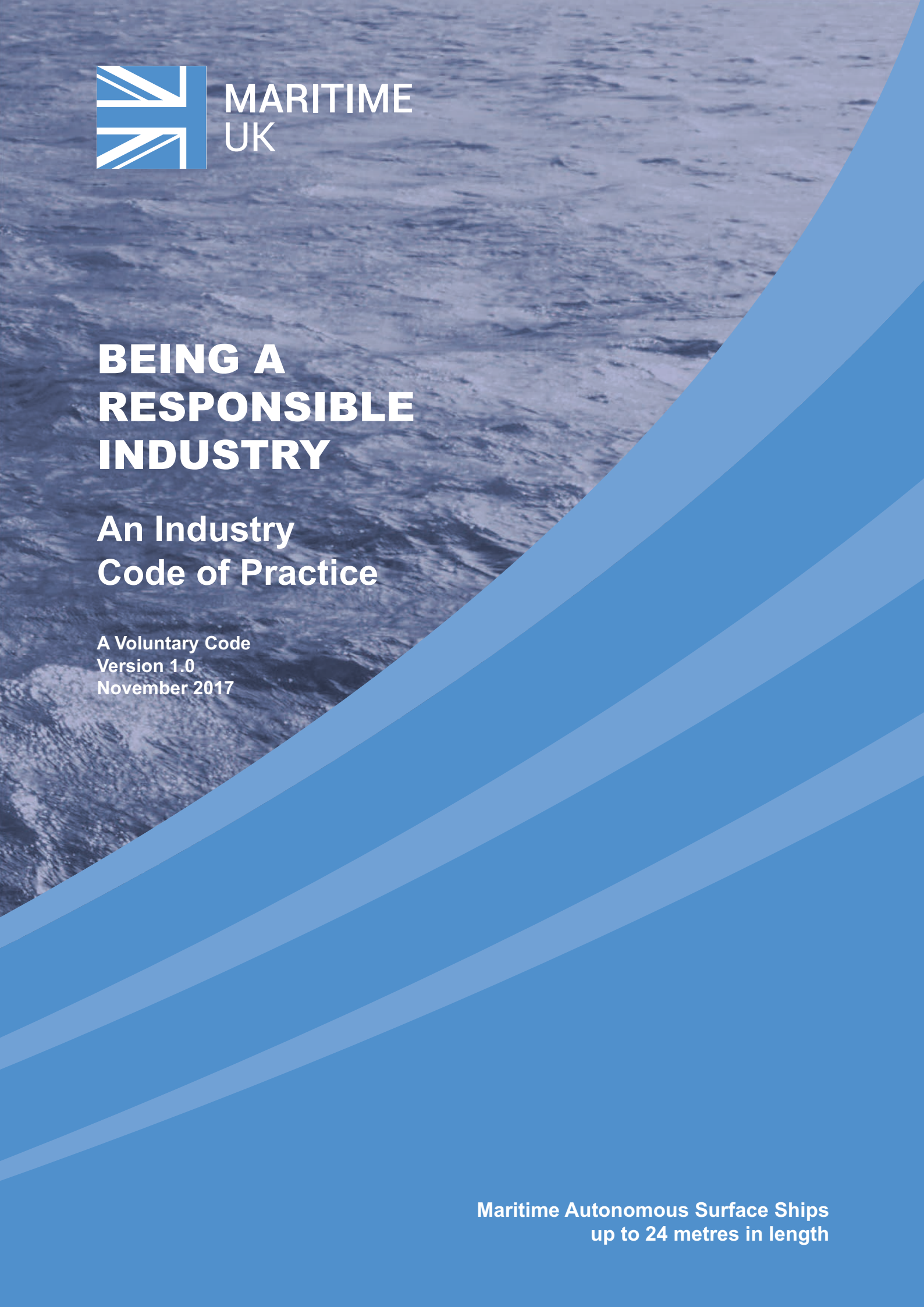

MARITIME UK

BEING A RESPONSIBLE INDUSTRY

An Industry Code of Practice

A Voluntary Code
Version 1.0
November 2017

Maritime Autonomous Surface Ships up to 24 metres in length

MARITIME UK

MARITIME UK brings together the UK's shipping, ports, marine and business services industries to promote the sector, influence government and drive growth.

The maritime sector is the fundamental enabler of British global trade. The UK sector exports its own innovative maritime products and services. With cutting-edge technology, high-quality design & manufacturing, unparalleled expertise in services and major investment opportunities, the UK is the natural home for your maritime business.

We support just under 1 million jobs and contribute around £40bn to UK GDP.

Our sector is a vital part of our island nation's heritage and of our modern economy – supporting jobs, driving innovation and enabling trade. Our sector also enables millions of people to enjoy the recreational benefits of the UK's coastal and inland waterways.

Contents

1 Foreword

1.1 Background

1.1.1 The development of Maritime Autonomous Surface Ships (MASS) has continued at a very significant pace over the last few years with more vessels entering operation all the time. They come in a variety of sizes and have a very diverse set of operational capabilities which all place their own unique demands on those who own and operate them and the remainder of the Maritime Community. MASS are an element of the development of Robotics and Artificial Intelligence (RAI) systems across the various transport sectors.

1.1.2 The term MASS has been adopted by the Maritime Safety Committee (MSC) of the International Maritime Organisation (IMO) for their scoping exercise which was accepted at MSC 98 on the 13th June 2017. The Executive Summary of the submission for the Scoping Exercise acknowledges that ***'the use of MASS creates the need for a regulatory framework for such ships and their interaction and co-existence with manned ships This document invites the [Maritime Safety] Committee to undertake a regulatory scoping exercise to establish the extent of the need to amend the regulatory framework to enable the safe, secure and environmentally sustainable operation of MASS within the existing IMO instruments'.***

1.1.3 This Code of Practice ("Code") has been prepared by the UK Maritime Autonomous Systems Working Group (MASRWG) and has been published by Maritime UK through the Society of Maritime Industries. It has been reviewed by the UK Maritime and Coastguard Agency (MCA) and the Agency will need to conduct a number of regulatory scrutiny processes before it will be in a position to publish this style of document. This will depend to some extent on the progress made within the IMO Scoping Exercise. For the interim period, this Industry Code of Practice seeks to provide practical guidance for the design, construction and safe operation of autonomous and semi-autonomous vessels under 24m while the more detailed regulatory framework for MASS is developed. This Code will be updated as required when guidance from the IMO Regulatory Scoping Exercise is published, and as the MCA develops policies to meet the needs of forthcoming technological, commercial and regulatory developments.

1.1.4 The primary aim in developing the Code has been to set initial standards and best practice for those who design, build, manufacture (including testing and commissioning), own, operate and control of MASS of less than 24 metres in length. But it will establish some principles and guidance which will be applicable for those operating larger vessels. It should be read in conjunction with 'An Industry Code of Conduct' for Maritime Autonomous Systems (Surface) which was published by the UK Marine Industries Alliance in March 2016.

1.1.5 The Code also deals with the equally important subject of remote manning and of the training and qualifications needed for those operating MASS, wherever they may be sited.

1.1.6 The intent is to ensure a degree of equivalence with the provisions of the current IMO instruments (COLREGS, SOLAS, MARPOL, and STCW) and to provide links to related documentation (e.g. ISPS, IMDG, ISM, Fire Safety Code and the Load Line Convention).

1.1.7 The Code also aligns with other relevant documents, for example the Lloyds Register Unmanned Marine Systems Code and the SARUMS Best Practice Guide for Unmanned Maritime Systems.

1.1.8 The Code provides guidance for MASS which are registered in the United Kingdom, specifically those less than 24 metres in length, and to other similar MASS operating within the United Kingdom or United Kingdom waters (at sea and/or inland waters).

1.1.9 It is considered that it can also be applied effectively to MASS operating in other parts of the world under similar environmental and operating conditions to those of the UK.

1.1.10 United Kingdom registered MASS, to which this Code applies, when operating outside of United Kingdom waters, may however be subject to additional requirements of overseas administrations. Owners/operators/managing agents should contact the relevant administration controlling those waters regarding the acceptability of the Code and any other requirements to which they may have to adhere.

1.1.11 Compliance with the Code in no way obviates the need for MASS operations to comply with relevant bylaws made by either the local/navigation authority or the port/harbour authority for the area in which the MASS operates. Local authorities may, for instance, have powers to require MASS to have third-party insurance cover, and to set the level of that cover.

1.1.12 Additionally, recognising that some MASS operate both at sea and on inland waterways, attention is drawn to the common approach to vessel safety adopted by the major UK inland navigation authorities. Owners/operators/managing agent(s) of such vessels should also comply with any applicable requirements of any relevant authority for the area of operation. It should also be noted that local authorities may also have powers over the use of the foreshore and landing places, and to issue licenses for their use.

1.1.13 Designers and builders of MASS will need to pay special regard to the intended area of operation and the working conditions in which a MASS will be subjected when selecting the standards for the design and specification of the craft, and the materials, products or components to be used in its construction. The builder, repairer or owner/managing agent of a MASS, as appropriate, should take all reasonable measures to ensure that a product, material or component fitted, or used in accordance with the measures in the Code, is suitable for the purpose intended, having regard to its location onboard the MASS, the area of operation and the weather conditions which may be encountered.

1.1.14 When new standards are developed and finalised by the British Standards Institution (BSI), European Committee for Standardization (CEN), International Maritime Organization (IMO), International Organization for Standardisation (ISO), International Electro-technical Commission (IEC) or any other international bodies, which impact upon the requirements of the Code, amendment of the Code may be considered immediately.

1.1.15 In accordance with the EU Directive 1998/34/EC, as amended by 98/48/EC, laying down a procedure for the provision of information in the field of technical standards and regulations, any requirement for goods or materials to comply with a specified standard should be satisfied by compliance with:

- *a relevant standard or code of practice of a national standards body or equivalent body of any EEA State; or*
- *any relevant international standard recognised for use in any EEA State; or*
- *any relevant technical regulation with mandatory or de facto mandatory application for marketing or use in any EEA State in so far as the standard, code of practice, technical regulation or process in question enables the requirements for safety and fitness for purpose of this Code to be met in an equivalent manner. This should include consideration and acceptance of sub-contracted materials.*

1.1.16 It is important to stress that, whilst all reasonable measures have been taken to develop standards which will result in the production of safe and seaworthy MASS, total safety at sea can never be guaranteed. Therefore, owners/managing agents of a MASS are encouraged to take out an appropriate policy of insurance. It is advised such insurance provide cover against any foreseeable claims that may arise. It is advised, if a policy of insurance is in force, that a copy of the Certificate of Insurance be either displayed (if practicable) or available for inspection.

1.2 Environmental considerations

1.2.1 MASS operations will also need to respect any environmental designations applicable to the area in which the MASS operates. For example, in England, Marine Protected Areas (MPAs) are designated in territorial waters to protect marine wildlife of national and international importance. These include Special Areas of Conservation (SACs), Special Protection Areas (SPAs), Sites of Specific Scientific Interest (SSSIs), Ramsar sites (if applicable) and Marine Conservation Zones (MCZs). A large proportion of estuaries, for example, will have one or more of these designations. Operating a MASS in designated areas, particularly at times of the year when there is the potential for disturbance to wildlife (e.g. migrating birds), may be an activity which requires assent from the relevant environmental or conservation authority and their advice should be sought.

1.2.2 The Code also summarises the requirements for environmental protection and carriage of cargoes and dangerous goods where appropriate. These are covered by other regulations which should be consulted for full details.

1.3 Health and Safety Regulations

1.3.1 The owner/master of a MASS is responsible for the health and safety of anyone working on or around the MASS. When the owner/master employs support crew, the Merchant Shipping and Fishing Vessels (Health and Safety at Work) Regulations 1997 (SI 1997 No. 2962) and other regulations made under these apply.

1.3.2 Every employer is to be aware of any risks affecting workers and others and to ensure that appropriate measures are taken to minimise them through improving procedures or equipment where necessary. Employers must instruct those affected about the risks and how to ensure their own health and safety and the health and safety of others.

1.3.3 The Provision and Use of Work Equipment Regulations 1998 (PUWER) impose duties on the employer, self-employed person, and to any person who has control to any extent of work equipment.

1.4 Authorisation of Recognised Organisations

1.4.1 The Code has been developed with input from a number of elements of the UK MASS industry. It is hoped that Maritime Administrations may be able to use the Code as a basis for their instructions to their Recognised Organisations (RO), or other flag State authorised bodies, to facilitate due regulatory compliance.

1.4.2 The potential for authorisation of RO has been influenced by the requirement to have a local capability for the efficient handling of the needs of owners and operators of some classes of MASS. Authorised RO are generally permitted to charge for undertaking Code of Practice examination and certification processes as a provision of their authorisation. Arrangements for charges will be made directly between the RO (or the RO's authorised person) and the party requesting such services.

1.5 Contributing Organisations

1.5.1 The organisations that contributed to the development of the MASS Code of Practice are listed below.

- The UK Maritime and Coastguard Agency
- ASV
- Atlas Elektronik UK Ltd
- AutoNaut
- BAE Systems
- BMT Group
- BMT Cadence
- Birch Reynardson & Co
- British Marine
- BP
- DSTL
- EP Barrus
- Frazer-Nash
- Fugro
- H Scientific
- HT Chambers
- International Association of Institutes of Navigation (IAIN)
- IMarEST
- Lloyds Register EMEA
- Ministry of Defence – Naval Authority Group
- MSubs Ltd
- National Oceanography Centre
- The Nautical Institute
- Plymouth University
- QinetiQ
- Rolls Royce
- RYA
- Seebyte
- Seiche
- Thales
- Warsash Maritime Academy – Southampton Solent University

The Code will be reviewed at regular intervals by the MAS Regulatory Working Group in consultation with the appropriate UK Maritime authorities and the MAS Steering Group.

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Maritime and Coastguard Agency

2 Definitions

In this code the following definitions have been established for the sake of clarity. It is stressed that they carry no legal status and will need to be amended or removed as the International and UK regulatory organisations charged with the overall policies for MASS complete their phased work.

"Administration", for the purpose of this Code, means the UK Maritime and Coastguard Agency.

"Annual examination" means a general or partial examination of the ship, craft or vessel, its machinery, fittings and equipment, as far as can readily be seen, to ascertain that it has been satisfactorily maintained as required by the Code and that the arrangements, fittings and equipment provided are as documented in the Record of Particulars and Record of Equipment. The hull, shell fittings, external steering and propulsion components of the craft or vessel should be examined out of the water at intervals not exceeding 5 years. The Recognised Organisation may stipulate a lesser interval in consideration of hull construction material, condition, age or the type and service of the craft or vessel.

"Approved" means approved by, or acceptable to, the MCA under Merchant Shipping legislation, unless otherwise specified in the Code.

"Area of operation" are those identified and promulgated in this and other similar codes and are as shown at Table 2.1 below:

Table 2.1: Areas of Operation

Area	Definition
Area Category 6	To sea, within 3 miles from a nominated departure point(s) and never more than 3 miles from land, in favourable weather and daylight.
Area Category 5	Area Category 5 – within 3 miles of land and not more than 3 miles radius from either the point of departure to sea or the seaward boundary of protected waters (see definition of "protected waters") in favourable weather.
Area Category 4	Up to 20 miles from a safe haven, in favourable weather and in daylight
Area Category 3	Up to 20 miles from a safe haven
Area Category 2	Up to 60 miles from a safe haven
Area Category 1	Up to 150 miles from a safe haven
Area Category 0	Unrestricted service

"as amended" refers to any other document that replaces, revokes or amends the document that the term "as amended" follows.

"Authorised person" means a person who by reason of relevant professional qualifications, practical experience or expertise is authorised by the Recognised Organisation chosen by the owner/managing agent to carry out examinations required under Chapters 5 and 12 of the Code.

"Base Control Station" – See "Control station".

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"Cargo" for the purpose of the Code means all items which are transported by the ship except fuel for the ship, ballast (either solid or liquid), consumables to be used on board, permanent outfit and equipment of the ship, stores and spare gear for the vessel.

"Certificate" means the certificate appropriate to a ship to which the Code is applied which the Merchant Shipping (Small Workboats and Pilot Boats) Regulations 1998 (SI 1998 No. 1609), as amended, require to have been issued.

"Charter" means an agreement between the owner/managing agent and another party which allows that other party to operate the ship, and the "Charterer" is that other party.

"Code" means this Code unless another Code is specified.

"Company" means the owner of the ship or any other organisation or person such as the manager, or the bareboat charterer, who has assumed responsibility for the operation of the ship from the ship owner and who, on assuming such responsibility, has agreed to take over all duties and responsibility imposed by the Code (and by extension the associated IMO instruments).

"Company Security Officer" means the person designated by the Company for ensuring that a ship security assessment is carried out; that a ship security plan is developed, submitted for approval, and thereafter implemented and maintained and for liaison with port facility security officers and the ship security officer.

"Compartment" means all spaces within the watertight or fire-resisting boundaries on any one level which have inter-communicating access.

"Competent harbour authority" has the same meaning as it has in the Pilotage Act 1987.

"Competent Authority", in respect of operating qualifications (Ch 11), means either the MCA or an organisation that issues Certificates of Competence which has applied for and been granted recognition by the MCA as having the appropriate technical and administrative expertise in accordance with the procedures established for vessels of any type or size.

"Competent Person" in respect of fire extinguisher servicing has the same meaning as it does in BS 5306: Part 3; 2003 which is a person with the necessary training, experience, with access to the relevant tools, equipment and information, manuals and knowledge of any special procedures recommended by the manufacturer of the portable device.

"Compliance examination" means an examination of the ship, its machinery, fittings and equipment, by an authorised person, to ascertain that the ship's structure, machinery, fittings and equipment comply with the requirements of the Code. Part of the examination should be conducted when the ship is out of the water. Part of the examination should be conducted when the ship is in the water. For simple waterborne craft (e.g. RHIBs) of a design, with no through hull fittings below the water line the Responsible Organisation may exercise discretion in carrying out the compliance examination entirely out of the water.

"Control position" means a location on the ship/vessel/craft during any periods of manned operation from which control of propulsion, steering and other systems can be exercised.

"Control Station" means a location remote from the MASS from where control of the MASS' functions and systems can be exercised. The control station may exercise varying degrees of control as defined under "Levels of Control".

"Controller" means a person undertaking control functions appropriate for the Level of Control of the MASS. The controller may report to either a Watch Officer or the Master depending on the constitution of the control function, the MASS category and the required Level of Control.

"Coxswain" refers to any person controlling the MASS, either remotely (depending on the category of control applicable to the vessel during an operation) or to a person controlling the vessel/craft from an onboard control station during any period of operation under direct manned control (e.g. pilotage).

"Crew" means a person employed or engaged in any capacity on-board a ship on the business of the ship or any person engaged in the direct control and operation of the ship from a remote location.

"Daylight" means from civil twilight before sunrise until civil twilight after sunset.

"Decked vessel" means a vessel with a continuous watertight weather deck which extends from stem to stern and has positive freeboard throughout, in any condition of loading of the vessel. Where an appropriate ISO standard is used, the definition should be taken from those standards as applicable.

