development of the chapters of part 3 of the Code. The updated list of lead volunteers is shown in annex 2.

Proposal of next steps in the development of a goal-based instrument for MASS

40 Regarding the ongoing work on development of the Code, and with the expectation that the MASS Working Group and the MASS intersessional Correspondence Group will be re-established at MSC 108, the Group agreed to propose that consideration be given to establishing two Intersessional Working Groups (ISWG) in the latter part of 2024 to further the work on MASS, bearing in mind that the expectation is for the non-mandatory MASS Code to be finalized and adopted at MSC 109. If the establishment of two ISWGs is agreed, the Group proposes that they be held on the following dates:

.1 MSC MASS ISWG 3: 9 to 13 September 2024; and

.2 MSC MASS ISWG 4: 25 to 29 November 2024.

41 If the requested ISWGs are established, the Group further proposes that the Correspondence Group, which is expected to be re-established at MSC 108, provide each ISWG, in turn, with the, then, current status of its work and, in return, any output generated by the ISWGs should form the basis for the further work of the Correspondence Group and MSC 109.

42 Regarding the proposed dates for the MASS ISWG 3 (9 to 13 September 2024), one member pointed out that the applicable deadline for the submission of the Correspondence Group to MSC 109 may need to be taken into consideration, given its close proximity to the proposed dates for ISWG 3. The same member also questioned if the Correspondence Group would provide an interim written report to ISWG 3.

Proposal of terms of reference for MASS WG at MSC 108

43 The Group agreed to recommend to the Committee, the re-establishment of the MASS Working Group at MSC 108, taking into account any decisions made in plenary, to:

.1 further develop the draft non-mandatory MASS Code, using document MSC 108/4 (Report of the Correspondence Group) and its annexes as the basis, and taking into account submissions made to MSC 108, as appropriate;

.2 consider the outcome of the third session of the Joint MSC-LEG-FAL Working Group on MASS (JWG) and, if time permits, consider and identify if there are additional common issues that should be submitted to the JWG ;

.3 consider the involvement of sub-committees in the further development of the MASS Code;

.4 update the road map for developing a goal-based code for Maritime Autonomous Surface Ships, based on annex 15 to document MSC 107/20/Add.1;

.5 develop draft terms of reference for:

.1 the intersessional Correspondence Group on Development of a goal-based instrument for Maritime Autonomous Surface Ships (MASS); and

.2 MSC MASS Intersessional Working Group 3 on Development of a goal-based instrument for Maritime Autonomous Surface Ships (MASS); and

.6 submit a written report to the plenary by Thursday, 23 May 2024.

Action requested of the Committee

44 The Committee is invited to approve this report, in general, and, in particular to:

.1 note the progress made by the Group on the development of the non-mandatory International Code of Safety for Maritime Autonomous Surface Ships (MASS Code) (annex 1);

.2 consider the proposal for the establishment of two intersessional MASS Working Groups, on the dates proposed, to meet the tight time schedule for the completion of the work on the non-Mandatory MASS Code (paragraphs 40 to 43); and

.3 agree with the Group's recommendation to re-establish the MASS Working Group to further the work of development of the draft non-mandatory MASS Code, with the proposed terms of reference (paragraph 43).

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ANNEX 1

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

TABLE OF CONTENTS

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] [reflected] within SOLAS and other IMO instruments.

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

4. This Code addresses the functions needed for safe, secure, and environmentally sound operations of MASS insofar as they are not adequately or fully addressed in other applied IMO instruments, while ensuring that required safety levels are maintained when implementing remote controlled or autonomous operation of key functions.

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

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).]

10. [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.]

PART 1 INTRODUCTION

CHAPTER 1 PURPOSE, PRINCIPLES AND OBJECTIVES

1.1 Purpose

The purpose of this Code is to provide an international regulatory framework for the remote control and autonomous operation of key functions 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.

1.2 Principles

This Code is developed on the principles that it be:

a) supplementary to any applied base instruments, such as SOLAS, and only address MASS issues as far as they are not adequately or fully addressed in the applied base instruments;
b) holistic to ensure the objectives, aims and principles of the IMO base instruments are maintained whilst also enabling the MASS functions and operations to be addressed across all instruments;
c) goal-based and addressing matters at the functional level;
d) non-mandatory although developed in such a way as to facilitate future transition to mandatory status; and
e) technology neutral and [taking note of] [allowing for] industry practices and experience in the deployment of new technologies.

1.3 Objectives

In achieving its Purpose, this Code is intended to:

a) prevent relaxation of the level of accepted standards for design, construction, or operation and ensure a level of safety 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) allow for the application of solutions that are demonstrably safe, secure, and environmentally sound in performing the designated functions in all defined conditions; and
d) 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.
e) [facilitate human oversight and [meaningful control][Meaningful Human Control] of MASS operation or MASS functions.]

CHAPTER 2 APPLICATION

[This 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].]

CHAPTER 3 CODE STRUCTURE AND RELATIONSHIP TO OTHER IMO INSTRUMENTS

This Code addresses the functions needed to obtain safe, secure and environmentally sound operations of MASS as far as they are not adequately or fully addressed in other applied IMO instruments and is therefore intended to be supplementary to those IMO instruments.

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

- Part 1: Introduction covering overarching matters to be considered in the application of the Code.
- Part 2: Technical principles applicable in all cases when applying this Code to autonomous or remotely operated functions. These principles and requirements should be met as part of any approval and certification process.
- Part 3: Goals, functional requirements, and provisions applicable to autonomous or remotely operated functions. Depending on the mode of operation and functionality being certified, not all chapters of Part 3 may require to be met.

CHAPTER 4 TERMINOLOGY AND DEFINITIONS

For the purposes of the Code, unless expressly provided otherwise, terms used have the meanings defined in the following paragraphs. For terms used, but not defined in this Code, the definitions as given in the 1974 SOLAS Convention, as amended, shall apply.

Note - Following feedback from multiple delegations, it is felt that certain terms are included which are not required as they are either copied or defined already in other IMO instruments and do not add value. Therefore, any terms in italics indicate those which are defined elsewhere may be removed at a later stage.

4.1 Administration

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

[4.1 bis Alarm – to be defined.]

[4.1 ter Alert – to be defined.]

4.2 [[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)

or

[An *annunciated failure* is the situation when a failure is accompanied by information to the crew of the failure by virtue of system generated cues such as visual and/or audible notifications, warnings, and alarms]]

4.3 [Approved

Approved means approved by the Administration.]

4.4 [Automated] [Autonomous] 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. [Note - 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)).]

4.5 [Automatic

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

4.6 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)

4.7 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)]

4.8 [Cargo Ship

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

[4.8bis COLREG

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

4.9 [Company

Company means the owner of the MASS ship 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.]

4.10 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 as MASS.

4.11 [Control function

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

4.12 [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.]

4.12bis. Degraded state

Degraded state means a [divergence/deviation] in the normal operation which can potentially result in a fallback state.

4.13 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. (RBAT)

4.13.bis Fallback response

Fallback response means the actions and procedures to enter into, safely stay within, and eventually recover from, a predefined fallback state.

4.14 Fallback state

Fallback state means a designed state that can be entered through a fallback response when it is not possible for the MASS with its autonomous or remote-controlled ship functions to stay within the operational envelope.

4.15 Fault

Fault means an abnormal condition that [may cause a reduction in, or loss of, the capability of a functional unit to perform the required function] or [can cause an element or an item to fail]. (MSC 107/5/7)

4.16 Function

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

4.17 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).

4.18 [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:* ∇ *= displacement corresponding to the design waterline (m3). (2008 IS Code)]*

4.19 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)

4.20 [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.]]

[4.20bis Human Machine Interface (HMI) - to be defined.]

4.21 In service (operating, under remote operation, under remote supervision; need to cover in dry dock [ready to operate]) - to be defined.

4.22 [International Convention on Maritime Search and Rescue

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

4.22 [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.]

4.23 [Intolerable risk

[*Intolerable risk* means the level of risk at individual and societal level that would be higher than ALARP (As Low As Reasonably Practicable) assessed during the design [of ConOps for] [Mission] of MASS.] (India proposed from MSC 91-16).]

4.24 [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.]

4.25 Maritime Autonomous Surface Ship (MASS)

Maritime Autonomous Surface Ship (MASS) means a ship which, to a varying degree, can operate independent of human interaction.

4.26 [MASS Onboard Crew

MASS onboard crew means a master, other officers and operational staff [physically][who may be present] on board a MASS.]

4.27 [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.]

4.28 Master/master of a MASS

Master [of a MASS] means the person having command of a MASS ship (STCW)

Key principles agreed/requirements of a master (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; and

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

.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).]

[4.28bis Minimal Risk Manoeuvre (MRM) - to be defined if used in Code]

4.29 Mission

Mission means the commercial, political or public intentions which have contributed to and justifies the vessel concept development and operation.

4.30 [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.]

4.31 Mitigation

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

4.32 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.

4.33 Modes of Operation

Modes of Operation means the condition(s) under which the functions of a MASS are controlled, i.e. remote-control or autonomous with or without persons on board.

[4.33bis. Normal operation

Normal operation means ship operations within the Operational Envelope of a MASS, where the ship is able to continue sailing even at a degraded state.]

[4.33ter [Operational Design Domain (ODD)]

[*Operational Design Domain (ODD)]* means a document providing the conditions, related control modes and modes of operation under which any individual autonomous or remote-operated ship function is designed to operate, including all tolerable events]

[4.33ter Operator failure]

Operator Failure means a situation where an operator either fails to take an appropriate action or takes incorrect actions in a particular context that could be driven by numerous factors including limited or poor-quality information, insufficient time to respond effectively, and a lack of understanding regarding the proper course of action to take.]

4.34 Operational Envelope

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

4.35 [Organization

Organization means the International Maritime Organization.]

[4.35bis Quality of Service - to be defined if used in the Code]

4.36 Process

Process means a set of interrelated or interacting activities that transforms inputs into outputs (IEC, 2018)

4.37 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))

- 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)
- 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)

4.38 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.

4.39 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.

4.40 Remote Master

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

4.41 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:

MSC 107/5/3

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.

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.

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.

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.

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.

