ShipRight
Design and Construction

Additional Design Procedures

LR Code for Unmanned Marine Systems

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Lloyd's Register

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for a safer world

Document History	
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Chapter 1 General

■ *Section 1*
Aim

1.1 Aim

1.1.1 The Unmanned Marine System (UMS) shall be safe, dependable, capable and resilient in all Reasonably Foreseeable Operating Conditions.

■ *Section 2*
Principles

2.1 Principles

2.1.1 The purpose of this Code is to provide a framework for the assurance of safety and operational requirements for UMS.

2.1.2 The implementation of this Code is dependent upon defining the operational requirements that will determine applicable safety and operational risks.

2.1.3 The Code is goal-based providing a set of Performance Requirements that support design innovation.

2.1.4 Performance Requirements may be met by the application of Class Rules, National / International Codes, National / International Standards, where relevant and justified; and, where relevant Rules, Codes or Standards do not exist, risk-based assessment.

■ *Section 3*
Scope

3.1 Scope

3.1.1 This Code is applicable to autonomous vehicles and remote controlled vehicles operated on or below the surface. It is not applicable to remotely operated underwater vehicles tethered to a mothership.

3.1.2 This Code does not cover the risks resulting from embarked cargo or mission specific equipment.

3.1.3 This Code specifies requirements to support safe operation and maintenance but does not address Operator training and qualification.

3.1.4 If the UMS is periodically manned, or carries dangerous goods or harmful substances, all relevant Codes and Conventions must also be complied with.

■ *Section 4*
Definitions

4.1 General definitions

4.1.1 **Anchoring and mooring equipment.** Fixed and non-fixed devices to hold a UMS in position such as anchors, windlasses, bollards, fairleads, chains and mooring ropes.

4.1.2 **Autonomy Levels (AL) - Adapted from the Lloyd's Register Cyber Enabled Ships – Draft ShipRight Procedure**

AL 0) Manual: No autonomous function. All action and decision-making performed manually (n.b. systems may have level of autonomy, with Human in/ on the loop.), i.e. human controls all actions.

AL 1) On-board Decision Support: All actions taken by human Operator, but decision support tool can present options or otherwise influence the actions chosen. Data is provided by systems on board.

AL 2) On &Off-board Decision Support: All actions taken by human Operator, but decision support tool can present options or otherwise influence the actions chosen. Data may be provided by systems on or off-board.

AL 3) 'Active' Human in the loop: Decisions and actions are performed with human supervision. Data may be provided by systems on or off-board.

AL 4) Human on the loop, Operator/ Supervisory: Decisions and actions are performed autonomously with human supervision. High impact decisions are implemented in a way to give human Operators the opportunity to intercede and over-ride.

AL 5) Fully autonomous: Rarely supervised operation where decisions are entirely made and actioned by the system.

AL 6) Fully autonomous: Unsupervised operation where decisions are entirely made and actioned by the system during the mission.

A higher Autonomous Level (AL) system may use a lower AL system as part of its reversionary control and a complex system may be a combination of multiple systems at different levels.

4.1.3 **Capable**. Having the ability, fitness, or quality necessary to do or achieve the specified objects of the ConOps**.**

4.1.4 **Client.** LR's point of contact with the organisation contracted to undertake work.

4.1.5 **Concept of Operations.** The Concept of Operations (ConOps) is a statement of an Owner's intention for the operation of the UMS. The ConOps describes the UMS intended service in terms of purpose and function and is to include, but not be limited to, information on the following: operational speeds, service area, operating depths, wave heights, maximum and minimum sea and air temperatures and deadweight under reasonably foreseeable, normal and abnormal conditions.

4.1.6 **Dangerous goods.** Those packaged goods referred to in the International Maritime Dangerous Goods IMDG Code.

4.1.7 **Dependable**. A measure of a system's availability, reliability, and its maintainability, and supportability.

4.1.8 **Designer.** Organisation which provides detailed design, drawings and information required for construction.

4.1.9 **Hazards.** Anything that may cause harm.

4.1.10 **Inspection and maintenance.** All measures for the preservation and/or restoration of the original conditions of the technical elements of a system as well as measures for the determination and evaluation of the actual conditions.

4.1.11 **Main electrical power supply.** The main source of electrical power for the UMS.

4.1.12 **Speed.** Speed surfaced: The maximum operational speed of the UMS or surfaced UMS according to the maximum continuous propulsion power surfaced.

Speed submerged: The maximum operational speed of the submerged UMS according to the maximum continuous propulsion power submerged.

4.1.13 **Mission equipment.** Equipment required for the UMS to complete the mission assigned to it. This may be permanently installed or fitted as required for the mission.

4.1.14 **Non-combustible material.** Material which neither burns nor gives off flammable vapours in sufficient quantity for self-ignition when heated to approximately 750°C, this being determined in accordance with the FTP Code or other standard agreed by the Owner and LR.

4.1.15 **Occasionally manned.** At some points, the UMS may be required to have personnel on board whilst in operation. This does not include maintenance if the UMS is not in operation during the maintenance, i.e. secured alongside / ashore / on-deck.