"Design Category" means a description of the wind and sea conditions for which a vessel is considered suitable under the EC Directive 94/25/EC of 16th June 1994, as amended by 2003/44/EC, on the approximation of the laws, regulations and administrative provisions of the Member States relating to recreational craft, and used for the application of relevant ISO and CEN standards. See Table 2.2 below:

Table 2.2: Design Categories

Design category	Wind force (Beaufort scale)	Significant wave height (HS, metres)
A - 'Ocean'	Exceeding 8	Exceeding 4
B - 'Offshore'	Up to, and including, 8	Up to, and including, 4
C - 'Inshore'	Up to, and including, 6	Up to, and including, 2
D - 'Sheltered waters'	Up to, and including, 4	Up to, and including, 0.5

"Designated Person" identified in the IMO ISM Code as a person ashore who should be designated by the company who has direct access to the highest level of management.

"Emergency Stop" means the ability to reduce propulsion to a safe state in a timely manner. In this context:

- *"a safe state" means a level at which it is not likely to cause damage either directly or indirectly. Note that some MASS (e.g. wave propelled) may not have any means of cutting propulsion power to zero; but in a harbour or sheltered waters the wave propulsive power may reasonably be expected to be a safely low level;*

- *"in a timely manner" means within a time that is short enough to ensure that the risk from uncontrolled propulsive power can be contained before it is likely to cause damage. In open ocean conditions this may be relaxed, whereas in a docking situation the propulsion may need to be cut more quickly, within seconds or less;*

- *"Full Shut Down" means the ability to turn off all systems as required on the MASS remotely, for example in the case of a fire.*

"Length" and "(L)" in relation to a ship means the greater of the following distances:

- *96% of the total length on a waterline at 85% of the least moulded depth measured from the top of the keel, OR the length from the fore-side of the stem to the axis of the rudder stock on that waterline;*

- *Where the stem contour is concave above the waterline at 85% of the least moulded depth, both the forward terminal of the total length and the fore-side of the stem respectively shall be taken at the vertical projection to that waterline of the aftermost point of the stem contour (above that waterline). In ships designed with a rake of keel the waterline on which this length is measured shall be parallel to the designed waterline.*

Levels of control

A number of systems for categorising the level of control applicable to Unmanned Vessels have been developed, notably by the European Defence Agency's Safety and Regulations for European Unmanned Maritime Systems (SARUMS) group. Defined categories are shown at Figure 2.1.

Figure 2.1: Levels of Control

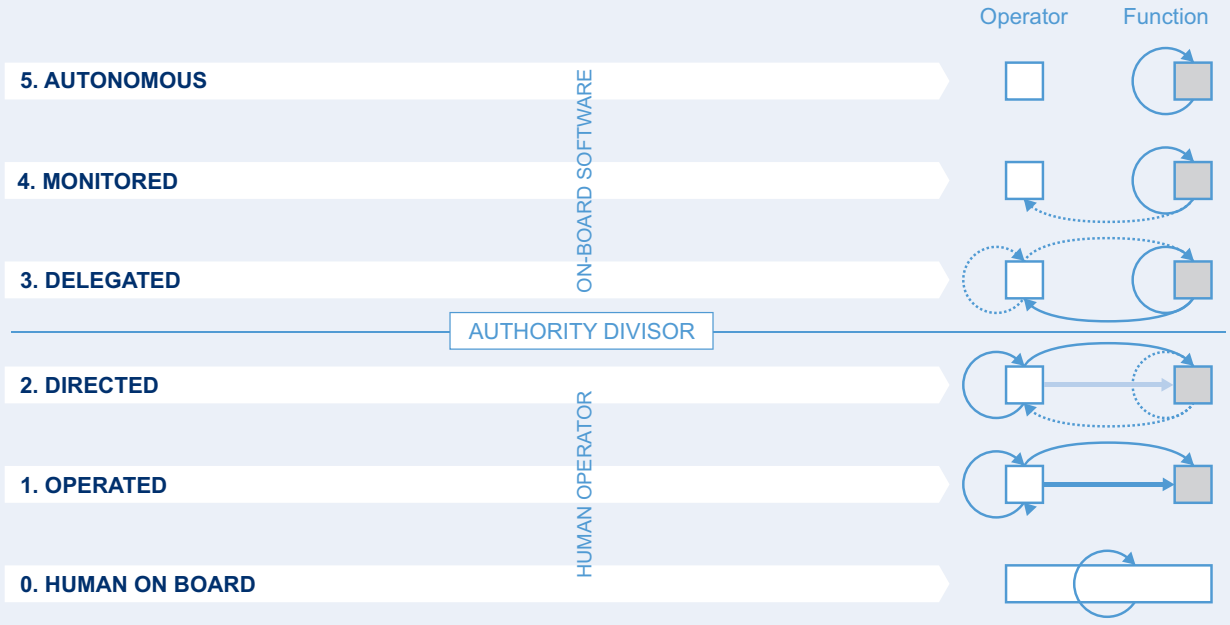

Table 2.3: Level of Control Definitions		
Level	**Name**	**Description**
0	Manned	Vessel/craft is controlled by operators aboard
1	Operated	Under Operated control all cognitive functionality is within the human operator. The operator has direct contact with the Unmanned Vessel over e.g., continuous radio (R/C) and/or cable (e.g., tethered UUVs and ROVs). The operator makes all decisions, directs and controls all vehicle and mission functions.
2	Directed	Under Directed control some degree of reasoning and ability to respond is implemented into the Unmanned Vessel. It may sense the environment, report its state and suggest one or several actions. It may also suggest possible actions to the operator, such as e.g. prompting the operator for information or decisions. However, the authority to make decisions is with the operator. The Unmanned Vessel will act only if commanded and/or permitted to do so.
3	Delegated	The Unmanned Vessel is now authorised to execute some functions. It may sense environment, report its state and define actions and report its intention. The operator has the option to object to (veto) intentions declared by the Unmanned Vessel during a certain time, after which the Unmanned Vessel will act. The initiative emanates from the Unmanned Vessel and decision-making is shared between the operator and the Unmanned Vessel.
4	Monitored	The Unmanned Vessel will sense environment and report its state. The Unmanned Vessel defines actions, decides, acts and reports its action. The operator may monitor the events.
5	Autonomous	The Unmanned Vessel will sense environment and report its state. The Unmanned Vessel defines actions, decides, acts and reports its action. The operator may monitor the events.

In practice, levels of control may be different for different functions aboard the same vessel (e.g. a vessel navigating under LoC4, may also deploy a payload that is controlled at LoC2). The LoC applied to the vessel may also change during a voyage (e.g. LoC 1 in a VTS, but LoC 4 in open ocean passage).

"Master" – for the purposes of this code, the term "master" as outlined in the IMO instruments should mean a specific person officially designated by the owning company / owner of the vessel as discharging the responsibilities of the Master of the vessel. This will be an employee of the company who has been assessed as competent to discharge these responsibilities in accordance with the provisions of this code. This person may be located anywhere provided that the required level of control and communication can be maintained to discharge these duties.

"MASS" – Maritime Autonomous Surface Ship. A term adopted by the IMO MSC for their scoping exercise which means, for the purpose of this code, a surface ship that is capable of being operated without a human onboard in charge of that ship and for which the level of control may encompass any of those shown at Table 2.3 above.

"MASS Watch Officer" is the individual who has responsibility for the MASS when it is operational.

"Owner" – The title holder of the vessel. If the "Company" is not the Owner, then the Owner shall report the name and details of the Company to the Administration.

"Operator" – An entity (e.g. a company) that discharges the responsibilities necessary to maintain the vessel in a seaworthy condition and compliant with all relevant IMO Instruments and national legislation. The operator is also responsible for ensuring that all staff concerned with the control of MASS hold appropriate qualifications as required by IMO instruments and national legislation.

"Recognised Organisation".Under the provisions of SOLAS 1974/1988 regulation 1/6, MARPOL Annex 1 regulation 6, MARPOL Annex II regulation 8, MARPOL Annex IV regulation 4, MARPOL Annex VI regulation 5, LLC 1966/1988 article 13, TONNAGE 1969 article 7 and AFS 2001 Annex 4 regulation 1, the inspection and survey of ships shall be carried out by officers of the flag Administration. The flag Administration may, however, entrust the inspections and surveys either to surveyors nominated for the purpose or to organizations recognized by it.

"Ship-owner" - The term ship owner shall mean the owner, charterer, manager and operator of a ship.

"Ship Security Officer" - means a person accountable to the master, designated by the Company as responsible for the security of the ship, including implementation and maintenance of the ship security plan and for liaison with the company security officer and port facility security officers.

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3 Application

This Code applies to all Maritime Autonomous Surface Ships of less than 24 metres in length and provides guidance for larger ships while operated on the sea or navigable waters, for reward, for pleasure andrecreation, or for other purposes, while on domestic voyages from the United Kingdom.

3.1 Classes of Maritime Autonomous Surface Ship (MASS)

3.1.1 The Code identifies several classes of MASS based on the intended use, size, speed and potential hazard to other shipping. The intention of these classes is to discriminate those MASS that are inherently unlikely to cause a hazard to most other marine users, by virtue of their size and speed, from those classes of MASS that by nature of their size and speed, are likely to pose an equivalent hazard to that posed by manned vessels to other marine users. These classes are primarily derived from the existing categories that are contained within either the COLREGS or the Load Line convention and are purposely selected to maintain commonality of requirement with those instruments wherever possible.

3.1.2 The classes also reflect the feasible level of situational awareness that can be provided, given size and payload constraints.

3.1.3 Classes of MASS are shown below at Table 3.1. It should be noted that this Code will primarily apply to Ultra-Light, Light, Small classes and some High-Speed vessels. It should also be noted that where two criteria are specified (e.g. length and speed) both must be satisfied or the class assignment defaults to the class above. Exemptions may be specially considered on a case-by-case basis.

Table 3.1: Classes of MASS

Class of MASS	Characteristic	Notes
Ultra-light	Length overall <7m and maximum speed <4kts	*Derived from MCA High-Speed Craft Code (https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/292155/hsc_2000_rev06-09_full-comp-all.pdf) where ∇ = moulded displacement, in m3, of the craft corresponding to the design waterline.
Light	Length overall ≥ 7m to <12m and maximum speed <7kts	
Small	Length overall ≥ 12m to <24m	
Large	Length ≥24m (and 100 GT)	
High-Speed*	Operating speed V is not less than V = 7.19 ∇1/6 knots	

3.1.4 For the purposes of this Code, these classes will apply to MASS constructed on or after 1 January 2019. Derogations from these classes may be appropriate in certain circumstances where risk to other marine traffic can be proven to be reduced and may be considered by the relevant authority. However, this will normally be the exception to the rule.

3.2 Standards

3.2.1 This Code provides standards which may be appropriate for operators to select to use for the various categories of MASS envisaged. The Code is based on an approach to which appropriate standards can be applied, noting that many of the existing Instruments and Regulations are derived from the SOLAS Regulations, which, for some unmanned surface vessels, may not be appropriate.

3.2.2 Ultra-Light MASS, as defined above, which are not used for financial gain or reward do not have to comply with the requirements for registration, or certification. This comparative freedom from regulation is in part based on an assumption that the sector will, as a matter of self-discipline and shared safety responsibility, pay proper regard to safety matters.

3.2.3 If an unmanned surface vessel is not a “pleasure or recreational MASS” it is considered to be used for reward for the purposes of this Code unless engaged on Government business.

3.2.4 It is the responsibility of the owner/managing agent to ensure that a MASS (and any associated control station) is properly maintained, examined and manned in accordance with the Code. The Code applies whether the owner/managing agent is corporate, private or of a charitable nature.

3.3 Certification

3.3.1 As per current national and international processes and practices, to be issued with a certificate for a particular area of operation, a MASS must comply with all the requirements of this Code for the relevant class of MASS and for the intended operating area where it is considered necessary, to the satisfaction of an appropriate RO. The requirement for, and issue of, certificates, will reflect the development of best practice and is included in this Code to demonstrate the clear intent of the Industry to show to the wider maritime community that unmanned vessels should not be exempt from established procedures wherever they are relevant and specifically where they will contribute to overall safety standards.

3.3.2 When issued to a MASS, a certificate should normally be valid for a period not exceeding five years.

3.4 Interpretation

3.4.1 Where a question of application of the Code or an interpretation of a part of the Code arises, the owner/managing agent of the MASS concerned should in the first instance seek clarification from the flag State authorised body or RO. In situations where it is not possible to resolve an issue of interpretation the Recognised Organisation may apply in writing to the Administration, who may consult with others as deemed appropriate.

3.5 Equivalent Standards

3.5.1 When the Code requires that a particular piece of equipment or machinery should be provided or carried in a craft or vessel, or that any particular provision should be made to a specified standard, consideration may be given to application to the Administration to permit any other piece of equipment or machinery to be provided or carried, or any other provision to be made. For vessels under 24 metres in length this is likely to be unnecessary. If an application is made, the Administrationwill need to be satisfied by trials or otherwise that the alternative is at least as effective as that stipulated within the Code.

3.6 Carriage of Additional Equipment

3.6.1 Equipment on board, which is expected to be relied on in situations affecting safety or pollution prevention, must be in an operational condition. If such equipment is inoperative and is in excess of the equipment required by this Code it should either be repaired, removed or if removal is not practical, clearly marked as inoperative and secured. The status of the (inoperable) equipment should also be reported at the relevant control station and/or within the control system of the vessel. Reference should also be made to MGN79 on Safety Equipment and Pollution Prevention Equipment carried in excess of Statutory Requirements.

QinetiQ operations at Unmanned Warrior 2016

4 Operations

4.1 Objective

The objective of this Chapter is to help the reader identify and produce the information required regarding a specific vessel, how and where it is to be operated, that will be required to support and inform other Chapters of this code.

4.2 Scope

4.2.1 The purpose of this Chapter is to help the reader outline the information required regarding the vessel that will be required to support and inform other Chapters of this Code. This will be required to support and inform the design, manufacture, in-service support and disposal elements of a suitable design code and to inform risk assessments as part of the design procedure. It is NOT intended to describe in detail the operation of all types of MASS, unmanned vessels or other unmanned craft and the appropriate procedures to be used.

4.3 Operation type

4.3.1 The operation type should define the purpose of the vessel, craft and its main operational phases. For example, a cargo vessel voyage might comprise loading, departure, voyage, arrival and unloading. These phases might each be subject to different levels of control and speed / manoeuvring envelopes.

4.3.2 Alternatively, a long-term monitoring or survey voyage might comprise departure, transit, operation on station, return transit, arrival. These phases may also have varying levels of control, speed, limitations on manoeuvring. For example – a vessel may transit at high speed to a survey area, during which one method of control may be appropriate, but when on station may operate at a much lower speed, which may materially change the risk of operation and allow a different level of control during this phase.

4.3.3 Unmanned vessels may be designed to operate in particular areas of operation – as defined in the Areas of Operation in Chapter 2 of this code, which will also imply Design Category allocations as at Chapter 2.

4.4 Ship type

4.4.1 MASS will have a number of different categories, including (but not limited to) the following:

- *Purpose (e.g. Naval, Survey, Cargo, Workboat, Tug);*
- *Cargo Type (if applicable);*
- *Propulsion method.*

4.4.2 This will inform the relevant IMO instruments that will apply and are to be addressed in Chapters 5, 6, 7, 8 10, 11 and 13. These factors may also influence the LoC applied in certain phases of voyage. For example, it may be assessed as inappropriate for vessels carrying polluting or dangerous cargos to be operated under LoC5 in high-traffic areas.

4.4.3 Size should be based on existing convention dimensions, defined in terms of length, GRT, and similar – see vessel classes in Chapter 3.

4.4.4 Operating speeds (including assessment of whether a High-Speed-Craft as defined at Table 31) – use maximum speed for structural design purposes, but lower speeds may be used for operation risk assessment as noted above.

4.5 Control method

4.5.1 The proposed control methods (and associated LoC) should be clearly defined. As noted above these may vary across different phases of a voyage.

4.6 Environmental demands

4.6.1 This Section should identify any particular environmental demands imposed by the perceived role and /or operating area of the vessel/craft and should specifically include the following factors:

- *Ice Navigation requirement;*
- *Max / Min Sea temperatures;*
- *Max / Min Air temperatures;*
- *Humidity;*
- *Atmospheric pressure.*

SEA-KIT trials

5 Vessel Design & Manufacture Standards

5.1 Objective

The objective of this Chapter is to provide a process to ensure that the design, manufacture, through life survey, maintenance and disposal requirements of the vessel are appropriately considered. This Chapter is written as a goal based requirement to permit the maximum scope to introduce innovative ideas into the design.

5.2 Scope

5.2.1 The scope of this Chapter is to cover the design, manufacture and through life survey, maintenance requirements and disposal requirements of the vessel. The vessel in this context is taken as the structure, equipment and systems (including software) which constitute the waterborne elements of the MASS.

5.2.2 The MASS should be designed, constructed and maintained in compliance with the requirements of a classification society which is recognised by the Administration; or in accordance with applicable national standards of the Administration which provide an equivalent level of safety.

5.2.3 For the defined operational life of the MASS it should be designed and constructed to:

- *Enable the MASS to operate in all Reasonably Foreseeable Operating Conditions (RFOC);*
- *Carry and respond to all foreseen loads in a predictable manner, with a level of integrity commensurate with operational and safety requirements;*
- *Ensure the watertight and weathertight integrity, to meet buoyancy and stability requirements;*
- *Minimise the risk of initiating fire and explosion;*
- *Minimise the spread of fire;*
- *Enable the maintenance and repair in accordance with the maintenance philosophy.*

5.2.4 Operators should be provided with adequate access, information and instructions for the safe operation and maintenance of the MASS.

5.3 Selection of Design Build and Survey Requirements

5.3.1 MASS shall be certified to demonstrate compliance with the requirements of the Code. Certification requirements are covered in Chapter 12.

5.3.2 The vessel supplier is to provide evidence and justification to the Recognised Organisation to demonstrate that the vessel is fit for the intended role and meets the goals of this Chapter. This evidence is to include the following information:

- *Concept of Operations (ConOps): To include details of the vessel's role, operating area, operating profile, environmental limits, maintenance and survey plans. The ConOps should also include any other information required by the administration to enable a certifying officer to determine if appropriate standards have been used. (Note: a good example of this is provided in the Lloyds Register Unmanned Marine Systems Code);*
- *The Design Standards, Codes or Rules used for the vessel;*
- *Periodic maintenance, trials and survey requirements necessary to demonstrate that the design intent is maintained through life;*
- *A design justification as to why the particular standard is suitable for the vessel and intended use.*

5.3.4 Typically, the design justification would be achieved by demonstrating that the performance requirements of the structure, equipment or system under consideration is the same as would be required for an equivalent manned vessel. (e.g. a 100m ship would require the same longitudinal stiffness and same propulsive power whether it is manned or autonomous).

5.3.5 Where the MASS design departs from the equivalent manned standard the justification shall demonstrate that either:

- *the change is acceptable because the manned vessel requirement is redundant in the MASS (e.g. Removal of crew habitability requirements or lifesaving equipment); or*
- *an alternative solution is required to maintain the same level of performance (e.g. Replacing a manual firefighting system with automatic systems).*

5.3.6 In either case the justification should demonstrate that the change does not result in an increased risk to other vessels, third parties or the environment.

5.4 Structure

5.4.1 The structure should be designed, constructed and maintained with a level of integrity sufficient to enable the MASS to be operated and maintained safely as and when required within its design or imposed limitations in all RFOC.