RBAT (4th report)

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

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

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

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

MSC 107/INF.8

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:

Active human supervisory control - supervisor intervenes at any stage based on continuous monitoring

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

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

4.42 Remote Operations - Term to be defined

4.43 [Risk Assessment

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

[4.43bis Safe State - to be defined if used in the Code]

4.44 [SOLAS

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

4.45 Situational Awareness

[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)

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)]

4.46 Software - term to be defined if used in the Code

4.47 [STCW Convention

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

[4.47bis Submitter

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

4.48 System

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

[4.48bis System Software - to be defined if used in the Code.]

[4.48ter Systematic failure events:

Systematic Failure means an event that is the consequence of inadequate work processes and may be introduced at all stages in the system lifecycle.]

[4.48quart Systemic failure

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

4.49 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.

or

[*Task* means a set of activities undertaken in order to achieve a specific goal. (ISO)]

4.50 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.

4.51 [[Unannunciated][Unannounced] 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 alerts, or the provided information is misleading, incomplete, or not presented in due time.]

4.52 Unsafe State

[Unsafe state means where a system is operating outside its 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)

4.53 Verification

[*Verification* means the process of systematically evaluating and confirming that autonomous maritime vessels' design, technology, and operational protocols align with this Code and involves a thorough examination, also by testing, to ensure that the autonomous ship's construction, software systems, sensors, and control mechanisms comply with or meet the specific safety, navigation, and operational requirements set forth by this Code.]

4.54 Validation

[*Validation* means the process of thoroughly assessing and examining methodologies, assessments, procedures, hypotheses, or criteria used in the context of requirements or calculations.]

CHAPTER 5 APPROVAL PROCESS

5.1 Process description

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

The approval process for MASS should be based on and follow the main principles of the *Guidelines for the approval of alternatives and equivalents as provided for in various IMO instruments* (MSC.1/Circ.1455) taking into consideration parts 2 and 3 of this Code. The level of detail should be proportional to the complexity, level of novelty and associated risk of the

MASS and on whether the Submitter is applying for preliminary or final approval and the necessary documentation may vary accordingly.

[The steps and documentation required in this chapter provide the general basis of the approval process, while a different approval process might be followed to the satisfaction of the Administration.] *or* [The steps and documentation required in this chapter provide the general basis of the approval process, not excluding other information or documentation that may be requested by the Administration.]

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

The approval process should be conducted using the following steps:

1. Preliminary design development;
2. Preliminary design approval;
3. Testing, simulation, and other verification methods;
4. Final approval;
5. [Survey and Certification]; and
6. Operation.

5.2 Evaluation criteria

The basic principle for the evaluation criteria should be safety, environmental protection and security equivalence. The evaluation criteria should be developed through compliance with the goals and functional requirements of part 3 of this Code in combination with a risk assessment (as described in chapter [2.4] of the Code). The evaluation criteria and an assessment plan thereof should be agreed with the Administration.

5.3 Design and documentation requirements

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

The ConOps (as described in Chapter 2.1) should be a base document in the approval process and should be the basis for the assessment in each step.

5.3.1 Preliminary design development

The following vessel-specific documentation should be compiled and submitted:

1. Concept of operations (ConOps); as described in Chapter 2.1 of the Code.
2. Preliminary design documents; preliminary documents should be submitted as deemed necessary to illustrate the main characteristics of the vessel and system arrangements, especially related to autonomous and remotely controlled functions.
3. High level risk assessment report; the objective of the high-level risk assessment is to identify safety critical areas and functions at an early stage and to assist as far as practicable to the drafting of the initial approval basis.
4. Approval basis; should be submitted for approval by the Administration at the end of the preliminary design development. It should be highlighted that within the context of

an iterative approval process, it is expected that that this document will be modified significantly throughout the process.

5. Preliminary actions register; the necessary actions for the completion of the process should be drafted, while the early involvement of key stakeholders should be ensured for a clear understanding of roles and responsibilities in the approval process.

5.3.2 Preliminary design approval

1. Risk assessment report; A risk assessment, as described in [2.4] of the Code should be performed for all the functions affected by autonomy or remote control. The level of detail of the risk assessment should be proportional to the complexity of the project.
2. Preliminary design documents; As the approval process is an iterative one, the purpose of the preliminary design documents is to further describe and illustrate the key elements of the project that prove the equivalence justification. At the end of this step and possibly after more than one iteration, the design parameters of the systems and system interaction in question should be clear enough to be able to determine appropriate performance criteria that could be verified through testing and other verification methods.
   At the end of the step, there should be an alignment between the submitted documents and the risk analysis in terms of assumptions and philosophy, especially regarding mitigation measures. The preliminary design documents could be the following:

   - Safety philosophy
   - Design philosophy
   - Operation and maintenance philosophy
   - Emergency response philosophy
   - General arrangement
   - Systems and Equipment matrix
   - ConOps [including OE] (updated)

3. Drawings & information documents (optional); While the iteration process of the project advances, it might be necessary for the approval process to also submit relevant drawings and information documents to clarify certain aspects of the design, especially on issues that are found to be safety critical (i.e. implying very high risk according to the risk analysis). It is expected that such issues that need to be demonstrated at a more detailed level are issues where redundancy, fault tolerance or fail-safe mechanisms need to be further explained.
4. Task allocation summary; A task and function allocation summary should be submitted describing the distribution of functions and tasks between human and machine/systems in both normal, abnormal and emergency situations. The task allocation summary should be aligned with the other design documents. There should be particular focus on the expected control actions performed, while especially in the case of human operators it should be made possible to evaluate their expected workload but also their cognitive support.
5. Approval basis; it is expected to be updated with each iteration especially when design details and assumptions are decided and documented. At the end of this step the approval basis should be a significantly more detailed document than the one presented in 1.7.3.1.
6. Regulatory gap analysis; A regulatory gap analysis should be submitted to document any deviations from the applicable regulatory framework. At the end of the preliminary approval step, it is not expected that this document will cover all the applicable prescriptive provisions, however it would be beneficial for the detailed design approval to already introduce as much detail as possible. This should be demonstrated through

a link between the risk analysis and justification on why design or operational solutions are justified as being equivalent.

7. Verification and validation plan; The final step to the preliminary design approval is the detailed definition of how it is intended to perform verification and validation (V&V) of the systems and the MASS as a whole. The objective of the V&V plan should be to describe how functionalities regarding autonomy and remote operations will be verified. A V&V plan should be submitted for approval considering the following:

   - High risk functions and system components as they stem from the risk assessment
   - Boundary conditions and system safety requirements and constraints
   - Cybersecurity related features upon which the protection of the safety critical components is based
   - Incorrect and unexpected inputs and input sequences and timing
   - Reaction of the system-to-system faults and failures
   - Fail-safe modes and fallback states
   - Operational procedures for V&V
   - Ensure that no additional hazards are introduced during V&V

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

8. Actions register; The actions register, as described in 1.7.3.1 should be updated accordingly.

5.3.3 Testing and other verification methods

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

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

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

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

[Simulations of control systems and/or parts of systems, with pertaining scenarios, may replace full-scale testing of individual systems, but may not replace full-scale testing as a whole.] *or* [Simulator based testing could be accepted for certain systems after agreement with the Administration. This testing does not replace the need for full-scale testing which should be used for validation purposes.]

5.3.4 Final approval

This approval step should follow the approach from MSC.1/Circ.1455. It is particularly important to correlate the different components and systems that constitute the MASS in consideration. In addition, this step should be used as a verification that the different steps leading to the final approval are consistent and can be easily verified.

Before the initial survey of the vessel, testing needs to have been completed to demonstrate the requirements in the Approval Basis have been met. This evidence would typically include the final Design Documents and the reports of activities undertaken including a link to the related item of the V&V Plan.

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

The Submitter should propose any survey requirements associated with the system in question. The operational requirements (e.g., training, maintenance) to address the innovative technology aspects should also be included in the In-Service Documentation. Focus should be put on any operational restrictions.

[5.3.5 Survey and certification

Survey and certification requirements as described in 1.8 of the Code should be followed.]

5.3.6 Operation

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

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

MASS may initiate operations while it is being tested. During such tests, the certification of the ship should follow [the interim certification process described in 1.8]. In addition, further mitigation layers to the system that is being tested should be foreseen such as different modes of operation from the ones of the final design.

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

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

* Preliminary and high level only
** In case of changes in the approved concept, assumptions and conditions

CHAPTER 6 CERTIFICATE AND SURVEY

6.1 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.]

6.1.1 The MASS functionality shall be subject to the following surveys:

.1 an initial survey before the ship is put in service;
.2 a renewal survey at intervals specified by the Administration but not exceeding five years; and
.3 a periodical survey within three months before or after each anniversary date of the MASS Certificate.

6.1.2 The surveys referred to in 6.1.1 should be carried out as follows:

.1 the initial survey should include verification and testing of the MASS functionality, to ensure that they comply with the requirements of this Code; and
.2 the renewal and periodical surveys should include verification and testing of the MASS functionality, to ensure that they comply with the requirements of this Code.

6.1.3 The periodical surveys 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.

6.2 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.

6.2.1 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.

6.2.2 The surveys referred to in 6.2.1 should be carried out as follows:

.1 the initial survey should include a complete verification and testing of the MASS functionality, to ensure that they comply with the requirements of this Code; and
.2 the renewal and periodical surveys should include verification and testing of the MASS functionality, to ensure that they comply with the requirements of this Code.

6.2.3 The periodical surveys referred to in 6.1.1 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.]

6.3 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 co-operation 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[4], 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[5], 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.

6.4 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.

6.5 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 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.

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.

Footnotes

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

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

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

CHAPTER 1 OPERATIONAL CONTEXT

The operational context for a MASS should, within the applicable regulatory framework, consider all aspects of the MASS operation and describe the autonomous or remotely operated ship function(s) and the external environment that influences its operation.

It should encompass a Concept of Operation (ConOps), an Operational Envelope (OE) detailing the ship-specific operational capabilities and limitations of the MASS, a system-specific Operational Design Domain (ODD) detailing the operational capabilities and limitations of any individual system, a fallback state to keep the MASS at a tolerable risk level in case of non-performance of autonomous or remotely operated ship functions, and the possible Mode(s)of Operation (MoO) of the MASS during its voyage.