4.1.16 **Operator.** Organisation responsible for operating and maintaining the UMS.

4.1.17 **Owner.** Organisation who own and task the Operator to control the UMS.

4.1.18 **Potential hazards.** Examples may include:

- Flammable atmospheres including dust laden atmospheres;
- Areas that contain electrical and electronic equipment;
- Confined spaces or spaces where oxygen content may be depleted or enriched;
- Gas storage rooms;
- Electric shock;
- Areas of high noise level;
- Areas with equipment that may move unexpectedly;
- Refrigeration spaces;
- Cleaning or chemical stores;
- Areas with radiation hazards.

4.1.19 **Propulsion equipment.** Propulsion machinery includes all the equipment and systems required to generate thrust including but not limited to:

- Prime mover (e.g. diesel engines, gas turbines, electric motors, steam turbines);
- Combined propulsion and manoeuvring devices (e.g. azimuthing thrusters, athwartship thrusters, water-jets);
- Boilers;
- Batteries/energy storage;
- Gearing;
- Propellers (fixed pitch or controllable pitch);
- Shafting and couplings.

4.1.20 **Reasonably Foreseeable Operating Conditions.** Conditions in which the UMS can be reasonably foreseen to operate in an intact, degraded, aged and/or damaged state. They are normally defined in the ConOps.

4.1.21 **Reserve power supply.** Back-up power supply to the main electrical power supply.

4.1.22 **Resilient**. Having the ability to maintain its functions and structure in the face of internal and external changes and to degrade gracefully when it must.

4.1.23 **Stability information.** Documents required for stability certification.

4.1.24 **Structure**. All items of the UMS hull that contribute to its ability to withstand global and local loads, maintain watertight and weathertight integrity, support all equipment or other applied loads.

4.1.25 **Standard.** A set of appropriate requirements and/or criteria that are to be agreed by the Owner prior to the plan appraisal stage.

4.1.26 **System**. A combination of interacting elements (sub-systems, equipment, components, hardware, software), organised to achieve one or more of the functions stated in the Concept of Operations.

4.1.27 **Unmanned Marine System (UMS).** A surface or submersible system that can be operated without personnel on board.

4.1.28 **Watertight.** Prevent the passage of water in either direction with a head of water commensurate with the submergence limit in all Reasonably Foreseeable Operating Conditions.

4.1.29 **Weathertight.** Prevent the passage of water into the UMS in all Reasonably Foreseeable Operating Conditions.

■ *Section 5*
Structure of the Code

5.1 General layout

5.1.1 The Code is arranged in Functional Chapters, each containing requirements to realise the Chapter goals; which combine to realise the overall aim of the Code for UMS. Requirements only need to be applied where that system or feature is present.

5.1.2 The goal-based structure of the Code has a hierarchy of tiers as shown in *Figure 1.5.1 Goal-based Approach to Developing the Code* and detailed below. The increasing width of the triangle for lower tiers indicates an increasing level of detail.