5.4.2 Any penetrations in the structure of the MASS should not affect the watertight and weathertight boundaries.

AutoNaut ready for transportation

5.5 Stability

5.5.1 The buoyancy, stability, and watertight and weathertight integrity should be sufficient to enable the MASS to be operated and maintained safely as and when required within its design or imposed limitations in all RFOC.

5.6 Propulsion and Manoeuvring

5.6.1 The propulsion and manoeuvring systems should be designed with a level of integrity sufficient to enable the MASS to be operated and maintained safely as and when required within its design or imposed limitations in all RFOC.

5.6.2 The propulsion and manoeuvring systems should enable the MASS to manoeuvre as and when required by the Operator but still remain within the designed or imposed limitations.

5.7 Electrical Systems

5.7.1 The electrical system should be designed with a level of integrity sufficient to enable the MASS to be operated and maintained safely as and when required within its design or imposed limitations in all RFOC.

5.7.2 Sufficient electrical power should be provided to supply the required services of the MASS during all RFOC.

5.7.3 Sufficient power should be provided to supply for MASS to conduct its mission with an appropriate level of redundancy. It is acknowledged that for some smaller Classes of MASS there may be little or no redundancy required.

5.8 Fire safety

5.8.1 Where fire safety systems are required, they should be designed to detect and extinguish a fire with a level of integrity sufficient to enable the MASS to be operated and maintained safely and to protect the MASS in all RFOC.

5.9 Auxiliary Systems

5.9.1 The auxiliary systems should be designed to support mission equipment and mission functions.

5.9.2 If the MASS is to have a payload or carry cargo, it is not to have a detrimental effect on the MASS for the duration of its mission.

5.9.3 The MASS is to have sufficient systems to support the embarkation of cargo and equipment for the duration of its mission.

5.9.4 If seamanship systems are fitted to the MASS they are to ensure that the MASS can be recovered safely and undertake any seamanship operations as required e.g. (anchoring, mooring, towing etc).

5.10 Software Integrity

5.10.1 Functional Objective. For any activity that relies on the integrated use of equipment or sub-systems that include software, the risks associated with software and its integration into the equipment or sub-system are properly managed and that the software is safe to use. A failure or unspecified behaviour of the software shall not result in:

- *an event that escalates to a hazard; or*
- *impairment of the mitigation of a hazard; and*
- *impairment of recovery from a hazard.*

5.10.2 Performance Requirements. The way software could be a stimulus event to a hazard, or impair the mitigation of a hazard, or impair recovery following such a hazardous event, shall be communicated to the appropriate parties.

5.10.3 The production of software shall be managed so that the safety risks arising from the software production are reduced to an acceptable level.

5.10.4 Provision shall be made to protect systems against:

- *intentional or unintentional viruses or unauthorised code;*
- *unauthorised installation, change, or deletion of software or associated data;*
- *the installation or use of unauthorised software, (e.g. running games or office applications);*
- *modification of the software function by additional or modified physical devices.*

5.10.5 The system safety justification shall be developed to include the risks posed by the use of software and how those risks are reduced to an acceptable level. Any function of a MASS should be adequately validated in accordance with its consequence to safety and performance of the MASS, and any software implementation of this function adequately verified.

5.10.6 The configuration status of the software on each platform shall be captured and recorded, and the record maintained up-to-date for the life of the platform.

5.10.7 The development and testing of changes to the software and data, including specific arrangements for on-board testing, shall be managed so that the safety of the system, sub-system or equipment is not compromised.

5.10.8 The retention and release of earlier versions of software shall be managed to enable restoration of a previous known and trusted state when necessary.

5.10.9 The release and installation of software to each platform shall be appropriately and actively managed so that changes to software are controlled. The installation process shall include a strategy for managing a failed installation.

5.11 In-service Requirements

5.11.1 Independent verification should be undertaken to provide assurance that the MASS complies in all respects with the provisions of this Code and remains compliant throughout its life.

5.11.2 Construction surveys should be conducted at a periodicity and scope appropriate to the design and build and may include:

- *A review of the capability, organisation and facilities of the manufacturer to confirm that acceptable standards can be achieved for the construction, and fit out of the hull structure, systems and equipment;*
- *Certification of software, equipment and components;*
- *Survey of the material state during build to confirm compliance with the appraised design;*
- *Witness of tests and trials to demonstrate functionality;*
- *Details of software integrity testing and cyber-security compliance audits.*

5.11.3 Through life survey activities should be conducted at a periodicity appropriate to the design, construction, material state and operation of the MASS.

5.12 MASS Disposal

5.12.1 MASS, for the purposes of this Code, will follow the existing legal policies and practices already in place for manned ships when an owner decides to dispose of its MASS vessel.

5.12.2 Disposal will take two forms. These are:

- *Disposal by sale to new owner;*
- *Disposal by sale to a ship breaker as a MASS end of life activity, which is known as Recycling.*

5.12.3 Disposal by Sale. MASS owners will follow the existing maritime ship sale processes as agreed in maritime law. This may include the use of a ship broker to facilitate the sale to a third party. The selling process usually involves three stages. These are:

- *Negotiations and Contracts Stage;*
- *Inspection Stage;*
- *Completion Stage.*

5.12.4 A Memorandum of Agreement (MOA) will be drawn up by the shipbroker on behalf of the MASS owner. The MOA is the formal contract of sale of the vessel. MASS owners will, where possible, take advantage of the existing standard forms of MOA contract, one example being the Norwegian Sale Form (NSF).

5.12.5 Disposal by Recycling. MASS owners will follow the current recycling process and procedures as laid out in State, Regional and International law.

5.12.6 MASS ship builders will ensure that each vessel is supplied with an Inventory of Hazardous Materials (IHM).

5.12.7 MASS owners will ensure that the IHM is maintained during the period that they own the MASS platform.

5.12.8 MASS owners when disposing of a MASS platform for recycling will ensure that the IHM is up to date.

5.12.9 There are a number of guides on the recycling of ships that are applicable for application to the recycling of redundant MASS. The following is one example.
http://www.lr.org/en/_images/229-77058_ShipRecycling_040711_tcm155-223320.pdf

6 Navigation Lights, Shapes & Sound Signals

6.1 Objective

The objective of this Chapter is to provide guidance on the lights, shapes and sound signals required by MASS.

6.2 Scope

6.2.1 If it can be demonstrated that, for a particular vessel, full compliance with the regulations is impracticable, then application can be made to the Administration where considered necessary, via the Recognised Organisation, for consideration of exemptions and equivalent arrangements, taking into account the class and nature of the operation of the vessel concerned.

6.3 Lights & Signals

6.3.1 A vessel should comply with the requirements of the International Regulations for Preventing Collisions at Sea, 1972, as amended (COLREG). With regard to Part C, a vessel which operates only between sunrise and sunset, and in favourable weather, is not required to carry navigation lights where it can be demonstrated that the vessel will not be caught in or near an area of restricted visibility.

6.3.2 Table 6.1 is a summary table of navigation lights appliances for vessels. This Table is for guidance only and does not cover all possible operations. Reference should be made to the regulations stated in Paragraph 6.3.1 for all operations not covered.

BAE Systems RIB at Unmanned Warrior 2016

Table 6.1: Navigation Lights

Overall length	Power driven vessels when underway	At Anchor	Not under command	Aground
<7m	All round white, 1 mile + side-lights, 1mile (Note 1)	Required	Not required	Not required (Note 2)
≥7m- <12m	All round white + sidelights *OR* a masthead light, 2 miles; a sidelight, 1 mile; a stern light, 2 miles; a towing light, 2 miles a white, red, green or yellow all-round light, 2 miles. *OR* (if lights have to be offset from centreline) combined lantern sidelights plus either all round white or masthead and stern light.	Required	two all-round red lights in a vertical line where they can best be seen;	Not required
≥12m- <50m	a masthead light, 5 miles; a sidelight, 2 miles; a stern light, 2 miles; a towing light, 2 miles; a white, red, green or yellow all-round light, 2 miles.	Required	two all-round red lights in a vertical line where they can best be seen;	Required (Note 3)
Although vessels of 50 metres or more are not covered by this Code, this category has been included below for reference and guidance only.				
≥50m	a masthead light, 6 miles; a sidelight, 3 miles; a stern light, 3 miles; a towing light, 3 miles; a white, red, green or yellow all-round light, 3 miles.	Required	two all-round red lights in a vertical line where they can best be seen;	Required (Note 4)

Notes

1. Vessels not exceeding 7 knots maximum speed should show sidelights if practicable.

2. A vessel of less than 7 metres in length, when at anchor, not in or near a narrow channel, fairway or anchorage, or where other vessels normally navigate, should not be required to exhibit lights or shapes.

3. A vessel of less than 12 metres in length, when aground, should not be required to exhibit the lights or shapes.

4. A vessel at anchor may, and a vessel of 100 metres and more in length should, also use the available working or equivalent lights to illuminate their decks.

6.4 Sound Signals

6.4.1 Sound signalling equipment should comply with the requirements of COLREG, Part D, as amended. A vessel of less than 12 metres in length is not obliged to carry the sound signalling equipment, provided that some other means of making an efficient sound signal is provided where feasible and practicable.

6.4.2 Table 6.2 is a summary table of sound appliances for vessels. This Table is for guidance only and does not cover all possible operations. Reference should be made to the regulations stated in Section 6.1 for all operations not covered.

Table 6.2: Sound Appliances	
Overall length	**Power driven vessels when underway**
<12m	A vessel of less than 12 metres in length should not be obliged to carry sound signalling appliances prescribed in Part D, Rule 32 (a), but if she does not, she should be provided with some other means of making an efficient sound signal where feasible and practicable.
≥12m & <20m	A vessel of 12 metres or more in length should be provided with a whistle.
≥20m & <100m	A vessel of 20 metres or more in length should be provided with a bell in addition to a whistle. Although vessels of 50 metres or more are not covered by this Code, this category has been included below for reference and guidance only.
Although vessels of 50 metres or more are not covered by this Code, this category has been included below for reference and guidance only.	
≥100m	A vessel of 100 metres or more in length should, in addition to a whistle and bell, be provided with a gong, the tone and sound of which cannot be confused with that of the bell.

h-scientific SPECTRE remote controlled autopilot onboard FASTAR

7 Situational Awareness & Control

7.1 Objective

The objective of this Chapter is to outline the main requirements and considerations that should be included in a process to design and manufacture a Situational Awareness and Control system for a MASS.

7.2 Scope

7.2.1 A situational awareness and control system for a MASS can include the onboard sensors and offboard information sources, communications links and control logic that allow the MASS to operate safely.

7.3 Functional Objectives

7.3.1 The goal of Situational Awareness and Control is to ensure that the MASS has sufficient information, interpretation and control of its position and systems, to enable it to be as safe as a manned counterpart operating in similar circumstances. Any decision making that impacts safety and is performed by the MASS (i.e. independent of a human operator) should have been adequately demonstrated to be commensurate with that which a competent seafarer would correctly perform in the same circumstances.

7.3.2 A Risk Assessment shall be undertaken using an appropriate method, e.g. Failure Mode Effects Analysis (FMEA), in order to identify the risk levels associated with the MASS and its operation.

7.3.3 Internal and External sensors may be used to monitor the state of the platform and the external environment.

7.3.4 It is necessary to have the ability to interpret sensor data in terms of its immediate or impending impact on MASS performance, and its direct or indirect effect on the safety of the MASS, surrounding structures and vessels, humans and the environment.

7.3.5 The control system shall be designed and constructed to:

- *Enable its operation in all RFOC;*
- *Operate in a predictable manner with a level of integrity commensurate with operational and safety requirements;*
- *Ensure the watertight and weathertight integrity, to meet buoyancy and stability requirements;*
- *Minimise the risk of initiating fire and explosion;*
- *Enable the maintenance and repair in accordance with the maintenance philosophy.*

7.3.6 Operators shall be provided with adequate access, information and instructions for the safe operation and maintenance of the control system.

7.3.7 It is necessary to exert control over the MASS, in order to ensure its safe operation. In the case of a propelled and steered craft, this includes the ability to direct the MASS along a safe route at a safe speed. It also includes the ability to ensure that on-board systems are deployed in a safe manner – e.g. switching off or diminishing high power transmissions when they could cause harm to vulnerable systems or personnel nearby.

7.4 Risk Assessment

7.4.1 A Risk Assessment shall be performed for the MASS to identify potential failures which could impact on safety through:

- *Collision with fixed or floating objects;*
- *Grounding;*
- *Becoming a significant obstruction or hazard to other traffic;*
- *Leakage of noxious substances or other forms of pollution;*
- *Other potentially hazardous events or situations, which may depend on the type of MASS and how it is deployed and operated.*

7.4.2 The Risk Assessment shall consider MASS systems, sub-systems, and components, and shall take into account:

- *The probability of a failure occurring, in measurable units, e.g. probability per 10,000 hours of operation, and the direct and indirect effects of the failure;*
- *Whether the MASS is capable of inflicting significant damage in a collision, by reason of its kinetic energy or its mass. Even at zero hull speed, a significant mass may cause damage by drifting onto, being blown by wind or thrown by waves onto another object or vessel.*
- *Whether the MASS is liable to become a significant obstruction to other traffic, if left to drift without propulsion or steering. This is governed by size and weight and operating area.*
- *Whether the MASS carries significant quantities of hazardous or pollutant substances.*

7.4.3 If the consequence of failure identified in the Risk Assessment are deemed acceptable then the single point failure modes need not be analysed further for the purpose of the Code.

7.4.4 Failure modes to be considered in the Risk Assessment shall encompass, but not necessarily be limited to, the following:

- *Power generation, control, distribution;*
- *Propulsion systems including the control of thrust and its direction;*
- *Steering systems including actuators and their control;*
- *Propulsion;*
- *Electrical connectors;*
- *Fuel and hydraulic systems (potential fire, pollution, loss of control);*
- *Individual sensors and their power supplies;*
- *Individual actuators and their power supplies;*
- *Communication systems;*
- *The platform control system (including autopilots and Collision Avoidance systems);*
- *The autonomy processor(s), i.e. the interpretation and decision-making system which takes in sensor data and takes decisions on what control actions to take. This may be done on board, off-board, or as a combination of these;*
- *Signalling and lighting;*
- *Data quality or inconsistency.*

7.4.5 The Risk Assessment shall be able to show that the MASS is able to be operated to a tolerably safe level, ideally proven to be as safe as an equivalent manned counterpart (i.e. similar size and carrying similar payload / cargo).

7.4.6 The protection measures afforded on a manned vessel, e.g. emergency engine stop in the case of fire, often rely on a human operator to detect the fault and to trigger the stop mechanism. On the MASS, these measures must be fully automated unless the attendant risk can be otherwise reduced to an acceptable level (e.g. using electric propulsion, no fuel aboard; nobody on board put at direct risk; etc).

7.4.7 The Risk Assessment shall highlight all potentially critical failure modes which are mitigated using failure sensors and/or "defence in depth", dual or multiple redundant safety features, as these need to be identified for the purpose of test and accreditation of the MASS.

7.5 Situational Awareness Sensors

7.5.1 Most of the sensors considered in Sections 7.6 and 7.7 may be regarded as optional, but some may be considered essential on certain MASS under certain circumstances; or they may represent the best way to ensure the necessary levels of safety equivalent to a manned counterpart.

7.5.2 The overall need for monitoring shall depend on the considerations above, being guided specifically by the outcome of the Risk Assessment.

7.6 Internal sensors (platform monitoring)

7.6.1 Internal sensors may be fitted for monitoring the platforms' vital functions and safety. This may include a monitoring capability which would normally be provided by crew onboard.

7.6.2 Examples include:

- *Health status of command datalinks, in particular those with the ability to receive an Emergency Stop command (this may be considered essential);*
- *Operability and health status of sensors that are identified as vital;*
- *Operability and health status of on-board systems which govern the ability to control the direction and speed of movement of the MASS (Heading or COG and STW/SOG);*
- *Operability and health status of on-board systems such as propulsors, platform control systems, collision avoidance systems, autopilots, servos, communications datalinks, and other internal sensors which may be needed to maintain platform and mission integrity;*
- *Remaining fuel;*
- *Watertight integrity;*
- *Integrity of the hull (or hulls);*
- *Structural damage to the overall MASS or its components;*
- *Entanglement;*
- *Pitch, roll and heave;*
- *Vibration;*
- *Shock.*

7.6.3 The level at which these may be considered essential depends on the type of MASS and operational conditions, as indicated in Table 7.1 below. The need should be driven by the necessity to reach equivalent safety levels for all MASS with their manned counterparts.

Table 7.1: Platform Monitoring	
Factor	**Impact on need for monitoring**
MKE (Mass/Kinetic Energy)	High MKE - > greater need
HAZCHEM (Hazardous substances on board)	Payload integrity / fuel leaks: greater need
OP-RANGE (Operating range)	Outside LOS, greater need for monitoring
Level of Control (See definitions at Ch 2)	Appropriate monitoring required for the level of control in operation.
Area of Operation (See definitions at Ch 2)	Close to shore and busy seaways, greater need for monitoring, rapid response. Offshore/Open Ocean, reduced need, slower response may be acceptable

7.6.4 The MASS shall respond to a simultaneous failure (or deliberate interruption) of all critical data links, i.e. those which can deliver an Emergency Stop command, by applying an Emergency Stop command (i.e. Fail Safe). This may be considered essential on all MASS.

7.7 External sensors and sources of data

7.7.1 External sensors may be fitted to sense and/or measure the environment, surroundings, navigational data, and other platforms and systems, which may include, but not be limited to, the following:

- *GNSS (Lat/Long), with position integrity provided by Satellite Based Augmentation Systems (SBAS, i.e. EGNOS in Europe) and/or terrestrial DGNSS beacons, and with the inclusion of a complementary backup system for resilience against GNSS interference, jamming and spoofing;*
- *Heading (may be considered essential, unless operated at a range of less than 300m from a manned ground control station within LOS and capable of commanding Emergency Stop);*
- *Sea state (may be measured using pitch and roll sensors);*
- *Wind speed and direction;*
- *Depth below keel;*
- *Radar targets, and automatic target tracking;*
- *Sound signals;*
- *Visual signals, such as shapes, carried by other vessels or navigational marks;*
- *Relatively small floating objects that may reasonably be expected to be found in the area of operation.*

7.7.2 The exact number of, and performance requirements for, these sensors will be dependent on the MASS category, level of control and the operating area as defined in the risk assessment.

7.7.3 Third party data feeds may also be required including:

- *AIS data;*
- *Weather forecast data;*
- *Tidal almanac data.*

7.8 Data interpretation

7.8.1 The MASS shall have at least one of the following:

- *The ability to interpret sensor data on board in a timely manner with regard to its impact on MASS safety and performance and to execute its responsibilities in accordance with COLREG and international law;*
- *The ability to transmit sensor data in a timely manner to an off-board system or human operator who can interpret the data with regard to its impact on MASS safety and performance; and to receive appropriate commands in response, in a timely manner.*

7.8.2 Sufficient data from the sensors (internal and/or external) shall be made available in a timely manner to a System which is capable of exerting control over the MASS, bringing it to a safe haven or away from a danger area when deemed necessary. The System, in this context, must include at least one of:

- *A human operator using a Control Station (LoC L1-L3);*
- *An on-board or remote automatic system (LoC L3-L5);*
- *A distributed system comprising on-board and off-board elements, which may or may not include a human operator or supervisor, with appropriate communication links between them.*

7.8.3 In order to interpret sensor data in regard to its impact on MASS performance, the System shall be capable of determining or forecasting, by means of algorithms or data, as necessary to ensure safe operation:

- *Safe operating limits for sensor data where applicable;*
- *Permitted geographic area(s) and time window(s) for MASS operation;*
- *Expected water depth in relation to geographic position and time;*
- *Expected water current speed and direction in relation to geographic position and time.*

7.8.4 Where applicable and deemed necessary the MASS is to be capable of de-conflicting the data presented by different sources.