The ConOps, OE, ODD, fallback state and MoO should be part of the certification as MASS. *(N.B. Final location to be confirmed)*

1.1 Concept of Operation

The ConOps as the base document should be drafted to avoid threats to maritime safety, security and the environmental caused by the MASS operation. Risk assessments for the 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 include consideration of the Operational Envelope (OE) and the technical design of the MASS and of the Remote Operation Centre(s) (ROC), 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, if applicable, together with the integration of humans in the operation.

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 remotely operated ship function can operate safely in all operating conditions, including all 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 the different voyages stages;
.5 the use and management of the modes of operation, including the division of functions and allocation of tasks between humans and automation; and
.6 any other factors that have a significant impact on the operation.

1.3 Operational Design Domain

The Operational Design Domain (ODD), based on the results of a risk assessment, should:

.1 encompass the conditions and limitations under which any individual autonomous or remotely operated system or function of a MASS operates safely without human supervision or interaction, including all reasonably foreseeable degraded states;
.2 include the capabilities and limitations to be accomplished before activation of operation of the individual system or function;
.3 include the external environment and internal conditions, such as system or equipment malfunctions.

An autonomous or remotely operated system or function should operate within its ODD as specified in the manuals of the system and related equipment and should be able to detect whether its current state of operation meets the ODD.

The ODD should be incorporated into the OE of the MASS, as an integrated system of all individual autonomous or remotely operated systems or functions of the MASS. If a single autonomous or remotely operated system or function deviates from its ODD, this should not necessarily result in the MASS deviating from its OE. As long as the MASS as an integrated system can continue to be operated within its OE, the deviation of an autonomous or remotely operated system or function from its ODD should be considered as [an Acceptable Risk Condition (ARC) / a degraded state].

1.4 Fallback state

In case a MASS is deviating from its OE, it should enter into a fallback state and take appropriate action to avoid, as far as practicable, any harm to life at sea, other ships, infrastructure, or the marine environment until the MASS returns into its OE and the normal operation of the MASS is restored.

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

The conditions and procedure to enter into and recover from a fallback state should be predefined.

The MASS should notify any crew and the operator when transitioning to, and operating in, a fallback state. The MASS should in addition alert surrounding vessels, as appropriate.

Contingency plans should be established to address the case where there is further deterioration despite the MASS entering its predefined fallback state.

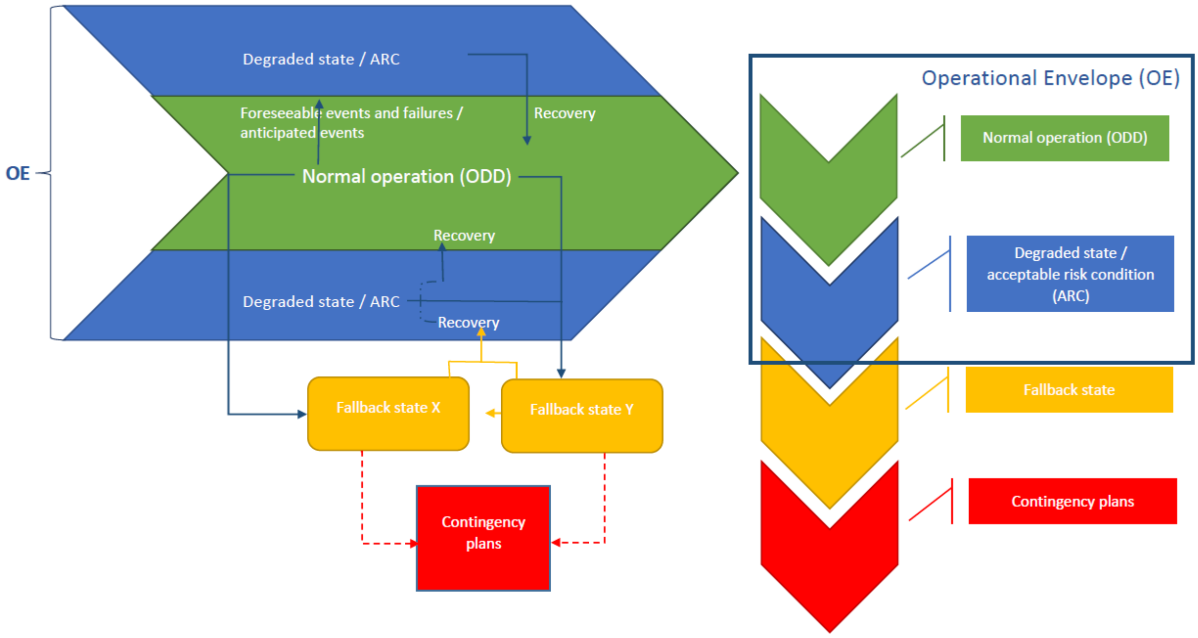

Figure 1: Illustration OE – ODD – ARC/degraded state – fallback1.5 Mode(s) of Operation

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

The description of MoO should also identify:

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

CHAPTER 2 RISK ASSESSMENT

2.1 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, taking into account identified goals and functional requirements, ensuring a level of safety equivalent to that of a conventional ship. The risk assessment can be conducted on MASS as a whole, and/or on the MASS functions. It should also consider the ConOps (and its OE) of the MASS. The risk assessment should address relevant mitigation measures. Should the risk assessment be carried out on specific MASS functions, the consequences on other ship's functions should be considered and mitigated.

2.2 A risk assessment should be carried out by personnel with relevant expertise as required by the Administration of the flag State (MSC.1/Circ.1212/Rev.1, Annex point 4). A Risk assessment may be performed at the following stage, including but not limited to:

.1 MASS (including ROCs) and system design phase;

.2 after alterations and modifications of a major characteristics of the ship or of the OE or ConOps of MASS that may have impacts on MASS functions.

2.3 Risks should be analyzed using suitable, recognized and appropriate risk assessment techniques.[1] Risk assessment should include a comprehensive description of the autonomous and remote-control function's utilization, effectiveness and reliability performing a thorough hazard analysis, conducting a mitigation [corrections and] analysis, evaluating the identified risks, and implementing effective risk control measures. The risk assessment should analyze and address hazards associated with the intended OE of the MASS including the associated ROCs, as described in the ConOps. Apart from the 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 OE.

2.4 The adopted mitigation measures should take into consideration single failure events, but also foreseeable events within the OE of the ship that may influence the performance of more than one system at the same time (e.g. heavy weather during hours of darkness). Such features should consist mainly of independent mitigation layers, including predefined fallback states. The number of such mitigation layers should be proportional to the risk. The assessment should ensure that hazards are eliminated wherever possible through inherently safe design and hazards that cannot be eliminated should be mitigated as needed, with the details of hazards and the means of mitigating them being documented to the satisfaction of the Administration. The effectiveness of the mitigation measures adopted in the risk assessment should be verified according to the verification and validation plan stipulated in [7.3.2.7].

Footnote:

[1]Refer to MSC.1/Circ.1455 and 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].

CHAPTER 3 SYSTEM DESIGN PRINCIPLES

In addition to complying with relevant rules and regulations, performing and supervising any specific function of the ship, MASS functions should comply with the following high-level [requirements] [principles].

3.1 Safety-Centric Design:

Systems should be designed to minimize risks to the ship, crew, cargo, and marine environment, and incorporate fail-safe mechanisms and emergency protocols.

3.2 User-Centric and Intuitive Interface:

Interfaces should be intuitive, user-friendly, and designed to serve the needs and capabilities of the operators.

[HMI should be designed appropriately for all the [possible] [expected] interactions between the crew/operator and MASS. Interactions between onboard crew and remote operators should be considered for HMI design.]

3.3 Robustness and Reliability:

.1 Systems should be robust and should be able to operate effectively under adverse conditions, including diverse maritime environments and operational challenges.
.2 It should be ensured that the systems perform their required functions effectively during the operational period specified by the manufacturer, up to predetermined maintenance intervals.

3.4 Adaptability and Flexibility:

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

3.5 Redundancy and Fault Tolerance

.1 edundant subsystems should implemented to maintain functionality in case of component failures including systemic or systematic failures.
.2 Systems should be designed to handle and recover from failures and continue operating at a reduced level (fall back state).

3.6 Scalability:

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

3.7 Security and Cybersecurity:

Security measures to protect the systems on the MASS and the ROC should be incorporated to prevent unauthorized access and cyber threats.

3.8 Energy Efficiency and Environmental Consideration:

Sustainable design should be incorporated aiming to reduce the environmental impact and the ecological footprint (energy efficiency) of the system throughout its lifecycle.

3.9 Data Management and Quality:

Efficient data management systems should be incorporated to ensure data accuracy, integrity, and quality [and design systems to leverage data for enhanced performance and decision-making].

3.10 Interoperability:

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

3.11 Testing and Validation:

Systems should be tested and validated [in real-case scenarios] to ensure they meet design specifications and operational requirements and operators should be involved in the validation.

[3.12 Ethical and Transparent Design:

Consider ethical implications in the design process, particularly concerning autonomy and decision-making, and maintain transparency in system operations and decision-making processes.]

CHAPTER 4 SOFTWARE PRINCIPLES

The following principles should be implemented to ensure that software, including AI and non-AI systems, are trustworthy, safe and secure. They should be used within the context of complying with the MASS Code, including the use of remote control and autonomous operation of key functions.

The principles should be considered as part of the approval process, and this may be done using software quality assurance standards.

4.1. Proportionality

Software should have an explicit and well-defined operational envelope. The use of software should not go beyond what is provided for in the concept of operations and risk assessment(s) should be used to prevent hazards which may result from such uses.

4.2. Safety and Security

Unwanted harm (safety risks) as well as vulnerabilities to external factors (security risks) should be avoided and addressed. 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.