7.8.5 The System shall be capable of taking operational decisions in accordance with the sensor data interpretation, in order to maintain the safety and integrity of the MASS, surrounding objects and personnel, and to pursue its mission subject to those safety considerations.

7.9 Control

7.9.1 The MASS shall have the ability to be controlled by a Control System which may be an on-board, off-board system or human operator, or a distributed system involving one or more of these elements. Control is typically a combination of high level and low level functions and behaviours, which may be implemented in separate modules, such as the following examples:

- *Sub-second control of a rudder actuator, with a feedback loop in order to control heading in response to Heading and Rate of Turn (ROT) set points;*
- *Following a sequence of waypoints by issuing Heading and ROT set points;*
- *Generating or selecting waypoints, and selecting which route to follow;*
- *Enabling waypoint-following, or superseding the mission controller with heading and speed set points calculated by a collision avoidance algorithm.*

7.9.2 Note that the MASS's ability to transmit situational awareness data to an off-board controller has been covered in the previous Section. This, and the ability to receive appropriate and timely commands from the controller, should be borne in mind in cases where some of these functions are performed remotely.

7.9.3 The control functions, (on-board, remote, or distributed) shall be capable of exerting timely and accurate control in such a manner as to maintain safety of (1) the platform; (2) surrounding persons, structures, vessels; and (3) the environment.

7.10 Emergency Stop

7.10.1 The MASS shall have a defined condition of Emergency Stop, which must be fail safe under conditions where normal control of the MASS is lost. Under Emergency Stop, propulsion is reduced to a safe level in a timely manner. In this context:

- *"a safe level" means a level at which it is not likely to cause damage either directly or indirectly; Note that some MASS (e.g. wave propelled) may not have any means of cutting propulsion power to zero; but in a harbour or sheltered waters the wave propulsive power may reasonably be expected to be a safely low level;*
- *"in a timely manner" means within a time that is short enough to ensure that the risk from uncontrolled propulsive power can be contained before it is likely to cause damage. In open ocean conditions this may be relaxed, whereas in a docking situation the propulsion may need to be cut more quickly, within seconds or less.*

7.10.2 The MASS shall have the ability to be placed in an Emergency Stop condition by a human or automatic controller or supervisor with access to sufficient Situational Awareness data to be able to determine when an Emergency Stop command is necessary.

7.10.3 In the case of an automatic operator, the design of that controller or supervisor shall be fail safe, in that it shall recognise all known unsafe operating conditions with no false negatives, and shall react to unknown or indeterminate safety conditions by invoking Emergency Stop in a timely manner.

7.10.4 On sensing a failure (or disabling, whether deliberate or not) of all data-links which may carry an emergency stop command, the MASS shall enter a 'render-safe' procedure. This should culminate in Emergency Stop. The first action should be that, if situational awareness has been, and continues to be, fully operational, the MASS should immediately shape a safe course and adopt a 'safe speed' (making appropriate sound and visual signals when feasible) commensurate with weather conditions, COLREGS and safe navigation at the time of loss of data-link. This should minimise hazards to the MASS and other vessels, whilst the MASS and the control station resolve the situation. If the data-link is not re-established after an appropriate grace time, and/or the MASS's own situational awareness deems it safe/necessary, the MASS should enter Emergency Stop. Consideration may be made of including 'dropping anchor' as part of the render-safe procedure, commensurate with accepted safe navigation practices.

7.10.5 In the event that the MASS experiences loss or compromise of Situational Awareness as well as loss of data-link, then Emergency Stop should be immediately initiated (making appropriate sound and visual signals when appropriate).

7.11 Propulsion control

7.11.1 MASS shall have propulsion control as far as necessary to be capable of ensuring that safe operating speeds appropriate to its situation are not exceeded.

7.12 Steering control

7.12.1 The MASS shall have steering control as may be necessary to maintain a safe heading. Note that 'passive' MASS, such as drifting sensor buoys, do not have steering control, but the risk is mitigated by deploying in safe areas and monitoring their position, and maintaining the ability to recover the MASS when necessary.

7.12.2 Note on Heading vs Course Over ground (COG). Marine craft may have control of heading but limited control of Course Over Ground (COG) because of environmental influences such as surface currents, waves, or wind, combined with low Speed Through the Water (STW). The risk posed by potential loss of control over COG shall be addressed by means of situational awareness, using sensor and almanac data or calculations as necessary to anticipate environmental influences, so as to avoid bringing the MASS into a situation where it is predictably carried in an unsafe direction by overwhelming environmental influences.

7.13 COLREG – compliant behaviours and fail-safes

7.13.1 The Control System shall be capable of operating in accordance with the requirements of Chapter 5 and Chapter 10 to a level of compliance with COLREGS appropriate to the MASS class.

7.13.2 The Control System may include a system or systems designed to sense and avoid obstacles. These obstacles may be fixed (e.g. coastline) or moving (drifting or other craft).

7.13.4 Sense and Avoid systems may be deemed necessary:

- *When operating within Line of Sight (LOS), as directed by area control authorities;*
- *When operating outside LOS.*

7.13.5 The performance of Sense and Avoid systems may be categorised using the following criteria and the ability to:

- *Accept externally defined fixed exclusion zones (e.g. based on geographical data);*
- *Accept externally directed control (third party) (e.g. VTS);*
- *Accept dynamic data on both fixed and moving obstacles via automatic electronic sensors (such as AIS, Radar with automatic target tracking (ATT);*
- *Take control of the MASS heading;*
- *Take control of the MASS propulsion;*
- *Interpret Situational Awareness sensor data automatically to provide the following information regarding any other object within range:o its position;*
  - *– whether it is a vessel according to COLREGs;*
  - *– if so, the aspect of the vessel in terms of its heading;*
  - *– its course and speed, either absolute or relative to the MASS;*
  - *– its classification according to COLREG (not under command, restricted in her ability to manoeuvre, sailing, fishing, constrained by her draft);*

- *Calculate and apply manoeuvring commands where practicable in such a manner as to comply with an appropriate interpretation of COLREGs where applicable;*
- *Calculate and apply manoeuvring commands in such a manner as to avoid collisions under all circumstances in which it is practicably feasible to do so.*

7.13.6 A classification matrix may be used to summarize the performance level of a Collision Avoidance System. The CA Category required for the MASS should be determined by the vessel category, Level of Control and operating area. An illustrative matrix is given at Table 7.2.

Table 7.2: Illustrative Classification Matrix

	Criterion							
CA Class	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
0	Yes	Yes		Yes	Yes			
1	Yes	Yes	Yes	Yes	Yes			Yes
2	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

SEA-KIT

8 Communications Systems

8.1 Objective

The objective of this Chapter is to outline the requirements for Communications Systems to be carried by MASS, as required for compliance with IMO instruments and for control of the vessel.

8.2 Scope

8.2.1 MASS will be heavily dependent on communications systems for control and monitoring of the vessel, irrespective of any existing regulatory requirements for carrying radio-communications systems.

8.2.2 RF communications requirements for MASS will include the following:

- *GMDSS compatibility;*
- *Communications for Control System Monitoring and Input.*

8.3 GMDSS Requirements

8.3.1 The application of SOLAS Chapter IV (Radiocommunications) is to cargo ships of 300 gross tonnage and upwards on international voyages. These SOLAS requirements are therefore not applicable to the majority of vessels within the application of this Code.

8.3.2 The Merchant Shipping (Radio Installations) Regulations (SI 1998 No. 2070) require cargo ships of 300 gross tonnage and upwards on domestic voyages to carry a GMDSS radio installation as described in the regulations. MASS of 300 gross tonnage and upwards should therefore comply with these regulations.

8.3.3 There are no requirements for ships under 300 gross tonnage, although any ship using the frequencies of the GMDSS are bound by the requirements of the ITU Radio Regulations. Guidance can be found in the Code for the construction, machinery, equipment, stability, operation, manning, examination, certification and maintenance of vessels of up to 24 metres load line length which are in commercial use for the carriage of cargo and/or not more than 12 passengers or neither cargo nor passengers; and pilot boats (the Brown Code).

8.3.4 The radio equipment to be carried depends on the area of operation. The minimum and recommended radio equipment is given in Table 8.1.

8.3.5 The controller of the MASS while operating should be capable of receiving, interpreting and acting upon information transmitted via the following communications channels:

- *Where practicable on VHF channel 16;*
- *On VHF DSC channel 70;*

- *If fitted with an MF installation, on DSC 2187.5 kHz;*
- *If fitted with a satellite installation, with enhanced group calling;*
- *For broadcasts of Maritime Safety Information e.g. by NAVTEX.*

8.3.6 The controller of the MASS should hold a certificate of competence for distress and safety radiocommunications (e.g. GMDSS Short Range Certificate or Long Range Certificate as appropriate).

Table 8.1: Communication Equipment requirements for MASS

Area Category	6 (up to 3 nm)	3,4,5 (up to 20 nm)	2 (up to 60 nm)	1 (up to 150 nm)
VHF radio installation with DSC	R	M	M	M
MF radio installation with DSC or a satellite installation	R	M	M	M
NAVTEX receiver			R	R
EPIRB			R	M
Search and Rescue locating device		R	R	M
Hand-held waterproof VHF radio	M	M	M	M

M = Minimum **R =** Recommended

8.4 Communications for Control System Monitoring and Input

8.4.1 RF Communications systems that are required to exercise the required Level of Control (as outlined in Chapter 2), or are necessary to enable the Emergency Stop functionality, should be provided with reversionary modes and backup energy supplies, the scope of which will depend on both the MASS Category (see Chapter 3) and the Area of Operation.

8.4.2 These reversionary modes and energy supplies should be considered in the Risk Assessment, such that the risk of loss of control communications and ability to execute the emergency stop function is reduced to a level As Low As Reasonably Practical (ALARP).

8.4.3 The communication suite is assumed to reflect the holistic coding requirements or registration certification of the vessel. Any reduction in system fit should be formally recorded, with each new mission/task requirement being reviewed and documented as 'fit for task' prior to operation.

8.4.4 If alternative communication systems are adopted as the primary method, the appropriate minimum level of RF communication capability should be fitted relative to the specific operation cycle.

8.4.5 In the case of a wider system failure, an adequate failsafe communication system to support COLREG compliance should be fitted. This system should have suitable range and endurance capabilities as to enable the operator to effect appropriate safe management of the uncontrolled vessel.

8.5 RF Communications Installation

8.5.1 All radio communication equipment should be of a type which is approved by the relevant authority.

8.5.2 VHF transmission and reception ranges are reliable only within the line of sight ranges of the aerials.

8.5.3 Aerials should be mounted as high as is practicable to maximise performance. When the main aerial is fitted to a mast, which is equipped to carry sails, an emergency aerial should be provided.

8.5.4 Masters, owners and managing agents should be aware of VHF coverage in the intended area of operation. Where the certainty of good VHF coverage in the UK coastal area is in doubt, masters, owners and managing agents should seek advice from the Administration on whether Medium Frequency (MF) or other equipment with long range transmission capability should be carried. (i.e. Mobile Satellite Communications Systems, etc.).

8.5.5 All radio installations should be:

- *Located to ensure the greatest possible degree of safety and operational availability;*
- *Protected against the harmful effects of water, extremes of temperature and other adverse environmental conditions.*

8.5.6 Notwithstanding the provisions of Section 8.4, when the electrical supply to radio equipment is from a battery, charging facilities (which are capable of recharging batteries to minimum capacity requirements within 10 hours) or a duplicate battery of capacity sufficient for the voyage should be provided.

8.5.7 The battery electrical supply to radio equipment should be protected against flooding/swamping as far as practicable and arranged so that radio communications are not interrupted in adverse conditions. When the efficiency of the required protection against flooding/swamping cannot be guaranteed with batteries located below the freeboard deck, an efficiently protected battery electrical supply to the radio equipment should be provided above the freeboard deck.

8.5.8 When fully charged, the batteries should provide at least the minimum required hours of operation to ensure effective use of the GMDSS installation.

ASV Global Base Control Station

9 Base Control Station Operation

9.1 Objective

The objective of this Chapter is to define the architecture and potential responsibilities of a Base Control Station and provide outline requirements for its functions.

9.2 Scope

9.2.1 The Base Control Station (BCS) is the set of equipment and control units that are needed at the site or sites where safe and effective remote control and/or monitoring of the MASS, or several MASS, is conducted.

9.2.2 The BCS enables the command and control of the MASS. The BCS may be located on board a vessel or ashore. The BCS may also interface with other BCSs that are separately located; the risk assessment will indicate which BCS takes primacy.

9.2.3 The BCS may be a fixed stationary unit or highly modular and portable.

9.3 Sub-System Architecture

9.3.1 The BCS architecture will vary from system to system, but enables the following tasks to be undertaken to a level appropriate for the mission, in accordance with the risk assessment:

- *Operation Planning*
- *Operation Control*
- *Post Operation Analysis*

These will be physically accessed through a Human Machine Interface.

9.4 Tasking Cycle of the MASS

9.4.1 The MASS tasking cycle is a sub-set of the overarching system life cycle and includes a number of tasks that involve the operation of the BCS. It is necessary to clearly define the concept of use and tasking cycle of the MASS and the roles, responsibilities and boundaries of those involved in these tasks. An example of a MASS tasking cycle is presented in Table 9.1.

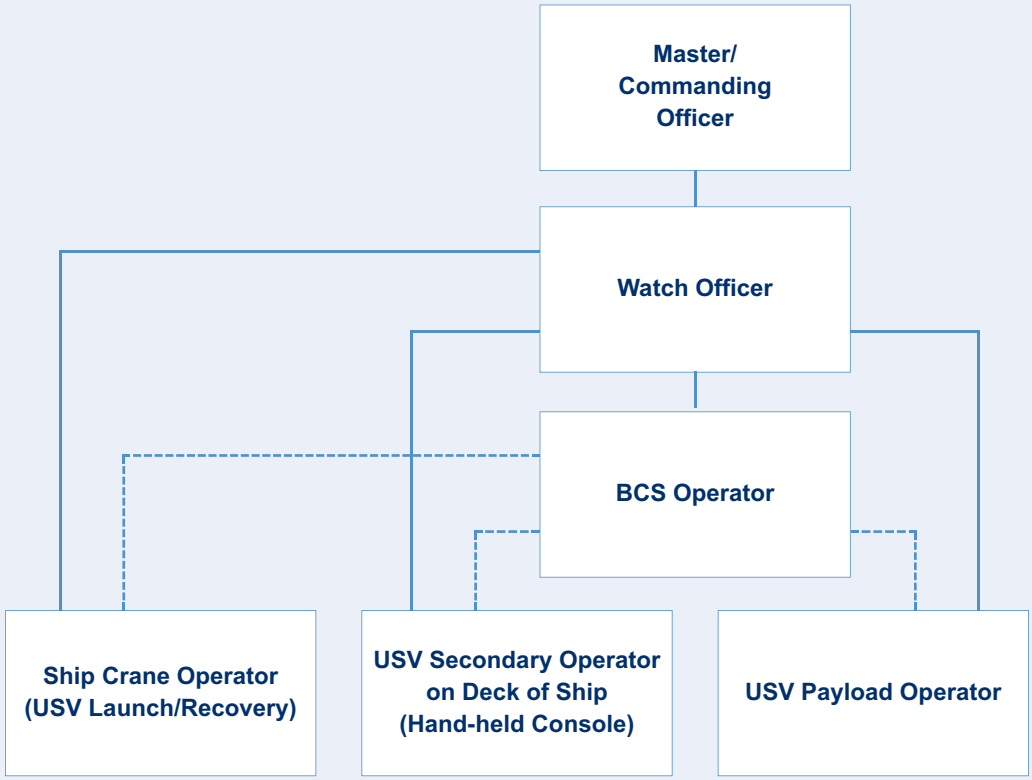
Table 9.1: Tasking Cycle of a MASS	
Task	**Description**
Operation Planning	Can be conducted ahead of actual operation and includes: ■ *Determine operational area;* ■ *Notification and permissions from port/sea authorities, joint force, other organisations;* ■ *Notice to mariners* ■ *Environmental assessment;* ■ *RF licences;* ■ *Route planning;* ■ *Infrastructure;* ■ *Description of incident handling processes and procedures.*
Pre-deployment	Mobilisation and configuration of equipment
Deployment	Deploy equipment to operational area by rail, road, air, sea
Pre-launch	Detailed operation planning and system checks. Normally performed immediately prior to launch.
Launch / cast off	In water launch or cast off of MASS from mother ship or from shore side, including lifting operations.
Post Launch	In water equipment checks prior to transit including: ■ *Propulsion and steering;* ■ *Communications links;* ■ *MASS Health / BITE status;* ■ *Emergency procedures and functionality of fail-safe equipment.*
Transit	Transit to operation start point.
Operation Conduct	Operation phase which will continue until the planned operation end time is reached or the operation is aborted. The operation may consist of one or several tasks and is highly dependent on the application. The operation may include re-planning, that is modification of the pre-launch operation plan, either automatically or commanded by the BCS. The operation may include deployment of other vehicles that perform their own operation. Will include handling of incidents (via the BCS) that occur during the operation.
Pilotage	Transit in confined waters and/or areas of high traffic density where a manned vessel would normally require a specialist pilot or navigator.
Replenish	Replenishment such as re-fuelling may occur within an operation or at its margins. This could also include changing or replacement of various operation equipment.
Transit for berthing	Transit to point of berthing.
Berthing	Berthing of MASS to mother ship, shore side or jetty/mooring. This could include lifting operations when recovering to mother ship or land.
Shut Down	Shut down in accordance with check list procedures. This could also occur prior to or as part of the recovery procedure.
Post Operation Evaluation & Analysis	Post operation analysis could include: ■ *Analysis of operation data capture* ■ *Evaluation and reporting of errors, faults, safety related issues.* ■ *Evaluation of the success of the operation.* ■ *Reporting of events to authorities, environmental monitoring agencies etc. as required.*

9.5 Responsibility of the BCS operator within an operational hierarchy

9.5.1 In most cases, there will be several personnel involved in the operation of the MASS with different types and levels of responsibility. The titles given to these personnel will differ depending on the type of commercial or military application. It is necessary to have a clear understanding of the responsibilities of all involved in the operation, particularly the BCS operator.

9.5.2 An example of a responsibility diagram is provided at Figure 9.1 below. In this example, the MASS is launched and operated from the mother ship. The BCS is located in the ship operations room with a second MASS operator on deck to conduct short range remote operations using a hand-held console during launch and recovery of the MASS.