4.3. Transparency and Explainability

Software should be transparent and explainable at all stages of its operational life, and for all decision-making processes. The transparency and explainability should: allow users and regulators to have sufficient information about the software, its associated inputs, decisions, and outputs; allow users to challenge outcomes; and ensure third parties know when they are engaging with a MASS that is utilizing software.

or

[Autonomous capabilities will be developed and deployed such that relevant personnel possess an appropriate understanding of the technology, development processes, and operational methods applicable to autonomous capabilities, including with transparent and auditable methodologies, data sources, and design procedure and documentation.] (USA proposal)

4.4. Accountability

Mechanisms should be implemented to provide accountability over the Organizations and individuals developing, deploying, or operating software to ensure proper operation. Software should be auditable and traceable to such organizations and individuals. There should be [governance] mechanisms in place for oversight, impact assessment, audit, and due diligence to ensure accountability for the software's impact throughout its operational life.

or

[Governable. Software will be designed and engineered to fulfill their intended functions while possessing the ability to detect and avoid unintended consequences, and the ability to disengage or deactivate deployed systems that demonstrate unintended behavior.] (USA proposal)

4.5. Robustness

Safe and secure software should be enabled through robust frameworks. Software should perform consistently with intended objectives, in a stable and resilient manner in a variety of circumstances. [Software should provide for continual improvement and provide for adapting situations.] The robustness of such systems should be tested and assured across their entire life cycle within that domain of use.

or

[Reliable. Autonomous capabilities will have explicit, well-defined uses, and the safety, security, and effectiveness of such capabilities will be subject to testing and assurance within those defined uses across their entire life-cycles.] (USA proposal)

4.6. Human Oversight and Determination

Software should be designed and developed to ensure people managing MASS operations can exercise meaningful oversight, including the ability to verify decisions when required. Humans should have the ability to interpret appropriate context, prevent or minimize risks, and contest decisions that impact the safe, secure, and environmental sound operation of MASS.

or

[Software should be designed and developed to prevent unintended bias, discrimination, and stigmatization of any kind. Appropriate actions must be taken to mitigate unwarranted discriminatory outcomes for individuals and groups to avoid unintended bias.] (USA proposal)

CHAPTER 5 CONNECTIVITY

5.1 Connectivity should be ensured at all times of MASS operations, including between the MASS and ROC. To achieve this, redundancy measured should be implemented based on the risk assessment.

5.2 The infrastructure for connectivity, and its performance, should be approved by the Flag Administration responsible for the MASS or an authorized Recognized Organization.

5.3 The connectivity between MASS and ROC should be established using redundant measures, including main and backup measures, preferably using different connectivity technologies [, bandwidth]/[, frequency] or/and service providers, as necessary according to the ConOps.

5.4 The connectivity between MASS and ROC should be operated according to appropriate Quality of Service (QoS) requirements.

5.5 The connectivity [connections] should be such as to operate the MASS safely using the minimal agreed levels of acceptable latency and bandwidth, or better. It should also consider the operational limitations as meteorological/oceanographic conditions (fog, wind, rain, thunderstorm, swell, etc.)

5.6 The connectivity between MASS and ROC should continue operating at full capacity even in the case of a single failure in the system for realizing the connectivity.

5.7 The data exchanged during in the connectivity with the ROC should be categorized and prioritized according to a pre-defined prioritization scheme to enable information with higher priority to prevail on lower prioritized information in case of decrease in communication capacity. The pre-defined categorization and prioritization of exchange of information should be included in the ConOps.

5.8 The connectivity should be monitored for real-time or near real-time against its performance requirements. If disconnection or performance degradation of the main connection is detected, the system should automatically switchover to a backup connection through means described in the Operational Envelope of the ship. If both, the main and the backup connections does not meet the connectivity requirements, the MASS should enter a Fallback state with alert to ROC until the connectivity automatically reestablished. Measures should be taken to alert stakeholders to any disconnection issues and recover from the abnormal condition. Automatic reestablishment should be in accordance with the specifications within the OE of the ship.

5.9 Connectivity including Computer Based System (CBS)* 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 IACS UR E26.

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

CHAPTER 6 ALERT MANAGEMENT

6.1 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.

6.2 Functional Requirements

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

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

- .1 the means used to draw the attention of the [human operator] to the existence of abnormal situations;
- .2 the means to enable the human operator to identify and [address][understand] that condition;
- .3 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;
- .4 the means to enable a human operator to handle alert announcements; and
- .5 the means to manage all alert related states in a distributed system structure in consistent manner.

6.3 Expected Performance

EP 1 If practicable, there should be no more than one alert [per human operator] for one [abnormal] 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, wherever located, 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 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 person operating 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 [including those required in Chapters of Part 3] 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 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, a sufficient number of dedicated human operators including the master of the MASS should be operating the MASS until the emergency is over.

CHAPTER 7 HUMAN ELEMENT

7.1 General

To cooperate addressing human element issues effectively, the safe operation of a MASS should consider the entire spectrum from human-machine cooperation/collaboration to human activities performed by and effect on shipowner/Company, personnel on board a MASS, shore-based ROC operators, regulatory bodies, recognized organizations, shipyards, legislators and other relevant parties.

To address human element issues, the Organization considers; workload (both on board and onshore), decision-making, living and working environment, operation and maintenance, other measures (i.e. training, practical skill development and competences, procedures, spares outfit, information/ manuals, occupational safety requirements including guarding and personal protective equipment (PPE), shore support).

Noting above, this chapter provides main principles and areas for a MASS and functions for MASS operations to ensure that human element issues are effectively addressed.

7.2 Human aspects

To comply with this chapter of the Code, the followings provisions should be considered:

7.2.1 Safe operation of a MASS is the responsibility of [the role of] a master. The master should be supported by their [crew]/[colleagues] [from the ship and the ROC] and relevant parties both on board and ashore, which have competencies to perform assigned functions, provided by this Code, timely guaranteed by all-time connectivity;

7.2.2 Roles and responsibilities [of humans] should be clearly defined. These assigned functions, such as duties of Remote Operators should be established, as part of the MASS' Safe Management System ;

7.2.3 The scope of [Human-Machine Teaming][Human-Autonomy/Machine Teaming] should be considered. This includes design and testing of the work system of humans, technology and procedures to identify what can be provided to assist humans. Human operators should also be involved in validation stages to ensure reliability and safety of the total System;

7.2.4 Human-System Interaction should be robust. This should include intervention strategies for reasonably foreseeable situations (normal, abnormal and emergency) and reversionary means of control based on the principle of what the System can provide to humans. The design processes should consider resilience, reliability, trust and sustainability of the whole Human-Machine System including the use of new innovations [(e.g. such as adding a new camera or sensor)];

7.2.5 Work system design and relevant policy should be developed. That should consider; and [different requirements for each stage of voyage]; cyber-social-technical systems; technical and cultural aspects for system integration; human physical, mental, emotional and social well-being; [diversity and inclusiveness]; [safeguarding]; ensuring human connections at all times; incident/accident reporting and support; and

[7.2.6 Consideration about situational awareness should split human and machine resilience].

7.2.7 Safety behavior principles for safe MASS operation in a form of user-assessable way in relation to human aspects are recommended and provided as an appendix 1 to this chapter.

7.3 Supplementary Competencies, Training and Familiarization

[7.3.1 Introducing advanced technological tools in shipping without providing sufficient training to the crew and staff can lead to underutilization or misuse of the technology. This can negate the potential benefits of the technology and even increase the risk of accidents or inefficiencies.]

7.3.2 [Noting the Principles of the Code [(Part 1, 2 Principle)] ensure the base IMO instruments are maintained,] this chapter provides principles for [new][supplementary] competencies, and corresponding training and familiarization provisions required when operating a MASS to fully demonstrate the roles and responsibilities including role allocation between the autonomous or automated system and for seafarers and operators on both the MASS and ROC(s).

7.3.3 Remote Operator of a MASS should have competency and experience as officers qualified in accordance with appropriate STCW requirements. [The Administration may allow the Remote Operator who has equivalent competency and experience in satisfaction of the Administration.]

7.3.4 Supplementary competencies

Both seafarers on board a MASS and Remote Operator(s) should be competent in areas including, but not limited to;

.1 having equal level of understanding on operational capabilities and limitations as listed in the Operational Design Domain (ODD) of the MASS systems properly;
.2 having an appropriate level of technical skill to be able to immediately take over the control of the MASS from the system and command manually when the autonomous or automated systems are malfunction and are departed from ODD;
.3 having [non-technical] managerial skills against the considerable risks while using the autonomous or automated systems. Especially, the dangers of over-reliance on automated systems;
.4 maintaining communication between ROC and the MASS all the time of operation and if communication is disconnected, Remote Operator should change over to the backup communication system for continuous operation of the MASS;
.5 carrying out a periodical maintenance and record keeping of the instruments composed for safe and sound operation and continuous monitoring at ROC in accordance with the instructions or recommendations from manufacturer or provider of the systems; and
.6 having knowledge and competencies across areas including but not limited to equipment operation, MASS manoeuvring; maintenance and repair of MASS; communication systems; safety and security of MASS; emergency and abnormal operation response; vessel and ROC operations; use of AI and advanced technologies.

Remote Operators should be competent in areas including, but not limited to:

.1 be trained to understand the information provided to them from onboard systems, the origins of this information, and the system limitations; and
.2 have an understanding of the different modes and system status that will be required at different points of a voyage and receive training in the methods of transitioning between them.

.3 [Administrations should consider clearly evidenced remote operational experience as sea time equivalency for those working within a ROC for the revalidation of [Certificate of Competency's / MASS Operator Endorsement] where appropriate.]

Supplementary Training and Familiarization

.1 Training should be conducted using a blended approach incorporating a combination of practical hands-on training and simulation-based scenarios. Training should be structured to cover normal, abnormal, and emergency scenarios to the satisfaction of the Administration.
.2 Training development should include the use of a Training Record Book and Remote Operators should maintain a record of their operational time that will provide a record of experience and aid in the process of certification revalidation.
.3 Both seafarers on board a MASS and Remote Operator(s) should be trained in areas including, but not limited to,;
.4 undertaking system specific training conducted by the manufacturer in addition to the development of generic MASS vocational skills and competencies;
.5 acquiring knowledge of the autonomous or automated systems on board MASS and ROC, corresponding to their roles and responsibilities, in association with situational awareness, collision avoidance, and auto tracking of the intended route, cyber security, propulsion plant etc. as well as proper competencies to apply the risk assessment on any operation of the MASS; and
.6 having knowledge on different types of decision-making processes for a MASS operation and understanding on when and how to be supported by the System.

Remote Operators should be trained in areas including, but not limited to,;

.1 receive an appropriate level of technical training such that they are able to correctly configure systems, diagnose emerging issues, and undertake initial remedial steps;
.2 Be trained in the different failure modes of MASS systems, the reaction of the system to an incorrect or absent input, and the means by which they can revert to the base level of control;
.3 be assessed by the incorporation of behaviour markers of MASS Remote Operator competency in order to evaluate decision-making, situational awareness, and stress management skills, essential for effective and safe remote vessel operations.
.4 Seafarers and Remote Operators of a MASS should be familiar with operations of the autonomous or automated systems, for which the seafarers are responsible, installed on the MASS.