Figure 9.1: Illustrative Responsibility Diagram



In this example, the following roles and responsibilities are applied:

- *Master/Commanding Officer*
  - *Overall responsibility for the ship and her crew and all operations including those involving off board systems (MASS);*
  - *Authorises the mission plan.*
- *Watch Officer*
  - *Manages and commands the complete MASS mission;*
  - *Manages the interaction between MASS BCS operator, crane operator, payload operators etc;*
  - *Involved in mission planning, execution and post mission evaluation;*
  - *Direct communication with equipment operators;*
  - *If the MASS Watch Officer (MWO) is located in the Operations Room, then the oversight of crane/deck operations will pass to the commanding officer on the bridge.*

- *BCS Operator*

– *Receives commands from the Watch Officer;*
– *Responsible for the MASS command and control when operated by the BCS;*
– *Responsible for mission planning, execution and post mission evaluation;*
– *Could be fully or partially responsible (shared by payload operator) for launch and recovery of vehicle payloads (ROVs, AUVs, towed systems);*
– *Likely to communicate with other operators, e.g. crane operator, secondary operator on deck and payload operators.*

- *Ship Crane Operator*

– *Receives commands from the Watch Officer;*
– *Responsible for lifting and lowering MASS to/from water; –*
– *Will require to have communication with the MASS BCS and MASS secondary operator on deck as appropriate.*

- *MASS Payload Operator*

– *Receives commands from the Watch Officer;*
– *Could receive commands directly from the MASS BCS Operator;*
– *Responsible for operation of payload;*
– *Could be fully or partially responsible (shared by BCS operator) for launch and recovery of vehicle payload (ROVs, AUVs, towed systems);*
– *Will have communication with MASS BCS Operator;*
– *This role could be conducted by the BCS Operator.*

9.6 Transfer of MASS Control

9.6.1 The person responsible for the operation of the MASS is normally the Primary BCS operator, however, in certain circumstances, this responsibility may be transferred to another person within the operation. Any hand-over of control of the MASS, whether internally or externally, should be formally planned and strict procedures developed and adhered to such that the full and itemised responsibility is always clearly allocated and promulgated both in terms of personnel and jurisdiction.

9.6.2 Control of the MASS could be transferred from the Primary BCS operator to one of the following operators:

- *BCS (Secondary) Operator - Where a network of two or more BCSs are used at different locations;*
- *Remote control using portable / hand held console - for example, during launch and recovery to/from mother ship or shore side;*
- *Manual operation - For optionally manned MASS, a qualified coxswain may take control of the MASS from the helm, for example, during transit, test scenarios, launch and recovery to/from mother ship or shore side;*
- *Fully autonomous operations – it is conceivable that in some circumstances full automated control could be given to the MASS. In this event, a BCS must be nominated as the immediate fall back if required;*
- *Pilotage – where port or other regulations require that a pilot is "embarked", suitable provision must be made to allow the pilot (embarked on the MASS or using other arrangements) to discharge his duties, (including taking Legal Conduct of the navigation of the vessel within stipulated pilotage waters where applicable), with due regard to any communications latency issues.*

9.6.3 It may be necessary for the BCS operator to interact with other operators and consideration should be given to the level of interaction required, methods of communication and any interdependencies. For example:

- *MASS Payload Operation:*

– *MASS payloads such as hull mounted sensors, towed sonars, may be controlled by a separate operator. This may form part of the MASS system and associated BCS or configured as a stand-alone system with its own dedicated BCS.*

- *MASS Launch and Recovery System:*

– *Launch and recovery of the MASS may involve the operation of a davit, crane or similar device. During these events, the davit/crane operator will have control of the MASS for a period of time;*

- *MASS start-up / shut down and transfer of control between the BCS operator and lifting device operator needs to be coordinated:*

– *External support, e.g. chase boats, port/harbour control, with the responsibility of controlling other vessels within the operational waterspace.*

9.7 Controlling MASS from a BCS

9.7.1 The BCS should enable the operator to effectively monitor the behaviour of the MASS at all times, with a sufficient level of data to assess and react to requests including the following examples:

- *Health Status of MASS, including warnings and alerts:*

– *Built in Test Equipment (BITE) data presented to BCS;*

– *Battery status;*

– *Fuel level;*

– *Engine or equipment condition and performance warnings;*

– *Fire on-board.*

- *MASS navigational data:*

– *Actual position, Heading, CoG, SoG;*

– *Planned course.*

- *MASS requests:*

– *Request to perform some form of action that requires BCS authorisation.*

- *Situational Awareness data within vicinity of MASS; For example:*

– *Target/obstacle Track Data;*

– *Camera data;*

– *Radar data;*

– *In water sensor data (e.g. obstacle avoidance sonar);*

– *Sound data (e.g. warnings from other vessels).*

- *Collision Avoidance:*

– *Warnings of potential obstacles.*

– *MASS intended action (autonomy level dependent)*

- *Attack or interference with the MASS or its subsystems.*
- *Chart overlays, including land mass, shipping lanes, charted obstacles, seabed topography (if required).*

9.7.2 When designing the BCS, the type and quality of data presented at the BCS should be assessed to ensure that a sufficient level of safety and incident management is provided. This will depend on several factors; for example:

- *Type of MASS:*

– *Small MASS will be limited in their ability to support situational awareness and collision avoidance sensors.*

- *Operation:*

– *What other measures are available, if any, to provide situational awareness and communication with other vessels?*

– *Where is the MASS operating, e.g. confined waters with high density traffic or blue waters?*

- *Level of control available (see definitions in Chapter 2):*

– *Data latency and ageing;*

– *Reliability of Communications Link;*

– *Weather;*

– *Geographic location.*

9.8 Relationship between autonomy level and BCS

9.8.1 There are several levels of control defined in Chapter 2. Irrespective of the LoC, the BCS should be designed to enable the operator to take control of the MASS at any time, including the ability to change the level of control or shut down the MASS completely.

9.9 Suggested BCS Operational Requirements

9.9.1 The following operational requirements are provided as illustrations for guidance:

- *The BCS should enable the operator to plan the MASS mission;*
- *The BCS should enable the operator to execute a MASS mission;*
- *The BCS should enable the operator to evaluate the MASS mission;*
- *The BCS should provide the operator with a sufficient level of situational awareness information both for the safe navigation and control of the MASS;*
- *The BCS should provide the ability for the operator to re-programme the required activities and responses of the MASS in timescales appropriate to the MASSs configuration, location and shipping conditions;*
- *The BCS should enable the operator to take direct control of the MASS at any time:*
- *In cases where the BCS is unable to assert direct control of the MASS, e.g. when MASS is operating in Level of Control 5, special provisions and control measures should be required to ensure safe operation.*
- *The BCS should alert the operator of any emergency warnings or a change in condition such as risk of collision, fire on board MASS, MASS equipment or functional failure/defect or 3rd party attack/interference;*
- *The BCS should alert the operator of any changes to the planned mission, such as change in speed, heading, collision avoidance manoeuvres;*
- *The BCS should be arranged such that the transfer of control from one base station to another or from one MASS to another may be undertaken safely;*
- *The BCS should be compatible with the communications link;*
- *The BCS should store data:*
- *This could include log data for fault diagnosis, scenario reconstruction, (e.g. collision event), last known coordinates following communications loss etc;*
- *Sufficient to meet international/local regulations;*
- *Two or more BCSs could be used to control one MASS from different locations. Only one BCS should provide control at any one time. Transfer of control from one BCS to another should be a simple seamless transition;*
- *Only one BCS will exercise control of a MASS at any given time;*
- *The BCS should clearly indicate the control status of the BCS and any other BCS that forms part of a networked control;*
- *The BCS should provide a sufficient level of security to prevent unauthorised access. This may include separate account access levels for Operator, Maintainer and Supervisor purposes;*
- *The BCS should be easy to use. The type of information displayed should be based on the priority of importance. Safety related warnings, graphical or audible, should be displayed on the Graphical User Interface (GUI), regardless of the GUI configuration.*

10 System Integrity Certification & Test Procedures

10.1 Objective

The objective of this Chapter is to outline the certification and test procedures required for the situational awareness, control and other mission-critical systems within a MASS.

10.2 Scope

10.2.1 Verification shall be undertaken to provide assurance that the Situational Awareness and Control System complies with the provisions of this Code and remains compliant throughout its life.

10.2.2 The Risk Assessment for the MASS shall be reviewed in detail, to check that no critical single point failures have been overlooked. The Risk Assessment shall be confirmed as being thorough and conservative in its safety assessment.

10.3 System test based on Risk Assessment

10.3.1 All safety critical items covered by failure sensing and remedial action, or by dual or multiple redundancy, having been highlighted in the Risk Assessment, shall be individually tested by simulating each failure mode of each sub-system or component and verifying that the backup measures are effective in mitigating any critical consequences.

10.3.2 The effects of power failures shall be checked, to ensure that simultaneous power failures on several sub-systems do not invalidate critical safety measures that rely on dual redundant systems.

10.3.3 System integrity testing shall be performed in a hierarchical manner in such a way as to ensure that each sub-module functions in accordance with performance requirements. Integration testing shall be performed to test the interfaces and the performance of the combined systems.

10.3.4 Electronic systems shall be installed in the same manner as for manned vessels. This includes EMC compliance, use of enclosures and connectors with suitable marine grade IP ratings, communications standards EIA-422, EIA-232, NMEA 0183 and NMEA 2000 and others as appropriate.

10.3.5 Simulators may be used to verify levels of performance of some but not all systems. This includes autopilot performance, collision avoidance algorithms, though not the systems whose performance is critically dependent on real-world stimuli, such as optical and inertial sensors.

10.4 Sensor tests

10.4.1 Any sensor whose performance is critical to MASS safety shall be tested and certified to give reliable results. As far as possible, this may be done for each sensor type; in some cases, the sensor performance is largely independent of the platform on which it is mounted.

10.4.2 Where indicated by the Risk Assessment, and where sensor performance is to some degree influenced by the platform on which it is mounted, sea trials shall be performed using the sensor/MASS combination, to test external and internal sensors in a real maritime environment that meets or exceeds the most demanding environments for which the MASS is to be certified.

10.4.3 In some cases, the dependence of sensor performance on the host platform is such that the tests may be performed using a representative platform, i.e. one where the sensor performance is expected to be equivalent or worse than on the MASS itself. This means that the sensor may be certified, on the basis of one set of trials, for many MASS platforms. In such cases, the critical parameters of the test and MASS platforms in question shall be recorded for comparison and justification. For example, if sensor performance depends positively upon antenna height above sea level, the test may be performed on a trials vessel using a lower antenna height, to provide accreditation for use on all MASS with higher antenna mountings.

10.5 Emergency Stop test

10.5.1 The Emergency Stop systems shall be tested, using all defined methods of triggering Emergency Stop, singly and in combination, and under datalink failure conditions, to demonstrate that the Emergency Stop system is fail safe.

10.6 Cyber security

10.6.1 Cyber security is defined as the protection of information systems from theft or damage to the hardware, the software, and to the information on them, as well as from disruption or manipulation of the data for the services they provide.

10.6.2 MASS shall have cyber security measures to protect sensors and control systems as far as practicable and necessary.

10.6.3 Key risks are identified as (but not limited to):

- *Backdoors;*
- *Denial of Service;*
- *Direct Access;*
- *Eavesdropping;*
- *Tampering.*

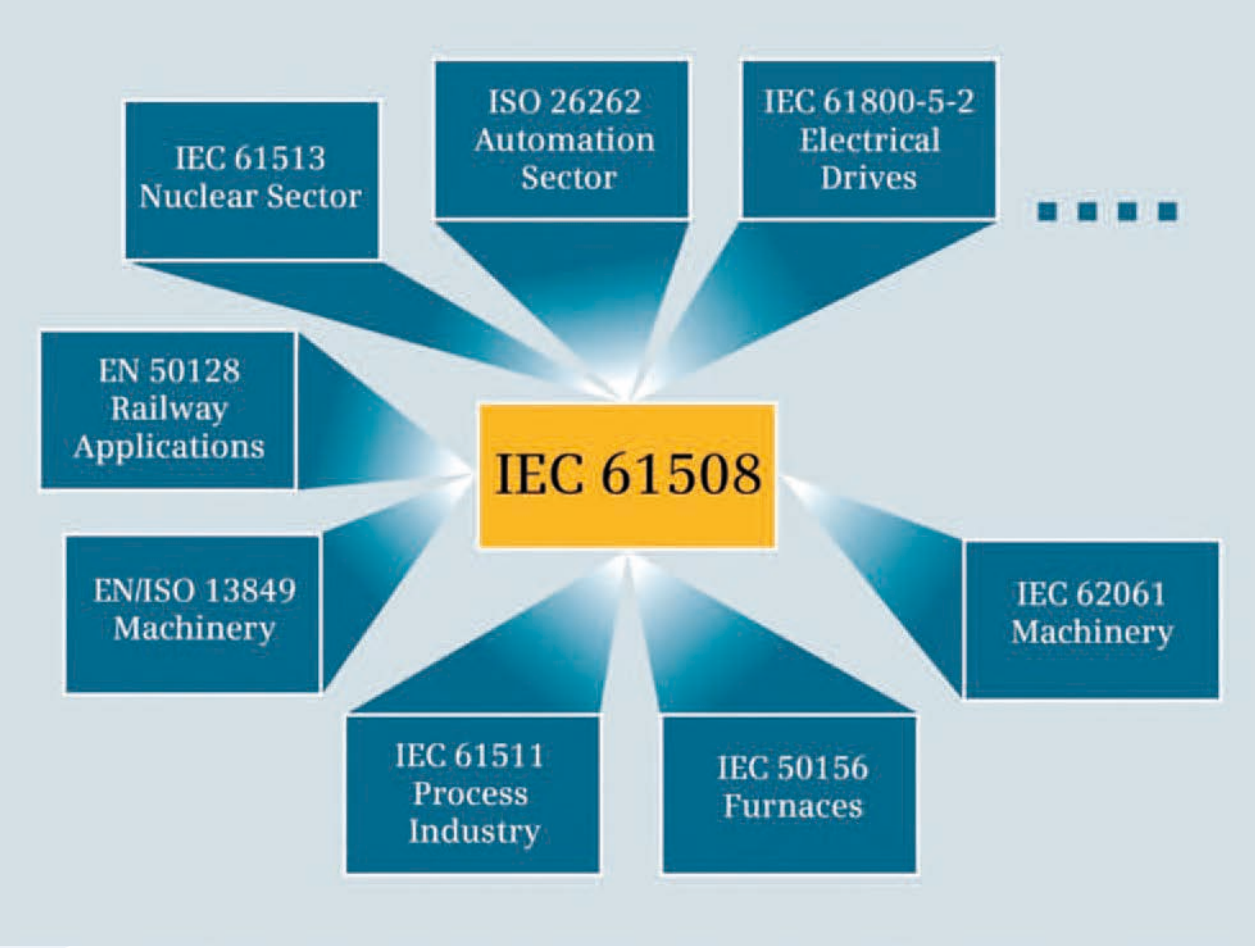
10.6.4 Key systems to be protected are those concerned with vital situational awareness and the display thereof (e.g. position sensors, heading sensors), control (steering, waypoint generation), operator override (including Emergency Stop provisions.

10.6.5 Security measures include:

- *Security by design, using best practice principles;*
- *Use of safe operating system (or no operating system at all), as many cyber-attacks exploit the operating system itself;*
- *Air-gapping (denial of communications so that the firmware, once programmed, is safe). This eliminates backdoor attacks and is effectively applied to many sensors such as GPS, heading and depth sensors;*
- *Command link encryption;*
- *Use of multiple command links, effectively providing command link backup.*
- *BIT testing to verify the integrity of firmware and mission and configuration data at run time.*

10.6.6 A Cyber Security Analysis shall be conducted to identify possible security vulnerabilities and their effects on the vital systems and the performance of the craft or vessel, including but not limited to the command link, the generation and dissemination of waypoints, steering, and the ability to initiate Emergency Stop.

10.6.7 The Cyber Security Analysis shall be interpreted and acted upon in a manner similar to the Risk Assessment, in terms of identifying the need to apply corrective measures to reduce risk to an acceptably low level.



11 Operator Standards of Training, Competence & Watchkeeping

11.1 Objective

The objective of this Chapter is to provide guidance on the required training qualifications for identified roles within a MASS operating organisation for classes of MASS and operating Level of Control.

11.2 Scope

11.2.1 The aim of this Chapter of the Code is to establish pan industry agreement on skill and competency requirements for MASS operation in advance of and alongside the establishment of governing regulations. However, operators should demonstrate a clear understanding of the relevant extant IMO instruments (COLREGs, SOLAS, MARPOL and STCW).

11.2.2 This Chapter sets out to identify the principles and considerations to be given to the skills and competencies required to operate MASS safely.

11.2.3 Skill and competency levels and team size for specific MASS operation should be defined in a Safe Operating Plan equivalent to the IMO Resolution A.1047(27) - Principles of Minimum Safe Manning. Paragraph 1.4 of Annex 2 (Guidelines for Determination of Minimum Safe Manning) states that, in determining the minimum safe manning of a ship, consideration should also be given to the number of qualified and other personnel required to meet peak workload situations and conditions, with due regard to the number of hours of shipboard duties and rest periods assigned to seafarers.

11.2.4 It is recommended that the organisation should produce a "Safe Manning Guide" similar to that required in the MCA Publication "A Master's Guide to the UK Flag".

11.3 General Principles

11.3.1 The UK Maritime Autonomous Systems (Surface) (MAS(S)) Code of Conduct sets out a clear Industry Principle for Training and Development:

- *The Industry will ensure the appropriate level of training and certification for all MASS operational staff to meet their Safe Operating Plan. It will enable staff development and the sharing of best practice through professional maritime bodies;*
- *MASS operational Staff should be trained and certified to at least the same recognised Flag State Authority or national equivalent standards, to a level equivalent to that appropriate for a similar manned vessel;*
- *Companies within the Industry will have staff development processes in place to capture and progress skill generation.*

11.3.2 It is important that training is provided to the appropriate recognised standards by an external and accredited organisation or other competent authority.

11.4 Applicability

11.4.1 In identifying the required skills for MASS operators, the organisation should consider:

- *The size of the Vessel, e.g. vessels under 24m in length, as defined by the Workboat Code; or by*
- *The Class of the Vessel - see MCA Guidance on Vessel classification and certification at https://www.gov.uk/guidance/vessel-classification-and-certification;*
- *The areas of operations: The MCA / NWA Workboat Code for Vessels defines a range of areas of operation as included in Chapter 2 – Definitions;*
- *The Nature of the Cargo: appropriate training for the carriage and care of Dangerous Cargoes (see Paragraph 15.5.1).*

11.5 Owner / Manager Responsibilities

11.5.1 As a responsible industry, it is essential that companies also implement a training, development and appraisal system for their MASS Operators and related personnel. Training needs should be identified and facilitated such that an appraisal system and competence scheme operates in an integrated manner. Table 11.1 below provides guidance on qualifications for categories of MASS. Large MASS are included for reference only.

11.5.2 It should be noted that the MASS Class of 'High Speed' may require further delineation of operator qualification depending on their size. Whilst MASS under 12m length may be operated under an RYA PB (Power Boat) certificate, this should be kept under review depending on their operating risk area and the capabilities of the vessel.