7.3.5 Manning/Crewing

Further progress by JWG needed to complete high level text in this chapter.

[This chapter could cover both MASS and ROC.

MASS and ROC Operations include competencies at three distinct levels:

Support Level: The Support level is primarily focused on hands-on operation and preparation of the MASS systems. Personnel may be on board or stationed at the location from which the MASS is deployed, or in support roles in the ROC.

Operational Level: Concentrating on the day-to-day operations on board and including tasks associated with remote operations of MASS.

Management Level: Addressing the strategic and managerial aspects of MASS & ROC operations.

.1 Crewing requirements, Crew Welfare and Mental Health.
.2 Ethical point of view, facilitating attracting workforce and making ethical decisions.
.3 Numbers, roles, skills and competence to determine safe manning/crewing requirements.
.4 Applicable work hour limits and/or rest requirements.
.5 Existing responsibilities and roles expected from seafarers and shore staff that have to be kept, such as the duty to render assistance.
.6 Redesign of the jobs of seafarers and shore staff to take account of new or changed responsibilities, including support and maintenance of software-intensive systems, and data analysis.
.7 The cumulative effect of all changes on the safe and effective performance of seafarers and shore staff, such as situational awareness and training.
.8 Sustainable workforce in maritime, onboard training and mentorship.
.9 Monitoring ship’s safe operation and adequate maintenance.
.10 Consideration regarding failure modes.
.11 Just Culture Protocols should be established to encourage the accurate and timely reporting of issues, to prevent escalation, and possible re-occurrence.]

PART 3 GOALS, FUNCTIONAL REQUIREMENTS AND EXPECTED PERFORMANCE

Each chapter in this part consists of the goal of the chapter, Functional Requirements (FR) to fulfil the goal, and the Expected Performance (EP) 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 meet all the expected performances associated with that functional requirement; or

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

CHAPTER 1 NAVIGATION

1.1 Goal

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

1.2 Functional Requirements (FRs)

In order to achieve the goal set out in paragraph 1.1 above, the functional requirements and expected performances are embodied in this chapter.

1.3 General

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

FR1.3.1 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 (OE) of MASS.

EP1 The use of autonomous systems for non-navigation functions or tasks should not endanger the safe operation of navigation systems.; and

EP2 In the event of failure of the ANS, the ship should be able to be controlled safely by operating the other installed navigation system.

[FR1.3.2All reasonable steps should be taken to maintain ANS and related equipment in efficient working order [and must be seaworthy]]

1.4 Sub-functions for MASS navigation

A MASS should comply with the following functional requirements of [FR 1.4.1, .2, .10 and .11]. In addition, any or all of the sub-functions below could be automated or remotely controlled and the MASS should comply with the following functional requirements of [FR1.4.3-.9] respectively corresponding to the sub-functions.

[.1 [Situational awareness]: FR1.4.3-.5;

.2 Route planning and determination for collision and grounding risk avoidance: FR1.4.6; and

.3 Heading, speed and track control: FR1.4.7-.9]

FR1.4.1 Voyage plan should be developed taking into account the following issues:

EP1 [The voyage plan should provide the [responsible person] with [sufficient]/[adequate] information to ensure that operations are conducted with due consideration to the safety of the ship and persons [on board];]

EP2 [[All] potential navigational [and hydro-meteorological] hazards [and [environmental conditions]/[traffic constraints]] should be [accurately] identified;]

EP3 [Charts and publications [are corrected [updated] in accordance with the latest information available]/[should be electronically available];]

EP4 Comprehensive information including OE [, ODD] and mode of operation should be provided;

EP5 [The voyage plan describing the [full] voyage from departure to arrival should be definable and updatable at any time; and]

EP6 [A voyage plan is an indication of preferred actions based on information available at the time the plan is prepared; therefore deviation from the plan may be necessary based on actual circumstances at the time the plan is executed.]

FR1.4.2 Means should be provided to ensure appropriate and correct voyage plan to be input into ANS.

EP1

<option1>

[Responsible person] should verify that the voyage plan input into ANS is correct.

<option2>

The voyage plan input into the ANS should be verified.

[EP2

<option1>

An ANS should not be used to navigate a MASS without an appropriately approved voyage plan.

<option2>

It should not be possible to activate the ANS without an approved voyage plan.]

FR1.4.3 When MASS is underway, MASS should be able to continuously monitor the following items:

EP1 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;

EP2 its own status such as heading, velocity, position and condition of each subsystem;

EP3 geographic information related to safety of navigation such as nautical chart information; and

EP4 environmental conditions such as weather, visibility and sea state.

FR1.4.4 [MASS]/[ANS] should integrate all information obtained from FR1.4.4 to interpret and analyze MASS's condition while taking into account the limitations of the equipment and prevailing circumstances and surrounding conditions.

FR1.4.5 Appropriate and accurate analysis of current and predicted vessel state, navigation path, and external environment should be made available to [responsible person].

FR1.4.6 ANS should plan an appropriate route to avoid collisions[, allision] and groundings [according to changing/in all] conditions and notify other system and/or the [responsible person] based on the results of the situational awareness, taking into account the following items:

EP1 Decisions and planning to amend course and/or speed should be both timely and in accordance with safe operating limits of ship propulsion, steering and power systems; and

EP2 The route should be updated [as required] based on the latest [changes]/[inputs and situation].

FR1.4.7

<Option1>

ANS should track with pre-defined accuracy based on the ship's manoeuverability over the planned route [including collision avoidance, berthing, un-berthing [and anchoring]] in order to ensure appropriate control and actuation based on situational awareness and decision.

<Option2>

ANS should be capable of adjusting route compliance accuracy and safe speed according to voyage phase considering information received from situational awareness systems.

FR1.4.8 Safe operating limits of ship propulsion, steering and power systems controlled by ANS should not be exceeded in normal operations.

FR1.4.9 The ANS should be capable of making adjustments made to the ship’s course and speed to maintain safety of navigation, giving due consideration to the [ship’s loading condition and stability]/[stowage and securing of cargo and ship’s stability].

FR1.4.10 Proper records relating to navigation should be stored appropriately [and retrievable at all times] in order to adequately store data that contributes to safety navigation and casualty investigations.

EP1 Records of the movements, activities and time relating to ANS should be maintained at the same level as voyage data recorders.

[EP2 [In the case of MASS without crew on board,] records of navigational activities and daily reports should be automatically stored on board and at the ROC as appropriate.]

[FR1.4.11

<option1>

In case of MASS without crew on board, MASS should be capable of transmitting and receiving information for navigation.

<option2>

In case of MASS without crew on board, A MASS should achieve the following EPs in order to safely navigate by utilizing the services described in SOLAS Chapter V.

EP1 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 responsible person and/or ANS].

EP2 Observed meteorological data, information relating to ship reporting systems, reports to VTS and danger messages should be reported automatically or by the ROC, as required.]

1.5 Override and fallback response

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

FR1.5.1 A [responsible person] should be able to override ANS at any time of their own choice, in accordance with the following requirements:

EP1 Mode switching to override should be a [single]/[double] action operation;

EP2 Mode switching to override should be immediate on switching between ANS and operator controlled; and

EP3 Means to remote override should be provided taking into account cybersecurity and connectivity.

* Note: The concepts of "fallback" in following option 1 and 2 are different.

<option1>

FR1.5.2 Fallback response should be promptly performed in case of deviation from the ODD (including internal ANS conditions and external environment). The [responsible person] 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.

FR1.5.3 In case MASS cannot 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:

EP1 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

EP2 MASS should notify the [responsible person] and surrounding vessels promptly when it transitions to MRM.

<option2>

FR1.5.2 In case MASS cannot continue normal operations, the MASS should transition into a [pre-defined][fallback] state in accordance with the following requirements:

EP1 The condition for transition to the [pre-defined]/[fallback] state and the content should be designed, taking into account the ConOps and mode of operation of MASS; and

EP2 MASS should notify the [responsible person] and surrounding vessels promptly when it transitions to the [pre-defined]/[fallback] state].

* Note: to be transferred to other part or chapter

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

FR The use of ANS should not endanger the safety of persons on board, the vessel or [the traffic environment including] other vessels.

FR For autonomous or remotely controlled navigation, ODD of ANS should be [described][clarified], in accordance with the following requirements[, as appropriately taking into account ConOps]:

.1 The ODD should include information on the ship-specific capabilities and limitations that relates to the [risk] assessment required for activation of the ANS; and
.2 ANS should operate within its ODD as specified in the [ANS manual] /[Information material related to the usage of the ANS and related equipment].
.3 ANS should be able to detect whether the current state meets ODD.

FR

<option1>

[Functionalitis 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 expected performance:

<option2>

Functionalities related to navigation, operating within its ODD, should achieve an equivalent level of safety, with the following expected performance:

.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 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];
.4 [Manuals for the use of ANS]/[Informative material related to the usage of the ANS and related equipment] 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
.5 ANS should be designed to ensure that it can recover properly in case of an unexpected shutdown.

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

FR Interactions between onboard crew and remote operator should be considered for HMI design.

FR Hardware interface for autonomous control should be appropriately [compatible and] connected. [Maintenance and] performance checks and tests for the ANS comply with the ANS provider's documentations, e.g. safety [manuals and recommendations]/ [informative materials and recommendations related to the usage of the ANS and related equipments].

FR [Any] ANS operators should be trained for the use of the system.

(FR) The ANS should be able to address conflicting input in a predetermined manner.

CHAPTER 2 REMOTE OPERATIONS

2.1 Goal

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

<option 2>

[The goal of this chapter is to ensure the safe, secure and effective remote operation of MASS [, or automated functions thereof,] when duties and responsibilities for safe operation are assigned to a Remote Operations Centre (ROC),] [taking into account the modes of operation, the number of persons on board, and the total number of MASS that are operated from the same location.]

2.2 Functional Requirements:

In order to achieve the goal, set out above, the following functional requirements and expected performances are embodied in this Chapter.

FR2.1: A [location/ROC] should be provided to ensure the safe, secure, and effective operation of MASS [or the automated functions thereof] at any time when they are in service.

A [location/ROC] should have:

EP.1. facilities that are secure and protected from unauthorized access.

EP.2. means to enable reliable connectivity and communication between ROC(s) and the MASS, third parties and persons on board.

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. arrangements, such that the failure and [subsequent] recovery of the ROC would not result in an unsafe state or intolerable risk on or around the MASS in service [, including the use of redundancy or enter a fallback state].

EP.5. validated and verified systems to support the effective operation of MASS.

EP.6. sufficient and relevant qualified personnel [in accordance with Management of Safe Operations requirements] to enable safe operation of MASS.

EP.7. facilities to ensure data and information used, produced, sent or received is retained in reliable and tamper-proof storage and at a suitable standard of data quality, and referring to the SOLAS requirements for Voyage Data Recorders.

FR2.2 A control station(s) should be provided to ensure the safe, secure and effective operation of MASS [or the automated functions thereof]. A control station 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) that the related on-board equipment and devices have appropriate compatibility and interoperability.

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.

FR2.3 Validated and verified systems and interfaces between control station(s) and the MASS should be provided to ensure the remote operator can operate the MASS safely, securely and effectively. This will be accomplished by ensuring the remote operator is able to:

EP.1. keep a watch at sea or in port in a manner conforming to the principles of watchkeeping,

EP.2. send and receive sufficient and accurate information/commands effectively and securely between the ROC, MASS, third parties, and any shipboard personnel.

EP.3. take all decisions necessary to ensure the safe operation of MASS.

EP.4. know the status of the connectivity at the control station(s) and MASS and where relevant by third parties.

EP.5. know which systems can be controlled, and the current control position is known and clearly visible [OR have the location which is in control clearly visible].

EP.6. know of when conditions on the MASS in service or at the ROC deviate from the operational envelope.

EP.7. monitor the condition and mode of operation of MASS equipment and systems and, take measures to prevent and/or rectify deficiencies when [alerted][warnings actuate].

FR2.4 The transfer of operation of MASS [, or the automated functions thereof] should be safe and secure to ensure no loss of safe navigation. This will be accomplished by ensuring:

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

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][possible] 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.

FR2.5 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 to ensure safe, secure and effective operation. This will be accomplished by ensuring 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, 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.

CHAPTER 3 COMMUNICATIONS

3.1 GOAL

The goal of this chapter is to ensure adequate communication with all relevant entities (ships, ROCs etc.)

3.2 FUNCTIONAL REQUIREMENTS

To achieve the above-mentioned goal, the following functional requirements and expected performances supplementary to SOLAS chapter IV are embodied in this chapter.

3.2.1 General

FR3.2.1.1 Measures should be taken to [ensure] [establish] that the communication between the MASS and all relevant entities is achieved.

EP 1: The technologies used in communication between the MASS and all relevant entities should not be limited to those used in GMDSS.

EP 2: The communication between the MASS and all relevant entities should consider cyber security.

FR3.2.1.2 The communication between the MASS and all relevant entities should meet the following expected performance.

EP 1: Communication between the MASS and all relevant entities should be available during the voyage.

EP 2: The communication between the MASS and all relevant entities the external actors/users should be reliable, stable, and secure.

EP 3 : The communication between the MASS and all relevant entities should at all times operate with a quality of service, particularly including bandwidth, transmission errors, and latency, sufficient to support the necessary interaction between MASS and all relevant entities. This minimum quality of service should be maintained may vary during the voyage.

FR3.2.1.3 The communication failure of MASS should be monitored and an alarm with sound and visual indication should be provide to relevant operators on board or in ROCs. The detail communication failures and response means should be reflect in the ConOps.

3.2.2 Communication between MASS and ROC

FR3.2.2.1 A ROC should be able to communicate with one or more MASS.

EP 1: When ROC communicates with one or more MASS simultaneously, these communications should not affect each other.

EP 2: If applicable, ROC should seamlessly switch to communication with other MASS supposed to be under its control when her communication with previous ROC.

FR3.2.2.1 A MASS may be communicated by one or more ROCs.

EP 1: MASS is controlled by only one ROC at any given time.

EP 2: If a MASS can be operated by multiple ROCs, communication conversion between the ROCs should be not endanger safe operation of the MASS.

FR3.2.2.3 For remote operated ships, communication with ROC should be performed by ROC operators through the MASS.

EP 1: MASS should automatically transmit without delay the received external information to its ROC.

FR3.2.2.4 As for MASS without qualified radio operator on, means should be provided for ROC to communicate with automated systems on the MASS.

EP 1: Mass automatically transmits and receives relevant information and communicates with ROC.

EP 2: Distress alerts of the MASS must be automatically generated onboard. The alerting process must ensure that alerts are transmitted when required and that false alerts are avoided (see resolution MSC.514(105)).

FR3.2.2.5 The ROC should be capable of continuously monitoring all operational aspects of MASS, including but not limited to the OE and the Mode of Operation, regardless of the manufacturer. Additionally, compatibility and communication between different ROCs should be ensured to facilitate safe and efficient interoperation among vessels.

CHAPTER 4 SUBDIVISION, STABILITY & WATERTIGHT INTEGRITY

4.1 Goals

The goal of this chapter is to ensure that the subdivision, stability, and watertight integrity are maintained as appropriate.

4.2 Functional Requirements

In order to achieve the goal, set out in paragraph 4.1 the following Functional Requirements (FR) and Expected Performances (EP) are embodied in this chapter.

FR.4.2.1:

Any automated/autonomous function for the control of intact and damaged stability should be provided with an independent automated/autonomous supervising function. The action of the supervising independent function shall be triggered by failures/events (*) of the stability control system.

EP.4.2.1.1: It should be able to monitor, control, and operate any systems (*) onboard that may affect the stability of the ship.

FR.4.2.2:

The automated/autonomous functions, supervising functions, and functions carried out at the ROC should provide means to ensure compliance with the relevant intact stability criteria (*).

EP.4.2.2.1: Capable of continuously determining the ship's intact stability and assessing survivability during operation.

EP.4.2.2.2: Capable of continuously control the loading conditions, the longitudinal and local strength.

EP.4.2.2.2: Capable to assess the survivability of the ship in case of damage, to maintain the ship, at all times is operating within the stability envelope as prescribed in the stability booklet.

EP.4.2.2.3: Capable of restoring compliance with relevant intact stability requirements if the system has detected that these requirements are not met.

EP.4.2.2.4: Able to bring the ship to the Fallback State upon activation of a critical alarm related to the intact stability.

EP.4.2.2.5: Able to detect existing or predictable stability failures and raise alarms.

FR.4.2.3: The supervising function, as the dedicated monitoring function, is explicitly responsible for continuously monitoring system performance, detecting failures/events of the automated/autonomous stability function, as well as other failures/events, and promptly initiating corrective responses. It shall achieve this through active oversight, relying on an independent measuring system (provided with a comprehensive array) of sensors.

FR.4.2.4:

The stability control system and the supervising function should be resilient to single failure.

FR.4.2.5:

The independent measuring system and sensors should be designed and maintained to consistently provide accurate and reliable data to ensure that the ship stability, subdivision, and watertight integrity is maintained under all conditions.

FR.4.2.6:

The independent measuring system and sensors should incorporate redundancy mechanisms to ensure data availability in the event of component failure.

EP.4.2.6.1: Regular calibration and maintenance procedures should be in place to ensure accuracy over time.

EP.4.2.6.2: Data from the measuring system and sensors should integrate seamlessly with the supervising function and other systems.

EP.4.2.6.3: The system should alert operators in case of issues with the measuring system or sensors.

EP.4.2.6.4: The measuring system and sensors should be compatible with the ship's overall stability and safety systems.

EP.4.2.6.5: Comprehensive documentation should be available detailing specifications, maintenance procedures, and testing protocols.

FR. 4.2.7:

The stability control system should provide measures to prevent excessive motions of the ship in adverse sea conditions.

EP.4.2.7.1: Able to continuously measure amplitudes and accelerations of ship motions.

EP.4.2.7.2: Able to detect when the ship's motions exceed predefined thresholds, triggering alarms onboard and/or at the ROC, while recording readings from the sensors.

EP.4.2.7.3: Adjusting speed and course from the ship and/or the ROC, in response to the wave direction to ensure compliance with predefined limits for the ship's movements.

EP.4.2.7.4: Able to predict the combination of ship's speed and course, under current weather conditions, that may cause the ship to exceed the limits, and initiate appropriate corrective mitigation actions from the ship and/or at the ROC.

(*) Footnotes:

• 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.

• Systems like e.g., watertight doors (if any), valves, cross-flooding systems, ballast water and anti-heel tanks. Rolling accelerations or amplitudes exceeding prescribed limits.

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

CHAPTER 5 FIRE PROTECTION/SAFETY

5.1 GOAL

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

5.2 FUNCTIONAL REQUIREMENTS

To achieve the above-mentioned goal, the following functional requirements [and expected performances] are embodied in this chapter.

FR5.1: A MASS should remain under control or enter a fallback state during and following a fire event. This will be accomplished by ensuring:

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.

FR5.2: Means should be provided to enable detection, confirmation, and localization of a fire incident.

EP 1: All alarms related to the fire safety systems shall 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.]

FR5.3: Means should be provided to enable the appropriate use of fire extinguishing systems, taking into account the possible presence of people.

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 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 personnel boarding the ship.

FR5.4: Means should be provided to assess the fire-fighting effectiveness during and after fire.

EP 1: Means should be provided to assess any smoke development 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.

FR5.5: Means should be provided to enable the control of all active fire protection measures.

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 at regular intervals.

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

FR5.6: Means should be provided to facilitate an intervention from external fire responders.

EP 1: Procedures should be in place to transmit any relevant information and data to external fire responders during and following a fire incident.

EP 2: Means of communication between the MASS 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 provide for safe escape, evacuation, [and survival].

6.2 Functional requirements

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

[FR6.2.1All ships should provide means for a safe abandonment for all persons.]

FR6.2.2 All personnel involved in the operation of MASS shall be trained to take appropriate measures in case persons on board are required to abandon the MASS.

[FR6.2.3All MASS and survival craft should provide means for the safety and survivability of all persons on board the survival craft to allow time for a rescue after the abandonment of the MASS.]

FR6.2.4 All ships should have an effective emergency management system.