Table 11.1: Provisional Risk and Qualification matrix

LOW RISK		Vessel Category				
Level of control		**Ultralight**	**Light**	**Small**	**Hi-speed**	**Large**
0	Manned	RYA	RYA	OOW	OOW	OOW
1	Operated	RYA	RYA	OOW	OOW	OOW
2	Directed	RYA	RYA	OOW	OOW	OOW
3	Delegated	RYA	RYA	OOW	OOW	OOW
4	Monitored	RYA	RYA	OOW	OOW	OOW
5	Autonomous	RYA	RYA	OOW	OOW	OOW
MEDIUM RISK		**Vessel Category**				
Level of control		**Ultralight**	**Light**	**Small**	**Hi-speed**	**Large**
0	Manned	RYA	RYA/OOW	OOW	Master	Master
1	Operated	RYA	RYA/OOW	OOW	Master	Master
2	Directed	RYA	RYA	OOW	OOW	Master
3	Delegated	RYA	RYA	OOW	OOW	OOW/Master
4	Monitored	RYA	RYA	OOW	OOW	OOW/Master
5	Autonomous	RYA	RYA	OOW	OOW	OOW/Master
HIGH RISK		**Vessel Category**				
Level of control		**Ultralight**	**Light**	**Small**	**Hi-speed**	**Large**
0	Manned	RYA	RYA/OOW	Master/OOW	Master	Master
1	Operated	RYA	RYA/OOW	OOW/Master	Master	Master
2	Directed	RYA	OOW	OOW/Master	Master	Master
3	Delegated	RYA	OOW	OOW	OOW/Master	Master
4	Monitored	RYA	OOW	OOW	OOW/Master	Master
5	Autonomous	RYA	RYA	OOW	OOW/Master	Master

11.5.3 All companies operating and/or owning MASS of any size must:

- *Provide for safe practices in MASS operations and a safe working environment;*
- *Continuously improve safety management skills of personnel operating MASS vessels, including preparing for emergencies related to both safety and environmental protection;*
- *Comply with all mandatory rules and regulations;*
- *Ensure that applicable code, guidelines and standards recommended by IMO, Flag States, Classification Societies and marine organisations are taken into account.*

11.5.4 Therefore, for MASS, the vessel operator, whether owner or charterer, must ensure that their personnel undertake the required initial training and that the operator(s) are completely familiar with the equipment installed on the MASS, both for normal operations and emergency situations.

11.6 Entry Requirements

11.6.1 The MASS Operators should have an appropriate Seafarer certificate of competence applicable to the area category and vessel size. Possible certificates include:

- *RYA Certificates for powerboats at all appropriate levels;*
- *MSN 1858 (M+F) Certificates of Competency: Yacht Deck Officers Training and Certification Guidance;*
- *The Safety of Small Workboats and Pilot Boats – a Code of Practice applicable to small workboats operating in commercial use to sea and all pilot boats. (The Merchant Shipping (Small Workboats and Pilot Boats) Regulations 1998 (SI 1998/1609), as amended);*
- *MSN 1853 The Merchant Shipping (Boatmasters' Qualifications, Crew and Hours of Work) Regulations 2015. Structure and Requirements;*
- *MGN 280 Small Vessels in Commercial Use for Sport or Pleasure, Workboats and Pilot Boats Appendix 3 – The Manning of Small Vessels;*
- *MGN 411 (M+F) – "Training and Certification Requirements for the Crew of Fishing Vessels and their Applicability to Small Commercial Vessels and Large Yachts";*
- *International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978 and Manila 2010 Amendments.*

11.7 Experience

11.7.1 It is recognised that MASS are an emerging technology. The approach adopted for this Code recommends starting with current seafarer skills; specific training needs will develop as solutions emerge.

10.8 Training Needs

11.8.1 The following MASS specific training needs, shown at Table 11.2, have been identified. Where possible an equivalent MNTB National Occupational Standard has been identified to provide guidance.

Table 11.2: MASS Training Needs		
Key Training areas	**Explanation**	**MNTB Occupational Standard (if applicable)**
Principles of Autonomous Systems	Understanding of the levels of automation and specifically the level of operator's interaction with the MASS	N/A
MAS Regulations, permissions, notifications, requirements	Understand and produce the required notifications, permissions and requirements for the operation of MASS in the given area	MNTB NOS Series A: A35
MAS Safety Principles including Machine Application of Regulations	Understand the safe operation of the MASS and any limitations in the application of regulations within the system	
MAS Command Control and Communications to include Security	Operate and control communications with the MASS, awareness of security aspects (e.g. cyber) and responses when communications are lost	MNTB NOS Series C:C12, C13, C14, C23, C45
MAS Deployment and Recovery	Control the launch and Recovery of vessels from land or other vessels	MNTB Series A: A41
MAS Responsibilities (Owner, operator, insurer, accreditor, certifier)	Understand the responsibilities of all parties involved with a MASS operation	
MAS Operations Risk Assessment	Conduct Risk assessment for MASS operations including deployment and recovery	
MAS Vessel Specifics	Control the specific MASS and understand all operational requirements according to the MASS vessel in operation.	Manufacturers' training courses
System Maintenance & Checks	Training on the servicing, repair to (including fault finding), maintenance, pre-launch checks & overhaul of all appropriate components of the whole system	Manufacturers training courses
Operator Facilities and interactions	Understand all vessel controls and interactions available to the operator and awareness of the specifics of operating a vessel at distance	Manufacturers' training courses
Limits of Operation	Understand the limitations of the vessel	
Sea Awareness and Handling	Demonstrate awareness of the performance of the MASS under different conditions and any specific handling limitations	
Operations	Control all MASS system operations, maintaining safety at all times and meeting regulatory requirements	MNTB Series B: B02, B04, B13, B14,
Emergencies contingencies and Faults	Control the vessel or take appropriate action in the event of emergencies including loss of communications with the MASS	MNTB Series B: B11, B12, Series C C42, C43, C44, C45
Mission Planning	Conduct mission planning for the MASS Operation according to the area, type and vessel solutions	MNTB Series B: B03, B15,

11.9 Training Records

11.9.1 Formal proof of service and training records for operational staff should be developed and maintained to include:

- *Proof of Service and Training Records;*
- *Assessment Records;*
- *Portfolio of Evidence;*
- *Regular Competence Appraisals;*
- *Work Records;*
- *Witness Testimonies.*

HUGIN UUV onboard SEA-KIT

12 Registration, Certification, Examination, Maintainance & Record-Keeping

12.1 Objective

The objective of this Chapter is to provide guidance on the Registration, Certification and Survey requirements for the various Classes of MASS.

12.2 Registration

12.2.1 For reference only, Large MASS should normally be registered on the UK Ship Register, in accordance with SI1993/3138 as amended.

12.2.2 Light, Small and some High-Speed MASS should be registered on the UK Small Ship Register.

12.2.3 Ultralight MASS may be registered on the UK SSR, or alternatively conform to a Type-Approval certificate issued by an appropriate recognised organisation. Ultralight MASS should, as a minimum, display a label identifying the owner and contact details.

12.2.4 For vessels on the UK Ship Register or UK Small Ship Register, identification should be as shown at Table 12.1. Large MASS are included for reference only.

Table 12.1: Identification Requirements for Classes of MASS

MASS Type	Description	Requirement
Large MASS	Cargo ships > 100GT Generally, length >24m	IMO number. “IMO” followed by a unique 7-digit number. Managed by IHS Maritime & Trade (IHSM&T), owner of Lloyds Register
Light / Small / High-Speed MASS	Required for all [vessels/water borne craft] under the Recreational Craft Directive in Europe	Hull Identification Number. 14-digit alphanumeric identifier. EN ISO 10087:2006 establishes a coding system to achieve identification of any small water borne craft. In the UK, British Marine manage the issuing of the Manufacturer Identity Code (MIC) on behalf of the British Government.

12.3 Survey & Certification

12.3.1 The range of MASS covered by the classes outlined in Chapter 3 require different certification requirements.

12.3.2 Where mandatory requirements do not apply, the recommendations in Table 12.2 below should be followed, particularly when undertaking any risk assessment. This table is not a definitive list: other relevant certification, e.g. base station certification, will need to be considered.

Table 12.2: Outline Certification Requirements for Classes of MASS

	MASS Category				
O = Optional R Recommended M = Mandatory	**Ultralight MASS/MASS**	**Light MASS/MASS**	**Small MASS/MASS**	**High-Speed MASS/MASS**	**Large MASS/MASS**
Vessel construction group	R Approved design code or RC design standard	R Approved design code or MGN280/ Workboat code	R Approved design code e.g.MGN280 or Workboat Code	R Approved design code or IMO HSC craft code	M Approved design code or Class Soc Rules
Vessel certificate issued by	O Recognised organisation	R Class Society / Flag Administration	R Class Society / Flag Administration	R Class Society / Flag Administration	M Class Society / Flag Administration
Vessel Control System certificate	R Approved design code or standard iaw Ch 10	R Approved design code or standard iaw Ch 10	R Approved design code or standard iaw Ch 10	R Approved design code or standard iaw Ch 10	R Approved design code or standard iaw Ch 10
Certificate Issued by	Appropriate authority	Recognised organisation	Recognised organisation	Flag Administration or Recognised organisation	Flag Administration or Recognised organisation
Master Certification	As per Ch 11	As per Ch 11	As per Ch 11	As per Ch 11	As per Ch 11

12.4 Survey & Certification procedure

12.4.1 The owner or operator will apply as appropriate to the Flag State (or Recognised Organisation, as deemed suitable by the national maritime Administration) for survey & certification. Copies of the certificates should be held in the company and/or owner offices and available in hardcopy or electronically on demand.

12.5 Survey Procedures

12.5.1 Examination of the MASS for certification purposes will as far as possible follow the regime adopted for ships of similar type, in terms of periodicity and content of survey.

12.5.2 Surveys will be conducted by Recognised Organisations as approved by the Flag State administration.

12.6 Maintenance Procedures and Records

12.6.1 All MASS should be provided with a recommended maintenance schedule from the designer / manufacturer.

12.6.2 Configuration control of maintenance procedures and maintenance records should be assured as part of the Safety Management System and procedures for the operator.

12.7 Responsibilities for records keeping

12.7.1 Survey & maintenance records should be kept up to date by the operator and be readily accessible.

12.7.2 MASS should carry a marking which identifies contact details for examination/inspection of records by the Flag Administration.

Thales MCM USV Trials

13 Safety Management

13.1 Objective

The objective of this Chapter is to provide guidance on the requirements for Safety Management systems for MASS operations to meet the provisions of the IMO codes.

13.2 Scope

13.2.1 The objectives of this Code are to ensure safety at sea, prevention of human injury or loss of life, and avoidance of damage to the environment, in particular to the marine environment and to property. This can be successfully implemented by the use of a Safety Management System (SMS) as part of the management and operation of MASS.

13.2.2 The purpose of this Chapter is to provide guidance on how to develop and implement an effective SMS for MASS.

13.3 General

13.3.1 Safety management objectives of the Operator should provide for:

- *Safe practices in MASS operation and a safe working environment;*
- *Assess all identified risks to the MASS, personnel and the environment and establish appropriate safeguards; and*
- *Continuously improve safety management skills of personnel ashore and aboard MASS, including preparing for emergencies related both to safety and environmental protection.*

13.3.2 The safety management system should ensure:

- *Compliance with rules and regulations; and*
- *That applicable codes, guidelines and standards mandated or recommended by the International Maritime Organisation, administrations (e.g. The Maritime & Coastguard Agency), classification societies (e.g. Lloyds) and maritime industry organizations are taken into account.*

13.3.3 Every Operator should develop, implement and maintain a safety management system, which includes the following functional requirements:

- *A safety and environmental-protection policy;*
- *Instructions and procedures to ensure safe operation of MASS and protection of the environment in compliance with relevant international and Flag State legislation;*
- *Defined levels of authority and lines of communication between, and amongst, shore and MASS personnel;*
- *Procedures for reporting accidents and non-conformities with the provisions of this Code;*
- *Procedures to prepare for and respond to emergency situations; and*
- *Procedures for internal audits and management reviews.*

13.3.4 The following paragraphs explain in more detail how the Operator can fulfil the functional requirements.

13.4 Safety and Environmental Protection Policy

13.4.1 All issues of health, safety and the environment that can affect the Operator, its staff and those third parties affected by its business, both ashore and afloat, should be considered and recorded in an effective policy statement.

13.4.2 The policy should describe how the objectives of ensuring safety at sea, prevention of human injury or loss of life and avoidance of damage to the environment are to be achieved.

13.4.3 Such a policy might read along the following lines:

- *"The policy of [name of Owner/Operator] is to conduct its activities taking full account of the health and safety of its employees and of all persons using or connected with the Operator and with due regard for the protection of the environment.*
- *In implementing this policy, [name of Owner/Operator] will ensure that the MASS is, at all times, properly maintained and operated by qualified personnel in full compliance with relevant legislation.*
- *In particular, [name of Owner/Operator] will carry out an assessment of the risks to the health and safety of workers and others affected by [the operation], and will take the necessary measures to minimise the risks identified."*

13.4.4 The Operator should ensure that the policy is implemented and maintained at all levels of the organisation, both onboard and ashore.

13.5 Operator Responsibilities and Authority Documentation

13.5.1 The Operator should have authority at all times to make decisions with regard to the safety of the MASS and any persons on board.

13.5.2 To ensure that there is no ambiguity regarding the authority of the Operator, there should be a simple written statement to this effect.

13.5.3 For all personnel who manage, perform and verify work associated with safety and pollution prevention, their respective responsibilities, authority and relationship with affected personnel should be demarcated and documented.

13.5.4 Suitable and sufficient resources and shore support are to be provided to enable the designated person/persons to fulfil their duties.

13.5.5 A form of quality system should be established where procedures to control all documents and data which are relevant to the SMS are recorded, maintained and kept current.

13.5.6 The Operator should ensure that:

- *Current, in date and vessel specific documentation is available at all relevant locations;*
- *Changes to documents are reviewed and approved by authorised personnel; and*
- *Obsolete documents are promptly removed/destroyed/archived and change management controlled effectively.*

13.5.7 The system and form of documentation adopted by the Operator should suit their own policy and be effective to meet the requirements of the Operator.

13.5.8 The documents used to describe and implement the SMS may be referred to as the Safety Management Manual. Each vessel should retain on board all relevant documentation to that platform but this will depend on the size of the vessel. Where a MASS does not have the size or capacity to retain the applicable records a suitable alternative arrangement of document retention should be provided by the Operator.

13.6 General Health & Safety Protection Policy

13.6.1 One or more competent person(s) should be delegated to take responsibility for health and safety, and these personnel should be clearly identified. It is the responsibility of the Operator to ensure that the policy is complied with, and that the responsibilities are understood.

13.6.2 The Operator should develop a policy on the prevention of alcohol and drug abuse for all its staff.

13.6.3 All personnel, both ashore and afloat, have a duty to take care of themselves and other persons who may be affected by their acts or omissions.

13.7 ISM Code Certification

13.7.1 The International Safety Management Code (ISM Code), under Regulation 3 and 4, has a requirement for vessels to have a level of certification for safety. These are:

- *Document of Compliance;*
- *Safety Management Certificate.*

13.7.2 The provisions of this Code (Chapter 13) and the development and use of an SMS will assist the Operator in showing compliance to the ISM Code certification requirements.

13.8 Risk Assessment

13.8.1 Hazard identification and risk assessment are key tools in identifying those potential hazards that the operation and maintenance of the MASS may impart and the associated realisation of those hazards occurring.

13.8.2 Therefore, a key duty of the Operator is to develop an effective Risk Assessment system. This will, through a logical approach, systematically identify risks to personnel and the environment that the MASS could potentially influence.

13.8.3 Risk assessment system outputs will assist in the production of the MASS safe systems of work and operational procedures.

13.8.4 Any Risk Assessment system should be simple to understand and implement such that Operators can carry out effective risk assessments, taking into account any deviations from the perceived ‘normal’ operating envelope.

13.8.5 Further guidance can be sought in Chapter 1 of the Code of Safe Working Practices for Merchant Seafarers.

13.8.6 Where a MASS uses, transfers or holds bulk quantities of substances, materials or liquids that, in the event of a spillage could constitute an environmental impact then the Operator is recommended to develop and implement a MASS Oil Pollution Emergency Plan (MASSOPEP).

13.9 Procedures to Ensure Safe Operation of MASS

13.9.1 The regulations and rules, not addressed by this Code of Practice, which apply to all MASS include, but are not limited to:

- *The IMO Instruments;*
- *Local navigation rules;*
- *National health and safety regulations;*
- *The Code of Safe Working Practices for Merchant Seamen;*
- *All relevant national shipping or guidance notices.*

13.9.2 The Operator should pay due adherence to the many and varied statutes, legislations, rules, regulations and codes of practice that apply to seafaring. Although the autonomous nature of the MASS operation may seem to negate some requirements, it is the unmanned aspect that should demand increased awareness. Any procedures produced should pay particular attention to this detail, especially those systems and equipment procedures that are required to avoid collision.

13.9.3 The Operator should formulate and document procedures to ensure that safe working practices are carried out in the operation of the MASS. These may be in the form of checklists, which can be followed by all personnel irrespective of their location.

13.9.4 Simple procedures should be developed for the operation of the MASS. These should include, but not be limited to:

- *Testing of equipment, including propulsion and steering gear, prior to commencing a passage;*
- *Navigation and handling of the MASS;*
- *Maintenance routines;*
- *Bunkering operations;*
- *Watertight/weathertight integrity;*
- *Stability of the MASS;*
- *Conduct of passengers and crew if utilised on board.*

13.9.5 Due to the autonomous nature of vessel operation the following areas should be considered on top of traditional vessel operating procedures:

- *Anti-Collision, unmanned vessels and the ability to detect and avoid collision;*
- *Cyber Security, anti-hacking and vessel hijacking for remote operated vessels;*
- *Anti-Piracy, close protection, remote control etc;*
- *SOLAS Reg 14, considerations pertaining to evidence of minimum manning level requirements;*
- *SOLAS Reg 33, Distress situations and how the Operator meets its obligations and responsibilities to other mariners in distress;*
- *SOLAS Reg III/17-1, How the MASS could possible assist in the removing persons from the water;*
- *Meet the various definitions of seaworthiness with no embarked manning.*

13.10 Manning requirements for larger ships when pilotage required.

13.10.1 For some MASS, it might be appropriate to have permanently exhibited checklists, e.g. at the control position for navigational items in the event of platform manning and the need to take local control.

13.10.2 Alternatively, in a smaller MASS, the record could take any suitable form. These could include a diary, as distinct from a specially printed logbook, or a shore/remote pick up data-logger.

13.10.3 Whatever form the record takes, such entries should be accepted as evidence of compliance with the Shore-Side, On Board, Remote Procedural requirements.

13.10.4 The various tasks, once defined, should only be assigned to qualified personnel.

13.11 Lines of Communication between Personnel, Ashore and Afloat

13.11.1 Clear lines of communication detailing reporting routes and lines of authority should be established. This can be produced as a simple line diagram but should, as part of the system, be documented and kept up to date

13.11.2 The responsibilities and authority of each employee should be clear. The communications policy should contain the means of communication both in normal and emergency situations and for unmanned vessels should incorporate the means and methods of communication to third parties and stakeholders that may be affected by the MASS.