FR6.2.5 The use of [automated and/or remotely controlled] life-saving appliances should not endanger the safety of any persons on board or of the ship.

FR6.2.6 Proper instructions and information should be provided to all personnel involved in the operation of the MASS in relation to all life-saving appliances and their use.

[FR6.2.7Survival craft and life-saving appliances, and necessary equipment shall have the capability to operate automatically to enable the safe abandonment of personnel from the MASS.]

[FR6.2.8Survival craft, life-saving appliances, and necessary equipment that operate automatically should be deployed in accordance with pre-established procedures.]

FR6.2.9 Provision should be made to enable the deployment of life-saving appliances 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 an abandonment of personnel.

FR6.2.10 The life-saving appliances, associated media, and by-products of any [automated] [autonomous or remotely controlled] life-saving appliances should be managed so that they do not present a [an increased] risk to the safety of persons on board.

[FR6.2.11 A remote operations centre should be capable of taking measures to facilitate abandonment of the MASS. During an emergency situation the remote operations centre shall be provided with sufficient available information [from the MASS] to assess the risks to personnel and to manage appropriate response actions.]

[FR6.2.12 [An appropriate level of communication between the MASS and the remote operating centre shall be maintained during and following an abandonment of the MASS.]

CHAPTER 7 MANAGEMENT OF SAFE OPERATIONS

7.1 Goal

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

7.2 Functional Requirements

In order to achieve the goal, set out in paragraph 7.1 above, the following functional requirements (FR) and expected performances (EP), are embodied in the provisions of this chapter.

FR7.2.1 The Safety Management System (SMS) should provide for safe operation of the autonomous or remote-controlled ship functions by establishment of procedures, plans and instructions for all foreseeable operating conditions of the MASS, including those involving different physical locations, if applicable.

This will be accomplished by ensuring consideration of:

EP 1: risk control measures addressing autonomous or remote-controlled ship functions.

EP 2: internal processes verifying the effectiveness of procedures, plans and instructions addressing autonomous or remote-controlled ship functions.

EP 3: human-machine-interface aspects of autonomous or remote-controlled ship functions.

EP 4: role and expected performance for all physical location(s) where autonomous or remote-controlled ship functions are executed.

EP 5: interaction of autonomous or remote-controlled ship functions.

EP 6: capabilities and limitations of autonomous or remote-controlled ship functions.

EP 7: complexity of systems, including software systems or data services.

EP 8: equipment and systems necessary to maintain contact to the MASS.

EP 9: lines of communication to maintain contact to the MASS.

EP 10: cyber-threats.

EP 11: fall-back actions and processes to maintain safe operation of the autonomous or remote-controlled ship functions.

FR7.2.2 The Safety Management System (SMS) of the company should provide for the safety and well-being of the personnel involved in the MASS operations by identification of resources and training required and by establishment of procedures, plans and instructions for all foreseeable operating conditions of the MASS, including those involving different physical locations, if applicable.

This will be accomplished by ensuring consideration of:

EP 1: risk control measures addressing autonomous or remote-controlled ship functions.

EP 2: internal processes verifying the effectiveness of procedures, plans and instructions addressing autonomous or remote-controlled ship functions.

EP 3: human-machine-interface aspects of autonomous or remote-controlled ship functions.

EP 4: responsibilities with regard to the intersection and interaction to operate a MASS.

EP 5: how to maintain function of overriding authority.

EP 6: emotional pressure, specific stresses and strains to humans in the operation of a MASS.

FR7.2.3 The Safety Management System (SMS) of the company should provide for the safety of a MASS under all expected emergency conditions of the MASS by establishment of contingency procedures, plans and instructions, including emergency scenarios involving different physical locations, if applicable.

This will be accomplished by ensuring consideration of:

EP 1: risk control measures addressing autonomous or remote-controlled ship functions.

EP 2: internal processes verifying the effectiveness of procedures, plans and instructions addressing autonomous or remote-controlled ship functions.

EP 3: human-machine-interface aspects of autonomous or remote-controlled ship functions.

EP 4: monitoring autonomous or remote-controlled ship functions performance including relevant system and ship parameters.

EP 5: assistance for emergency handling, or handling of other potentially unsafe situations.

EP 6: capabilities and limitations of emergency response in the MASS operation.

CHAPTER 8 SECURITY

8.1 Goal
The goal of this chapter is to ensure adequate security.

8.2 High Level Functional Requirements

FR 8.2.1 Quality of system: Means should be provided on board [and remote] for management of automated [autonomous] systems to enable the assessment of security effectiveness.

FR 8.2.2 Key capabilities: Onboard [and remote] management of automated [autonomous] systems should be provided to enable control of the systems.

FR 8.2.3 Resilience: A MASS should remain under control during and following a security event.

8.3 Specific Functional Requirements

FR 8.3.1 Coordination with external responder by Interacting with the third party

EP.1 Provision should be made to enable security control and response to be undertaken on board by an external responder.

FR 8.3.2 Protection of equipment and people by preventing collateral damages

EP.1 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 8.3.3 Isolation of MASS when security breach through network is anticipated

EP.1 There should be a mechanism for safely shutting MASS communications down when the security of the remote operation centre has been compromised.

FR 8.3.4 Ensure resilience by providing capability to cope with security incident

EP.1 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.

EP.2 An appropriate level of communication between the MASS and the remote operating centre should be maintained during and following a security event.

CHAPTER 9 SEARCH AND RESCUE

9.1 Goal

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

9.2 Functional requirements:

In order to achieve the goal set out in paragraph 9.1 above, the following functional requirements are embodied in the provisions of this chapter:

FR9.2.1 Every MASS should be able to provide assistance to persons in distress at sea as far as such action may reasonably be expected of it.

EP1: The ship should be able to receive distress information from any source, included search and rescue service information (according to Communications Chapter 3).

EP2: Means should be provided to correlate the MASS own status and any given distress signal, and its ability to render assistance. *(NOTE: possibility to render assistance in fire-fighting, compare to FiFi chapter)*

EP3: MASS should be able to coordinate with coastal State SAR service if its cooperation is required or participation is necessary.

FR9.2.2 Every MASS should be able to detect distress signals.

EP1: MASS sensors should be able to collect environmental data and share them with the Remote Operations Centre (ROC).

EP2: MASS should be able to detect, recognize, and identify objects and lights (according to Navigation Chapter 1.4 Sub-functions for MASS navigation).

EP3: MASS should be able to identify distress signals of COLREGs Annex IV.

EP4: If within its operational envelope, MASS should be able to establish relative bearing and distance to detected objects. (according to Navigation Chapter 1.4 Sub-functions for MASS navigation).

FR9.2.3 MASS should be able to locate distress signals.

EP1: MASS should be able to locate distress signals with bearing and distance or with latitude and longitude, according to the detection system.

EP2: If within its operational envelope, MASS should be able to trace a course to the point where distress signal is located (according to Navigation Chapter 1.4 Sub-functions for MASS navigation).

FR9.2.4 Every MASS should proceed with all possible speed to the rescue of persons in distress.

EP1: If within its operational envelope, the MASS should be able to identify the possible speed to go to the area where persons in distress are (according to Navigation Chapter 1.4 Sub-functions for MASS navigation).

EP2: Environmental and internal factors that may affect the ship speed should be addressed.

FR9.2.5 After a collision with other ship, every MASS should render assistance and provide information.

EP1: Means to address the capability of ship to render assistance to the other ship, its crew and its passengers after a collision should be provided, included damage sustained and environmental factors.

EP2: ship should be able to identify the assistance that's able to render, according to internal and environmental data.

EP3: Means to provide the name of the vessel, its port of registry and the next port of call to other vessel should provided.

FR9.2.6 In case of distress, if required, a MASS master should be able to lead on-scene SAR activities.

EP1: Means to ensure that master is able to lead SAR activities, including communication and coordination of surface search, should be provided.

EP2: Environmental and internal factors that may affect the ship capability to lead on-scene activities should be addressed.

EP3: Master's authority and responsibility to make decisions on SAR operations, should be assured.

EP4: IAMSAR Manual Volume III (Mobile Facilities) should be available to the master, even if controlling the ship remotely."

FR9.2.7 MASS, with or without crew on board, should be able to maintain distress communications (directly and through ROC).

EP1: MASS should be able to emit distress communications, including ship to shore distress alerts (according to Communications Chapter 3).

EP2: MASS should be able to keep an operation watch at the distress frequencies.

EP3: MASS should be able to immediately identify distress communications.

EP4: Depending on the distress message, means to promptly identify the type and scale of the emergency should be provided.

EP5: MASS should be able to receive distress communications.

EP6: MASS should be able to relay distress communications.

EP7: MASS should be able to silent distress communications as applicable.

EP8: Means to report SAR information to MRCC should be available.

EP9: Means to ensure that alerts are transmitted when required and that false alerts are avoided should be available.

FR9.2.8 A MASS, with or without crew on board, should have means to recover persons in distress.

EP1: Means to recover persons could be operated even if there are no persons on board.

EP2: Means to recover should adapt to environmental conditions.

EP3: Means to recover persons should ensure easy boarding .

EP4: Means to recover persons should not expose persons in distress to a greater danger than that is intended to avoid.

EP5: MASS should have, included in the emergency management system, specific plans, procedures and training and drills for the rescue of persons in distress, as well as manuals available to the master and officers in charge of the MASS.

EP6: MASS should have a maintenance plan for the means of retrieval from the water of persons in distress.

EP7: MASS should have a sheltered space on board from harsh meteorological conditions to accommodate retrieved persons in distress until is able to deliver them to a place of safety.

EP8: Means to prevent the access of rescued persons to unauthorized spaces should be available (according to Security Chapter 9.3 Specific Requirements: Implementation of ship security plan).

FR9.2.9 A MASS should have specific plans and procedures, including responsibilities, for its own distress situations in the emergency management system.

EP1: MASS should be able to identify an internal distress situation according to its own internal and environmental sensors.

EP2: Procedures, training and drills to address internal distress situations should be available.

FR9.2.10 Every MASS vessel with persons on board should have a responsible master on board for leading activities on board MASS during distress situations. Master of the vessel shall also facilitate safe access and guidance of external rescue staff on board.