13.12 Procedures for Reporting Accidents

13.12.1 All accidents and near misses/dangerous occurrences should be reported to the management regardless of the incident size and its severity. The method for reporting of accidents should be well understood by all personnel. This in turn will improve the safety culture practiced through the Operator.

13.12.2 MASS operating under this Code should report any accidents to the Recognised Organisation and the Operator should therefore have a procedure in place to achieve this requirement.

13.12.3 The accident reporting system should be well documented, with all records retained as per Operator policy for the retention of records.

13.12.4 The system should include procedures ensuring that accidents and hazardous situations are reported to the Operator. After initial actions are completed to safeguard individuals or equipment, an investigation should be conducted. The incident results are to be analysed and recorded, with the appropriate measures subsequently implemented to improve safety and pollution prevention.

13.12.5 This procedure should also include any identified non-conformities to the standards followed after audit or through general observation.

13.12.6 The Operator should establish procedures for the implementation of corrective action, including measures intended to prevent recurrence.

13.13 Procedures for Responding to Emergency Situations

13.13.1 The risk assessment and hazard identification system process should identify potential emergency MASS situations. Safe systems of work and procedures should then be developed to respond to them. An Emergency Situation should be considered to have occurred when a signal has not been received by the MASS for a critical time period. This critical time period will be related to, but not dependent upon, the MASS last confirmed location,

its risk level and cargo. The appropriate authorities should be informed as soon as it is agreed by the Master and operators that the Emergency Situation exists.

13.13.2 Procedures for responding to emergency situations should be clearly established. These may include but are not limited to:

- *Loss of Control of MASS for a critical time period;*
- *Fire;*
- *Collision;*
- *Grounding;*
- *Flood;*
- *Violent act;*
- *Main propulsion or steering failure;*
- *Man overboard (if vessel manned);*
- *Abandon MASS procedure (if vessel manned).*

13.13.3 Checklists/Aide Memoirs may be useful in this regard onboard the MASS and at control stations.

13.13.4 The roles and responsibilities of all personnel in an emergency situation should be defined and recorded.

13.13.5 The safety management system should provide for measures ensuring that the Operator's organization can respond at any time to hazards, accidents and emergency situations involving its MASS. This is particularly important during unmanned periods of operation.

13.13.6 It is essential that there is the ability to communicate with the emergency services via the controlling shore control stations/vessel.

13.13.7 Preparation for emergency situations requires careful consideration and planning. All new and existing personnel should undertake suitable and sufficient training for each of the emergency scenarios. A programme of drills and exercises to react for emergency actions should be incorporated into any vessel management plan.

13.13.8 Any exercises conducted should be recorded. This record should include the names of those who participated.

13.14 Personnel and Training

13.14.1 All personnel should receive training appropriate to the tasks they undertake. It is the responsibility of the Operator to ensure that this training is given, and that the personnel have an understanding of the relevant regulations and rules. This training should be recorded in the MASS Operators Training Record Book (see Chapter 10).

13.14.2 As a minimum, this means:

- *For the Operator, the relevant qualifications;*
- *For the crew, relevant qualifications and any additional training appropriate to their designated duties.*

13.14.3 Training needs analysis should be conducted regularly for identifying any training, which may be required in support of the SMS and ensure that such training is provided for all personnel concerned.

13.14.4 Relevant information on the SMS should be distributed to all personnel in a clear, concise manner, which should include considerations of language.

13.14.5 The SMS should also incorporate an effective feedback procedure such that the MASS's personnel are able to communicate effectively in the execution of their duties related to the SMS.

13.14.6 Prior to the first occasion of working on the MASS, each employee should receive appropriate familiarisation training and proper instruction in onshore and on board procedures. This should include, but is not necessarily limited to:

- *Control of areas around a MASS, on the support vessel whether docked alongside or rafted, or whilst at sea;*
- *Manoeuvring in all modes at sea;*
- *Operations in restricted and restricted/busy navigational areas;*
- *Launching and recovery operations;*
- *Evacuation from all areas of the MASS;*
- *Use and handling of emergency equipment/systems.*

13.14.7 This training should be recorded in the MASS Operators Training Record Book and signed off as completed by the appropriate authority or responsible person.

13.15 Maintenance of the MASS and Equipment

13.15.1 A Maintenance Management System (MMS) is another important integral part of the MASS safety management regime.

13.15.2 Procedures need to be established to ensure that the MASS is maintained to conform with the provisions of the relevant rules and regulations and with any additional requirements which may be established by the Operator.

13.15.3 To ensure conformity to these requirements the Operator should ensure that:

- *Inspections are held at appropriate intervals;*
- *Any non-conformity is reported, with its possible cause, if known;*
- *Appropriate corrective action is taken; and*
- *Records of these activities are maintained.*

13.15.4 The equipment should be checked and tested in accordance with defined schedules produced by the original equipment manufacturer (OEM) and operator procedures when in use. This is in addition to the tests referred to in the procedures to ensure safe operation of MASS in compliance with the Regulations and Rules of the ISM Code.

13.15.5 There should be procedures for a more detailed inspection and maintenance programme of the MASS and equipment, which may be conducted by an outside authority/classification society.

13.15.6 The frequency of the inspections should be determined by the Operator in conjunction with the OEM Schedule and Classification Society/Professional Bodies requirements, but every event should be planned and recorded.

13.15.7 A checklist could be employed as an aide-memoire for the inspection of equipment.

13.15.8 The Operator should identify equipment and technical systems, which, if subject to sudden operational failure, may result in hazardous situations. The SMS should provide for specific measures aimed at promoting the reliability of such equipment or systems. These measures should include the regular testing of stand-by/reversionary arrangements and equipment or technical systems that are not in continuous use.

13.15.9 The inspections mentioned, as well as the measures referred to, should be integrated into the MASS operational MMS.

13.16 Review

13.16.1 Every management system has a cyclic approach and one of the key stages is review. This enables the Operator to undertake a review of the MMS and SMS and determine its effectiveness and to develop areas for continuous improvement and assurance that it is 'fit for purpose' and current in accordance with the latest legislation.

13.16.2 The ISM Code regulates and requires a review period for the safety system and award/retention of its certification. The details of review are as follows:

- *Document of Compliance - External audit of system every five years from date of initial issue and an Internal Verification to be conducted by the Operator on an annual basis;*
- *Safety Management Certificate - External audit of system every five years from date of initial issue and an Internal Verification to be conducted by the Operator between two to three years;*
- *The Operator should periodically evaluate the effectiveness of the SMS in accordance with procedures established by the Company. The audits and possible corrective actions should be carried out in accordance with documented procedures;*
- *Therefore, the Operator should carry out internal safety audits on board and ashore at intervals not exceeding 12 months to verify whether safety and pollution-prevention activities comply with the SMS;*
- *In exceptional circumstances, this interval may be exceeded by not more than 3 months, as agreed with the Authority;*
- *Personnel carrying out audits should be independent of the areas being audited unless this is impracticable due to the size and the nature of the Company;*
- *The results of the audits and reviews should be brought to the attention of all personnel having responsibility in the area involved;*
- *The management personnel responsible for the area involved should take timely corrective action on deficiencies found;*
- *All records and actions from audit should be retained within the organisations document management system.*

ASV Global personnel

14 Security

14.1 Objective

The objective of this Chapter is to provide guidance on the considerations and requirements necessary to meet the provisions of the IMO ISPS Code.

14.2 Scope

14.2.1 The scope of this Chapter is to ensure security in the operation of MASS by, inter alia:

- *Ensuring the performance of all MASS security duties;*
- *Controlling access to the MASS itself and to its control station;*
- *Reducing the risk of third-party cyber interception of MASS communications;*
- *Controlling the embarkation of persons on the MASS;*
- *Monitoring restricted areas of the MASS control station to ensure that only authorised persons have access;*
- *Monitoring both the MASS and the control station;*
- *Ensuring that security communication is readily available.*

14.2.2 The regulation of ship security may be found in a number of sources including in the Annex to the International Convention for the Safety of Life at Sea, 1974 (as amended), SOLAS Chapter XI-2, as well as the International Ship & Port Facility Security Code, 2003 and SOLAS amendments (the ISPS Code).

14.2.3 Both SOLAS Chapter XI-2 and the mandatory obligations found in Part A of the ISPS Code apply to “ships” of 500 gross tonnage and upwards. Such obligations would only find application to those MASS which are registered as “ships” under international law and meet this tonnage threshold.

14.2.4 The Administration may allow a particular ship, or group of ships, to implement other security measures equivalent to those prescribed under both SOLAS Chapter XI-2 and in Part A of the ISPS Code, provided those measures are at least as effective in ensuring security.

14.2.5 Even outside of the direct applicability of SOLAS Chapter XI-2 and the ISPS Code, general principles of law require measures to be taken by MASS Operating Companies to ensure security in the operation of MASS.

14.2.6 This Chapter recognises the important difference between conventionally manned ships, being assisted by shore-based personnel and the operation of MASS, which in most cases are completely dependent on shore-based personnel for their navigation. Therefore, there is a clear need to define and enhance the security of the control station and control beyond the current regulations.

14.2.7 MASS Owners and Operating Companies are responsible for security in the operation of their vessels. Ensuring MASS security will require technical requirements for the MASS itself as well as procedures to be observed by the MASS operating company and the employment of qualified security personnel.

14.3 MASS Technical requirements

14.3.1 MASS shall be designed so as to ensure appropriate compliance with the objectives of this Chapter.

14.3.2 The MASS should be provided with a MASS Security Alert System.

14.3.3 The MASS Security Alert System, when activated, should transmit a MASS-to-shore security alert to a competent authority designated by the Administration, identifying the MASS, its location and indicating that the security of the MASS has been compromised.

14.3.4 The MASS Security Alert System should be capable of being activated from the control station immediately by personnel charged with the MASS's navigation or supervision.

14.3.5 There should be protection from third-party interference with MASS communications

14.3.6 There should be a mechanism by which, in the event of third party communications interception, either the command of the MASS's shore-based personnel may reassume communications or, alternatively, shut down the MASS's operations, where it is thought safe to do so by the Master.

14.3.7 There should also be a mechanism for safely shutting MASS communications down when the security of the c ontrol station centre has been compromised.

14.3.8 The MASS hull/chassis must have a means of indicating:

- *That it is certified as compliant with the security requirements of the issuing authority;*
- *The means by which the MASS's control station may be contacted;*
- *Any other practical security-related information.*

14.3.9 The MASS Control Station should be secure. Reference should be made to the relevant guidance and regulations of ensuring the security of land facilities.

14.4 MASS Owner/Operating Company obligations

14.4.1 The MASS Owner/Operating Company should undertake a MASS security assessment. The MASS security assessment should include a security survey of both the MASS hull itself but also the MASS Control Station. It must include:

- Identification of existing security measures, procedures and operations in respect of both physical and cyber intrusion;
- Identification and evaluation of critical MASS and shore-based operations that it is important to protect;
- Identification of possible threats, both physical and cyber, to the key MASS operations and the likelihood of the occurrence in order to prioritise security measures;
- Identification of weakness, including human factors, in the infrastructure, policies and procedures.

14.4.2 The MASS security assessment should be documented, reviewed, accepted and retained by the MASS Owner/Operating Company.

14.5 MASS Security Plan

14.5.1 The MASS Owner/Operating Company should ensure that each vessel has a MASS Security Plan approved by the Administration.

14.5.2 The submission of the MASS Security Plan for approval should be accompanied by the MASS Security Assessment on the basis of which the plan has been developed

14.5.3 The plan should be in the working language of the MASS control station and should include the following:

- *Measures to prevent dangerous substances being taken on board the MASS or into its control station;*
- *Identification of the restricted areas and measures for the prevention of unauthorised access to those areas, both on the vessel and in the MASS control station;*
- *Measures to reduce the risk of compromise of MASS cyber-security;*
- *Measures to prevent unauthorised access to restricted areas on the vessel or at the control station;*
- *Procedures for responding to threats of security breaches, including provisions for maintaining critical operations of the MASS or, as the case may be, shutting them down;*
- *Procedures for responding to any security instructions made by port authorities;*
- *Duties of shore-based personnel assigned security responsibilities;*
- *Procedures for auditing the MASS security activity;*
- *Procedures for training, drills and exercises associated with the plan;*
- *Procedures for the interfacing with port facility security activities;*
- *Procedures for periodic review of the plan;*
- *Procedures for reporting security incidents;*
- *Identification of the MASS security officer;*
- *Identification of the Company security officer, including 24-hour contact details;*
- *Procedure for ensuring, testing, calibration and maintenance of security equipment on the MASS and that located in the control station;*
- *Frequency for testing, calibration and maintenance of security equipment on the MASS and that located in the control station;*
- *Procedures, instructions and guidance on the use of the ship security alert system, including the testing, activation, deactivation and resetting of that system.*

14.6 Records

14.6.1 Records of the following activities should be maintained at the control station as follows:

- *Training drills and exercises;*
- *Security threats and incidents;*
- *Breaches of security;*
- *Changes in security level set by the Administration;*
- *Communications relating to the direct security of the MASS such as the specific threats to the MASS or its control station;*
- *Internal audits and reviews of security activities;*
- *Periodic review of the ship's security activities;*
- *Periodic review of the ship security assessment;*
- *Periodic review of the ship security plan;*
- *Implementation of any amendments to the plan;*

- *Maintenance, calibration and testing of any security equipment provided on board, including testing the MASS security alert system.*

14.6.2 Records should be protected from unauthorised access or disclosure.

14.6.3 The MASS Owner/Operating Company should ensure that the MASS Master has available, at all times, information through which it may be ascertained, who is responsible for appointing members of the MASS control station and who is responsible for making decisions as to the employment of the MASS.

14.6.4 The MASS Operating Company should employ both a Company Security officer and a MASS Security Officer.

14.7 Company Security Officer

14.7.1 The MASS Owner/Operating Company should ensure that each of its MASS is assigned to the responsibility of a Company Security Officer (CSO).

14.7.2 The CSO's responsibilities should include, but are not limited to:

- *Advising on the level of threats (including cyber) to be encountered by the MASS and its control station facility using all relevant information;*
- *Ensuring MASS security assessments are carried out;*
- *Ensuring the development and submission for approval and thereafter maintenance of the MASS security plan;*
- *Ensuring that the MASS security plan is modified as appropriate and to correct deficiencies in the security plan;*
- *Ensuring that deficiencies and non-conformities identified in internal audits are addressed and dealt with;*
- *Arranging internal audits and reviews of security activity;*
- *Arranging initial and subsequent verifications;*
- *Enhancing security awareness and vigilance;*
- *Ensuring effective communication and co-operation between the MASS Security Officer and the relevant port facility security officers;*
- *Ensuring consistency between security requirements and safety requirements.*

14.8 MASS Security Officer

14.8.1 The control station team must include a MASS Security Officer (MSO) who takes responsibility for the security of the MASS, from both physical and cyber intrusion.

14.8.2 The MSO should be responsible for:

- *Undertaking regular security inspections of the MASS and control station facility to ensure that appropriate security measures are maintained;*
- *Maintaining and supervising the implementation of the MASS security plan;*
- *Proposing modifications to the MASS security plan;*
- *Reporting to the MASS Company security officer any deficiencies with the existing security arrangements identified in audits;*
- *Enhancing security awareness amongst the MASS personnel at the MASS control station;*
- *Ensuring adequate training has been provided to shore-based personnel on security matters, reporting all security concerns.*

14.9 Verification and certification

14.9.1 The MASS should periodically undergo verifications to ensure that its equipment guarantees safety to a comparable extent to those measures prescribed in SOLAS Chapter XI-2 and Part A of the ISPS Code.

14.9.2 The verifications will be undertaken by officers of the Administration.

14.9.3 Initial verification should be undertaken before the MASS is put into service. This should be a complete verification of the MASS security system and associated security equipment and a comparable verification must be undertaken of cyber security measures and measures to protect the MASS control station.

14.9.4 Renewal verifications should be undertaken at intervals specified by the Administration.

14.9.5 The Administration should issue a MASS Security Certificate if content that the MASS and its control station conforms to the requirements of this Chapter.

14.9.6 The details of any such certificate and the duration of its validity should be specified by the Administration.

15 Prevention of Pollution

15.1 Objective

The objective of this Chapter is to provide guidance on the considerations and requirements necessary for MASS to meet the provisions of the IMO MARPOL Instrument and Annexes.

15.2 General

15.2.1 A vessel complying with the Code should meet international, national, regional and local requirements for the prevention of marine pollution which are applicable to the area in which the vessel is operating.

15.2.2 Responsibility for the vessel to be properly equipped and maintained to meet the prevailing requirements rests with the owner/managing agent.

15.2.3 It is also the responsibility of the owner/managing agent to ensure that a charterer of a vessel receives up-to-date and adequate information on prevention of pollution in the area in which the charterer intends to operate. The information may include the need to seek advice from local or harbour authorities, for which contact details should be given.

15.2.4 The disposal of ship generated waste to port reception facilities is regulated in the UK through the Merchant Shipping and Fishing Vessels (Port Waste Reception Facilities) Regulations 2009 (MASSSI 2009 No.1776), as amended. Further guidance on the applicability of these Regulations can be found in MGN 387 (M+F) - Port Waste Reception Facilities Regulations 2003 and the “Port Waste Management Planning – A Guide to Good Practice” booklet available from Marine Offices. Vessel operators should ensure they manage their waste in a sustainable manner and fulfil the applicable requirements (if any) of these Regulations.

15.2.5 All MASS should comply with the requirements of UK Regulations implementing MARPOL and environmental protection requirements as applicable to the size and operating area of the vessel.

15.3 Oil pollution

15.3.1 MASS should retain on board oil or oily mixtures for discharge to shore facilities.

15.4 Garbage

15.4.1 Being unmanned, operation of the vessel should not generate substantial quantities of garbage or similar. However, any maintenance or cargo handling operations aboard which generate such arisings must comply with the provisions of the MARPOL annex as appropriate to the size of the vessel and material generated.

15.5 Air pollution

15.5.1 All engines with a power output of greater than 130kW, installed on a vessel which is a MASS of any size, or a vessel in commercial use for sport or pleasure over 24 metres length (as measured using EC Directive 2013/53/EU), constructed after 1st January 2000 should be issued with an Engine International Air Pollution Prevention (EIAPP) Certificate and a Technical File, according to schedule 2 of MSN 1819(M+F).

15.5.2 A vessel under 24 metres certified as a vessel in commercial use for sport or pleasure is not required to carry an EIAPP certificate if it is compliant with EC Directive 2013/53/EU. Further guidance on air emissions regulations can be found in MSN 1819 (M+F)85 and the Merchant Shipping (Prevention of Air Pollution from Ships).

15.6 Ballast Water

15.6.1 MASS using significant amounts of Ballast water should comply with the MARPOL Ballast Water Treatment annexes as appropriate for their size and use.

15.7 Use of Anti-Fouling Coatings and Paints

15.7.1 On the 5th October 2001, the IMO adopted the International Convention on the Control of Harmful Anti-Fouling Systems on Ships. This Convention prohibits the use of environmentally harmful organotins (for example, Tributyl Tin) in antifouling paints applied on vessels and prevents the possible use in the future of other harmful substances in anti-fouling systems. The Merchant Shipping (Anti-fouling Systems) Regulations 2009 (SI 2009 No. 2796)83 apply.