CHAPTER 10 CARGO HANDLING

10.1 GOALS

The goal of this Chapter is to provide for the care of cargoes during stowage in a manner that ensures that the ship, persons on board and the environment are safe.

10.2 FUNCTIONAL REQUIREMENTS

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

FR10.2.1 Connectivity

The necessary connectivity for transferring relevant cargo information should be provided, irrespective of the means of control of the ship and its cargo.

FR10.2.2 Cargo information

All relevant cargo information should be provided, irrespective of means of control of the ship and its cargo, to include relevant cargo information, cargo monitoring, safe stowage, and securing information are available, as necessary, to enable the operations to be safely planned and conducted, taking into account the mode(s) of operation and the number of persons on board.

FR10.2.3 Cargo handling

Handling of cargo required by IMO instruments should be provided, irrespective of means of control of the ship and its cargo, with due consideration to safety of property and personnel, and the number of persons on board, as necessary.

FR10.2.4 Cargo emergency response (may be moved to emergency response)

The Cargo emergency response should be provided, irrespective of means of control of the ship and its cargo, taking into account the cargo type, the mode(s) of operation, and the number of persons on board, as necessary.

CHAPTER 11 PERSONNEL SAFETY AND COMFORT

11.1 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.

11.2 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 11.2.1 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 11.2.2 Personnel should have safe means of embarkation and disembarkation to and from a MASS.

FR 11.2.3 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)

FR11.2.4 Remote Operation Centres and workstations should be ergonomically designed [including visual ergonomics]

(Note: *may overlap with Part 3 chapter 2)

FR 11.2.5 Use of wearable technologies should adhere to health and safety requirements.

FR 11.2.6 Personnel working at a Remote Operation Centre should have suitable hours of work and rest (Note: *may overlap with Part 3 chapter 2).

FR 11.2.7 Personnel should not be exposed to levels of noise that exceed safe working conditions.

FR 11.2.8 Human Machine Interfaces should be designed to meet the capabilities of all intended users (Note: *may overlap with Part 3 chapter 2).

FR 11.2.9 Personnel should not be exposed to levels of vibration that exceed safe working conditions.

FR 11.2.10 Risks to personnel from hazardous circumstances should be minimized.

FR 11.2.11 Personnel should be provided with appropriate medical care or aid.

FR 11.2.12 The facilities and working conditions of a Remote Operation Centre or MASS should [promote] [support] the health and well-being of all personnel.

FR 11.2.13: There should be sufficient and suitable ventilation, natural or artificial or both, supplying fresh or purified air.

FR 11.2.14: The best possible conditions of temperature, humidity and movement of air should be maintained, and larger fluctuations avoided.

FR 11.2.15: There should be sufficient and suitable lighting, natural or artificial, or both.

FR 11.2.16: Sufficient and suitable sanitary conveniences should be provided for in suitable places and be properly maintained.

FR 11.2.17: Sanitary conveniences should be adequately ventilated and so located as to prevent nuisances. They should not communicate directly with workplaces.

FR 11.2.18: Control room should have sufficient space to comfortably accommodate all necessary equipment and allow operator to move freely.

CHAPTER 12 TOWING AND MOORING

12.1 Goal

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

12.2 Functional Requirements

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

FR 12.2.1 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 [within the OE], taking into account the modes of operation and the number of persons on board.

FR 12.2.2 Means should be provided for effective coordination and conduct of mooring and towing operations, taking into account the modes of operation and the number of persons on board.

FR 12.2.3 Means should be provided to ensure the continuous monitoring/control capability for towing and mooring arrangements during normal conditions and in the event of failure, malfunctions and overload during operations, taking into account the modes of operation and the number of persons on board

FR 12.2.4 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 13 MARINE ENGINEERING/MACHINERY INSTALLATIONS

13.1 Goal

The goal of this chapter is to provide for safe MASS machinery installations capable of delivering the required functionality to ensure availability and backup functions sufficient for the automation, connectivity, and remote interaction levels of the ship to maintain operation in normal and emergency situations.

13.2 Functional Requirements

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

[FR13.2.1 Machinery installations should be able to support designed [fallback states] and be fault tolerant to connectivity being lost or below an acceptable threshold.]

FR13.2.2 Condition-based monitoring should be provided to assess system reliability.

[FR13.2.3 Measures should be provided to prevent the activation of machinery by remote or autonomous systems when operated or serviced by authorized persons on board.]

[FR13.2.4 Measures should be provided to detect machinery malfunctions or failures to maintain safe operation in normal and emergency situations.]

FR13.2.5 Availability and reliability measures should be provided according to the mode of operation to respond to machinery malfunctions and failures.

CHAPTER 14 ELECTRICAL AND ELECTRONIC ENGINEERING

14.1 Goal

The goal of this chapter is to provide for safe [power production] [electrical auxiliary services] and distribution capable of maintaining the ship in normal operational condition and ensuring that essential [systems] [functions] remain operational in emergency situations [for the period(s) specified by SOLAS].

14.2 Functional Requirements

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

[FR14.2.1 Electrical systems should be able to support designed [fallback states] and be fault tolerant to connectivity being lost or below an acceptable threshold.]

FR14.2.2 Condition-based monitoring shall be provided to assess to system reliability.

[FR14.2.3 Measures should be provided to prevent electrical systems being energized by remote or autonomous systems when operated or serviced by authorized persons on-board.]

[FR14.2.4 [Measures should be provided to detect electrical system malfunctions or failures to maintain safe operation in normal and emergency situations.]

[FR14.2.5 Availability and reliability measures should be provided according to the mode of operation to respond to electrical system malfunctions and failures.]

CHAPTER 15 MAINTENANCE AND REPAIR

15.1 Goal

The goal of this chapter is to provide for maintenance and repair to ensure that all [HME systems] [structure, machinery, and equipment] will remain fit to proceed to sea, without danger to the ship or persons on board,

15.2 Functional requirements

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

FR 15.2.1 Maintenance of Computer-based integrated systems should ensure safe operations in normal and emergency situations.

FR 15.2.2 Suitable monitoring and control capability should be provided to ensure system and machinery faults are detected in normal and emergency conditions and can maintain any [fallback states].

FR 15.2.3 Suitable redundancy actions should be provided taking into account the number of qualified persons on board that are available to respond to system and machinery faults.

FR 15.2.4 Maintenance requirements for the equipment and systems used on board should not be compromised by ships mode of operation.

FR 15.2.5 Qualified [authorized] 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 16 EMERGENCY RESPONSE

16.1 Goal
The goal of this chapter is to provide measures for adequate responses in emergency situations.

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

16.2.1 High Level Functional Requirements
FR16.2.1 Measures should be in place for emergency prevention, preparedness, identification, response, and recovery activities19.

FR16.2.2 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.

FR16.2.3 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.

FR16.2.4 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.

FR16.2.5 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.

[FR16.2.6 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.]

FR16.2.7 An 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.

16.2.2 Specific Level Requirements

FR16.2.8 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.

FR16.2.9 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
.8 interface between the human and autonomous system of MASS considering Modes of operation and emergency situation]
.9 roles and responsibilities
.10 other measures, etc.

FR16.2.10 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.

FR16.2.11 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.

FR16.2.12 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.

FR16.2.13 For crewless MASS, the autonomous system should be capable of assessing risk situations to identify additional risks and [refine][support] response strategies during emergencies.

FR16.2.14 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 16.2.15 To respond to the emergency situations, any responsible person 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.

FR 16.2.9 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.

[FR16.2.9 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.

FR16.2.10 Response command locations, including the ship and ROC, should be equipped with recording and storing functions for emergency response-related [information[data].

FR 16.2.11 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 16.2.12 [Measures][Means] for emergency communication including both within the ship and with external stations, should be prioritized over routine communications.

FR16.2.13 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.

FR16.2.14 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.

FR16.2.15 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.

FR16.2.16 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.

ANNEX

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

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ANNEX 2

VOLUNTEERING MEMBER STATES AND ORGANIZATIONS WITH OBSERVER STATUS FOR THE DEVELOPMENT OF CHAPTERS OF PART 3 OF THE DRAFT NON-MANDATORY GOAL-BASED MASS CODE

Part 3	**Lead State or Organization**	**Contact details for Lead Person**
Chapter 1: Navigation	Japan	Dr. Keiko Miyazaki miyazaki-k@m.mpat.go.jp Mr. Takahiro Yamazaki t-yamazaki@jstra.jp
Chapter 2: Remote operation	United Kingdom	Dr Katrina Kemp katrina.kemp@mcga.gov.uk Mr. Sam Hodder Sam.Hodder@mcga.gov.uk
Chapter 3: Communication	China	Ms. LI Zhe 158092224@qq.com Mr. SUN Wu, China Class Society wsun@ccs.org.cn
Chapter 4: Subdivision, stability and watertight integrity	BIMCO	Jeppe Skovbakke Juhl JSJ@bimco.org
Chapter 5: Fire protection/safety	Norway	Sifis Papageorgiou SIPA@sdir.no
Chapter 6: Life-saving appliances and equipment	United States	Lee Franklin, USCG (USA) Lee.N.Franklin@uscg.mil
Chapter 7: Management of safe operations	Germany	Jörg Kaufmann Joerg.Kaufmann@bsh.de

Part 3	**Lead State or Organization**	**Contact details for Lead Person**
Chapter 8: Security	Liberia	Motonobu Tsuchiya mtsuchiya@liscr.co.uk
Chapter 9: Search and rescue	Spain	Hernán del Frade hjdelfrade@mitma.es
Chapter 10: Cargo handling	Sweden	Mats Hammander mats.hammander@transportstyrelsen.se
Chapter 11: Personnel safety and comfort	ITF	Branko Berlan Berlan_Branko@itf.org.uk
Chapter 12: Towing and mooring	Italy	Cdr. (ITCG) Antonino SCARPATO antonino.scarpato@mit.gov.it
Chapter 13: Marine engineering/Machinery installations	United States	Lee Franklin - USCG (USA) Lee.N.Franklin@uscg.mil
Chapter 14: Electric and electronic engineering/ Electric Installations	United States	Lee Franklin - USCG (USA) Lee.N.Franklin@uscg.mil
Chapter 15: Maintenance and repair	Marshall Islands	P J Person pjperson@register-iri.com
Chapter 16: Emergency response	Republic of Korea	Dr. Han-Seon PARK hspark@kmi.re.kr

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