15.7.2 As a result of EC Regulation EC 782/2003 on the prohibition of organotin compounds on ships, it became compulsory for all vessels in the EEA not to apply or re-apply organotin compounds which act as biocides in anti-fouling systems from 1st July 2003. For vessels less than 24 metres in length it is not necessary to provide for a specific survey or declaration.

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16 Carriage & Transfer of Cargoes (including Dangerous Goods)

16.1 Objective

The carriage and transfer of cargoes under MASS operations should be conducted in an acceptable safe manner to maintain all practical equivalence to the prescribed regulations for conventional shipping. This Chapter of the CoP offers guidance to MASS Owners and Operators in the interpretation of their 'Duty of Care' to be considered in conjunction with the MASS Definitions, Operations and Certification within this Document.

16.2 Scope

16.2.1 The carriage and transfer of cargoes (including dangerous goods) by sea is controlled in order to prevent injury to persons or damage to ships and their cargoes and to prevent pollution of the marine environment under normal operating conditions. Dangerous goods are cargoes classified in the International Maritime Dangerous Goods (IMDG) Code which is given force of law through the Merchant Shipping (Dangerous Goods and Marine Pollutants) Regulations 1997 (SI 1997 No. 2367), as amended and applies to all vessels irrespective of size in UK (navigable) waters. MASS operations will be dictated by the operational requirements of the vessel and carriage of all cargoes should be subject to a risk based safety assessment.

16.2.2 This Section is divided into the following sub-Sections:

- *Cargo demarcation;*
- *Ships stores;*
- *Construction and certification requirements;*
- *Operational considerations including emergency and spillage provisions;*
- *Transfer arrangements of Marine Gas Oil (MGO) and equivalents from designated tanks;*
- *Transfer arrangements from portable tanks (greater than 450 litres) or intermediate bulk containers (IBCs);*
- *Transfer arrangements for receptacles less than 200 litres;*
- *Dangerous Goods Classes (listing).*

16.2.3 Control of dangerous goods is intended to cover all dangerous goods carried as cargo on a vessel. This includes any specialist equipment which may be classified as dangerous cargoes when carried by crew or workers in the event of partial manned operations.

16.2.4 When carrying dangerous goods identified in the IMDG Code, the vessel is required to have a Document of Compliance for the Carriage of Dangerous Goods issued by the Administration regardless of the quantities being shipped and held by the 'Operating' authority for all MASS operations.

16.2.5 Dangerous goods may only be carried at the same time as personnel on vessels holding a Document of Compliance only where such workers or industrial personnel are carried on the express business of the vessel in the event of partial manned operations.

16.2.6 For vessels engaged on voyages outside the United Kingdom continental shelf or between two ports, one of which is outside the United Kingdom continental shelf, the 'Operator' of the vessel has the obligation to contact the port of arrival and /or departure Administration prior to arrival to agree that this Code standard for the carriage of dangerous goods is acceptable to them, including the additional constraints implicit and mitigating the MASS operation risk assurance assessment.

16.3 Cargo demarcation

16.3.1 The carriage of cargoes is the process whereby a vessel is loaded, or intended to be loaded, with any item for delivery to, or collection from, one location and loading/unloading at another location.

16.3.2 Cargoes can be divided into:

- *General cargo – securing and other carriage requirements are Regulated through the Merchant Shipping (Carriage of Cargoes) Regulations 1999 (Statutory Instrument 1999 No. 336).*
- *Dangerous goods – cargoes which are classified as dangerous goods according to the criteria given in the IMDG Code are regulated through the Merchant Shipping (Dangerous Goods and Marine Pollutants) Regulations 1997 (SI 1997 No. 2367). Dangerous goods are assigned, and identified by, United Nations (UN) Numbers and Proper Shipping Names according to their hazard classification. Their system of containment systems, e.g. portable tanks, IBCs, drums etc must comply with the requirements of the IMDG Code with a minimum of equivalence to achieve operating certification of MASS.*
- *Clear warnings that a MASS vessel is carrying 'Dangerous goods' must be displayed in all appropriate spaces where personnel may board the vessel in any eventuality, and during normal ops i.e. safety checks, loading and unloading, maintenance etc.*

16.3.3 Vessels where bulk cargo is loaded into and carried in the vessels hold or tanks which are considered to be small tankers or bulk carriers should be certified in accordance with the provisions of equivalent standards, recognising the MASS definitions and operational employment constraints thereto.

16.4 Ships' stores

16.4.1 The IMO definition of ships' stores (MSC.1/Circ.1216) is as follows:

- *Ships' stores, for the purposes of the carriage of dangerous goods, means materials which are on board a ship for the upkeep, maintenance, safety, operation or navigation of the ship (except for fuel and compressed air used for the ship's primary propulsion machinery or fixed auxiliary equipment) or for the safety or comfort of the ship's crew or workers in the event of partial manned operations;*
- *Materials intended for use in commercial operations by a ship are not considered as ships' stores, such as: diving, surveying and salvage operations.*

16.4.2 For the purpose of this Code, when a total quantity of 25kg/25litres of the following dangerous goods are carried and used on board a 'light' category of MASS, of Classes 2.1, 2.2, 3, 6.1, 8 and 9, such materials can be considered as ships' stores and the vessel does not require a dangerous goods document of compliance. These materials can be specialist equipment to support the function of the vessel, in order to facilitate the specific tasks for which they are designed. Examples of such materials/specialist equipment would be compressed air bottles, portable generators/compressors etc.

16.5 Construction/Certification requirements to maintain MASS equivalence

16.5.1 Scuppers and Drains. The scupper and drainage arrangements are to be directed overboard with no connections to internal spaces.

16.5.2 Electrical Equipment. Electrical equipment installed in the cargo area should be of the certified safe type for the cargo being carried, or be capable of being securely isolated during the carriage of packaged dangerous goods.

16.5.3 Structural Fire Protection. Bulkheads forming boundaries containing fuel tanks, engine spaces and [in the event of partial manned operations] accommodation spaces are to be insulated to A-60 standard unless the dangerous goods are stowed three metres from such bulkheads and boundaries.

16.5.4 Vessel Certification. Prior to carrying dangerous goods, the vessel should be surveyed and a dangerous goods Document of Compliance issued. A risk based assessment should be undertaken in consideration of the size categorisation (CoP 3.1) and level of autonomy (CoP Ch 2, level of control).

16.5.5 Operators are recommended to undertake their own safety assessment before applying for a Document of Compliance for the Carriage of Dangerous Goods; this assessment procedure should be discussed with the Administration. This may consider specific requirements for the vessel including the carriage of additional safety equipment, (i.e. in MASS operations for remote sensing and reporting), additional emphasis on structural fire protection, automated fire suppression, separation between dangerous goods and control spaces. It may be necessary for the operator to submit a safety case.

16.5.6 This survey may only be undertaken by a Recognised Organisation, and will be valid for a determined period or specific operation. Upon successful completion of a survey, a Document of Compliance for the Carriage of Dangerous Goods will be issued to the vessel indicating the Class of goods that can be carried with a list of equipment fitted.

16.6 Operational considerations

16.6.1 Operator Training as prescribed in MASS certification, CoP Ch 11

- *The MASS operating authority should undergo training in the carriage of dangerous goods and the IMDG Code, commensurate with their responsibilities, and records kept of the training undertaken.*

16.6.2 Stowage and Segregation requirements [in meeting MASS equivalency]:

- *Dangerous goods are only to be carried on deck or in internal MASS certified stowages;*
- *They should be secured to the vessels to prevent movement during the voyage;*
- *The stowage and segregation requirements of the IMDG Code should apply;*
- *Packaging (including portable tank and IBCs) should be commensurate with the intended MASS operations and take due cognizance of eventual 'manned' interface;*
- *Dangerous goods should be packed in accordance with the IMDG Code.*

16.6.3 Documentation:

- *When carrying dangerous goods, a full manifest of the cargo should be retained ashore by the Vessel's owner/operator, or designated person [ashore], in case of an incident. The manifest should contain the UN Number, Proper Shipping Name, Packing Group and Quantity for each dangerous good being carried. The designated person ashore should have a list of contact numbers for the emergency services and relevant manufacturers/suppliers of the dangerous goods. The designated person should be employed by the Code vessel's owner and be aware of the details of the voyage. Prior to accepting back-loaded cargoes, the designated person should establish that their carriage will be in compliance with this Code.*

16.6.4 Emergency and spillage procedures:

- *When dangerous goods are carried, details of the emergency firefighting equipment and First Aid medical procedures should be provided as per the risk based assessment of need, and practicalities of the MASS design and operation. The IMDG Code and its supplement may give guidance on such items, to ensure that if an emergency occurs, it can be dealt with effectively by any attending support or safety team.*

16.6.5 Fixed and Portable Fire Fighting Equipment.:

- *The requirement should be assessed on categorisation, size, and level of autonomy. When operating MASS with 'partial manning'. fixed and portable Fire Fighting equipment must provide a minimum of manned vessels equivalence.*

16.6.6 First Aid Kit Requirements:

- *Although the vessel is by definition to be usually unmanned, the provisions of Annex 4 – "Medicines to be carried on ships carrying dangerous cargoes" to MSN 1768 (M+F), should be taken into consideration when carrying dangerous goods, to account for loading / unloading requirements, and/or any periods of manned contact.*
- *When a vessel is carrying a dangerous substance or substances, in quantities in excess of those defined in column 7 of the Dangerous Goods list of the IMDG Code, as whole or part of the cargo, the Operators must ensure the correct antidote to the substance (plus the necessary ancillary equipment e.g. syringes) is carried to account for loading/unloading requirements and or any periods of manned contact.*

16.7 Transfer Arrangements of MGO, UN1202, from Designated Tanks

16.7.1 Careful consideration should be taken with regard to meeting MARPOL regulations and MASS equivalence of Duty of Care. Vessels which are adapted and used for the transfer of MGO from designated oil fuel tanks to other external facilities (e.g. a wind turbine) should demonstrate that they comply with MARPOL's requirements as far as practically possible taking into account that pollution of the seas is an offence. All existing manned equivalence measures must be adhered together with the requirement to demonstrate MARPOL compliance with regard to a full risk assessment carried out for the particular vessel and operation, including but not limited to, the hose not breaking free, pollution, fire safety and training of the shore based operators.

16.7.2 Vessels should have operating procedures covering the loading, discharging and transferring of fuel, which should include safe use of the MASS equipment to minimise fire risks and pollution, and use of Safety Data Sheets (SDS).

16.7.3 The installation should be surveyed by the Recognised Organisation and the vessel's Certification should be endorsed to permit this operation.

16.7.4 The tank(s) should be of suitable design and construction, and have protection adequate for the service for which they are intended. Construction and fittings should be to an appropriate standard, to the satisfaction of the Recognised Organisation. Provision should be made to retain any oil leakage within the confines of the vessels

hull to protect the marine environment and any workers or crew on board partial MASS manned vessels, or any to be embarked at a later date. Tanks should be tested to class standards.

16.7.5 When considering proposals for the transport and transfer of MGO, UN1202 and other oils, in portable tanks or IBCs, the equivalency of MASS design should be satisfactorily addressed in the 'practical' context of MASS operations. This should take account of:

- *Portable tanks or IBCs should meet the requirements of the IMDG Code for the carriage of MGO, UN1202, or oils classified as dangerous goods;*
- *It should be verified that the intended stowage location is designed for the carriage of cargo and that the loads / point loads are within design limits of the deck;*
- *Stability – assessment on the impact on vessels stability should be carried out and free surface effect considered;*
- *"On board" filling of tanks - The filling and transfer arrangements including pipe work, transfer pumps, portable hoses, control of transfer, tank gauging and venting would need to be to the satisfaction of the vessel's Recognised Organisation taking into consideration the following:*

– *Utilisation of Flexible Fuel hoses;*
– *Filling arrangements;*
– *MASS design to include hi-level and remote operator emergency cut-off capability, whilst remote spillage sensing/reporting should be included in the Certified design;*
– *A Save-all is to be provided around the portable tanks and connections*

16.7.6 Satisfactory securing of a portable tank or IBC in its stowage position is to be provided taking into account the forces, directions and accelerations likely to be encountered.

16.7.7 Emergency response and contingency plans to be developed for spills, fire etc.

16.7.8 MASS remote sensing and monitoring should form part of the design risk based assessment of fuelling design and operations.

16.8 Transfer arrangements for receptacles containing less than 200 kg or 200 litres of dangerous goods

16.8.1 Receptacles should be secured within save-all (bunded) structures and any lifting to be carried out should use appropriate purpose-built cages/equipment.

16.9 Dangerous Goods Classes

16.9.1 The title of the dangerous goods classes is given below. For fuller descriptions, the IMDG Code should be consulted.

- *Class 1 Explosives*
- *Class 2 Gases*
- *Class 2.1 Flammable gases*
- *Class 2.2 Non-flammable, non-toxic gases*

- *Class 2.3 Toxic gases*
- *Class 3 Flammable Liquids*
- *Class 4 Flammable solids; substances liable to spontaneous combustion; substances which, in contact with water emit flammable gases*
- *Class 4.1 Flammable solids*
- *Class 4.2 Substances liable to spontaneous combustion*
- *Class 4.3 Substances which, in contact with water, emit flammable gases*
- *Class 5 Oxidising substances and organic peroxides*
- *Class 5.1 Oxidizing substances*
- *Class 5.2 Organic peroxides*
- *Class 6 Toxic and infectious substances*
- *Class 6.1 Toxic substances*
- *Class 6.2 Infectious substances*
- *Class 7 Radioactive material*
- *Class 8 Corrosive Substances*
- *Class 9 Miscellaneous dangerous substances and articles*

17 Rendering of Assistance to Persons in Distress at Sea

17.1 Objective

The objective of this Chapter is to identify applicable obligations on MASS and/or their operating personnel under international law to render assistance to persons in distress at sea and to prescribe the means by which any such duty might be effectively discharged. It should be stressed that this an area of MASS operation which will be the subject of considerable debate in the future. Feedback from operators will be an essential element of this debate.

17.2 Requirements of international law

17.2.1 Article 98 of the United Nations Convention on the Law of the Sea, 1982 (UNCLOS) requires flag States to enact laws to require the master of one of its flagged ships to render assistance to any person(s) found at sea in danger, insofar as it can be done without serious danger to the ship.

17.2.2 In particular, the Master, if informed of persons in distress, must proceed with all possible speed to the rescue of such persons insofar as such action may reasonably be expected of him.

17.2.3 The International Convention for the Safety of Life at Sea, 1974 as amended (SOLAS) prescribes the same obligation to contracting States in Regulation 33 of Chapter V (Navigation), adding that masters who have embarked persons in distress at sea should treat them with humanity, within the capabilities and limitations of the ship.

17.3 Applicability to MASS operations

17.3.1 The international State obligation of rendering assistance is to be practically discharged by the Master of a ship, rather than the ship itself. Therefore, the duty cannot lie with the MASS, but only potentially to persons operating it.

17.3.2 The State obligations will only find application to MASS operators to the extent that both:

- *the MASS is itself a "ship"; and*
- *an individual operator can be regarded as its "master" at the time of becoming aware of an incident.*

17.3.3 A "master" under s.313 of the Merchant Shipping Act 1995 is the individual with "command or charge of a ship". The Master for a MASS is as defined at Chapter 2 of this code.

17.4 MASS Remote controller task requirements

17.4.1 The duty to render assistance will fall to be discharged, if at all, by the MASS Master, potentially delegated to the controller, both as defined at Chapter 2 of this code.

17.4.2 The duty is qualified by what is reasonably to be expected given the limitations and characteristics of the relevant MASS. The duty does not require, nor is it limited to, taking persons on board.

17.4.3 The remote controller of a MASS will not breach the duty for failing to render a particular form of assistance on account of the MASS technical limitations or for the MASSs inability to take persons on board.

17.4.4 The MASS's technical capabilities will define the nature and the requirements of the duty and not vice versa. However, situational cognisance and communications capability may be required by other international regulations, considered elsewhere.

17.4.5 On the assumption that the MASS will have stand off and close up monitoring capability giving continuous feedback to the remote controller, as a minimum:

- *Having become aware of persons in distress, the MASS remote controller should make best endeavours to inform the appropriate search and rescue authorities through whichever means appropriate i.e. radio, camera live feed.*
- *In most circumstances, the MASS remote controller should ensure that the MASS is brought or remains in reasonable proximity with persons found in distress, to act as a visual reference point and communications point for research and rescue authorities.*

17.4.6 Efforts should not be made to embark persons if this cannot be done safely, relative to the peril faced by persons in distress.

18 Salvage and Towage

18.1 Objective

The objective of this Chapter is to cover the Salvage and Towage of a MASS vessel. The vessel in this context is taken as the structure, equipment and systems (including software) which constitute the waterborne elements of the MASS.

18.2 General

18.2.1 As MASS capability becomes more prolific at sea and also as they grow in size and complexity they will be subject to the same risks as their manned counterparts. The outcome of these risks may require the MASS to be subject to either Salvage or Towage. It is assessed that the existing body of law is, in principle, fit for purpose when applied to MASS.

18.3 MASS Salvage

18.3.1 Existing maritime salvage law as it applies to manned ships is deemed to apply to MASS. MASS owners will also make use of the existing standard salvage contracts, such as the Lloyds Open Form (LOF).

18.4 MASS Towage

18.4.1 Existing maritime towage law as it applies to manned ships is deemed to apply to MASS. MASS owners will also make use of the existing standard towage contracts such as the UK Standard Towing Conditions.

18.4.2 MASS owners will ensure that all the requisite documentation for towing their MASS platform is in place and up-to-date; e.g. towing plans.

19 Glossary

AIS	Automatic Identification System
AUV	Autonomous Underwater Vehicle
BCS	Base Control Station
CA	Certifying Authorities
COG	Course over Ground
COLREG	International Regulations for Preventing Collisions at Sea 1972, as amended (IMO)
CSO	Company Security Officer
EMC	Electro-Magnetic Compatibility
FMEA	Failure Mode Effects Analysis
GMDSS	Global Maritime Distress & Safety System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GUI	Graphical User Interface
IACS	International Association of Classification Societies (e.g. Lloyds Register)
IMCA	International Marine Contractors Association
IMO	International Maritime Organisation
ISM	International Safety Management Code (IMO)
ISPS	International Ship & Port Facility Security Code (IMO)
LoC	Level of Control
LoS	Line of Sight
MARPOL	International Convention for the Prevention of Pollution from Ships 1973/78, as amended (IMO)
MASS	Maritime Autonomous Surface Ship
MAS(S)	Maritime Autonomous System (Surface)
MCA	The UK Maritime & Coastguard Agency
MGN	Marine Guidance Note
MIA	Marine Industries Alliance
MNTB	Merchant Navy Training Board
MSN	Merchant Shipping Note
RFOC	Reasonably Foreseeable Operating Conditions
RO	Recognised Organisation
RoT	Rate of Turn
RYA	Royal Yachting Association
SARUMS	Safety and Regulations for European Unmanned Maritime Systems (European Defence Agency project)
SoG	Speed over Ground
SOLAS	Safety of Life at Sea 1974, as amended(IMO)
STW	Speed Through the Water
STCW	Standards of Training, Certification and Watchkeeping for Seafarers 1978, as amended (IMO)
UMS	Unmanned System
UNCLOS	United Nations Convention on the Law of the Sea, 1982
USV	Unmanned Surface Vessel

Notes

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