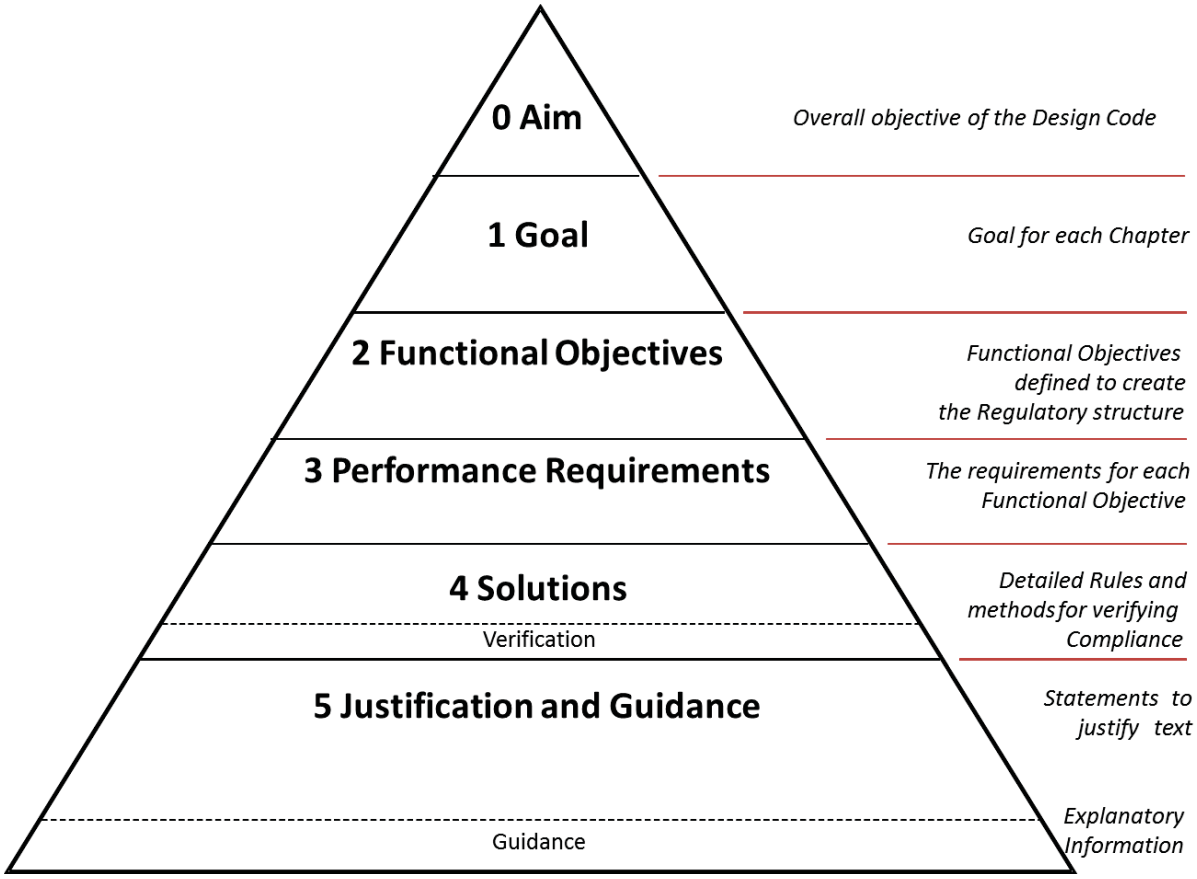

Figure 1.5.1: Goal-based Approach to Developing the Code

5.1.3 Tier 0 is the overall Aim of the Code, *see Ch 1, 1.1 Aim 1.1.1*.

5.1.4 Tier 1 defines high level Goals for the design of the UMS for the subject area covered by each Chapter in order to meet the Tier 0 Aim.

5.1.5 Tier 2 Functional Objectives define the regulatory structure by which the Tier 3 Performance Requirements are grouped in order to meet the Tier 1 Goals.

5.1.6 Tier 3 Performance Requirements provide the criteria to be satisfied in order to meet the Tier 2 Functional Objectives and Tier 1 Goals and are qualitative to allow them to be met by a range of solutions.

5.1.7 Tier 4 Solutions are used to demonstrate that the Tier 3 Performance Requirements are met by the design. Tier 4 Solutions may come from classification Rules and Regulations, recognised National or International Standards or risk-based analysis.

5.1.8 Tier 4 Solutions will be specific to the UMS operational requirements and design solutions and are not defined in this Code, *see also Ch 1, 6. Verification.*

5.1.9 Tier 5 Justification and Guidance provides information regarding origin of requirements, guidance and their application. These are not currently contained in this Code.

■ *Section 6* **Verification**

6.1 General

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

6.1.2 A Verification Plan shall be submitted for acceptance at the commencement of the project that describes the method by which the Tier 3 Performance Requirements will be met, including the details and justification of the Tier 4 Solutions, the method of assessment of these and the means of demonstrating conformance.

6.1.3 The verification method will be determined by the relevant Level of Integrity for each system, *see Ch 1, 9 Level of Integrity*, with reference to the table given in *Annex B Verification Methods*. Relevant verification methods will include design review, independent calculation, equipment and materials certification, audit, inspection, survey, testing and trials.

6.1.4 A design verification shall be undertaken to justify Tier 4 solutions against the performance requirements of this code and to verify that the design complies with the solutions chosen. The following information will be required to support design verification activities.

(a) A ConOps and definition of required Autonomy and Integrity Levels (*see Ch 1, 8 Concept of Operations* and *Ch 1, 9 Level of Integrity*);

(b) Constructional plans and particulars relevant to the hull, equipment and machinery;

(c) Design calculation and documentation;

(d) Certification of software, materials, equipment and components;

(e) Details of software integrity testing and cyber-security audits;

(f) Maintenance Philosphy & Survey Plan.

6.1.5 Construction surveys shall be conducted at a periodicity and scope, appropriate to the design and build, and may include:

(a) 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;

(b) Survey of the material state during build to confirm compliance with the appraised design;

(c) Witness of tests and trials to demonstrate functionality.

6.1.6 Where required through life survey activities shall be conducted at an agreed periodicity appropriate to the design, construction, material state and operation of the UMS.

6.1.7 On completion a Certificate shall be issued confirming compliance with the Code which shall remain valid subject to continued compliance with the Code and maintenance of through-life survey requirements.

■ *Section 7*
Materials

7.1 General

7.1.1 Materials shall be manufactured and verified in accordance with recognised standards and procedures appropriate for their application and the Level of Integrity required of the system.

7.1.2 There shall be a system to identify, record, and control hazardous materials and to restrict or mitigate known hazards.

7.1.3 Materials which are banned or restricted by national or international legislation due to their known hazards to human health or the environment shall not be used.

7.1.4 The risks posed by hazardous materials shall be communicated to those carrying out repair and routine maintenance.

■ *Section 8*
Concept of Operations

8.1 General

8.1.1 The Owner shall define and record the manner in which the UMS shall be designed, operated and maintained in a Concept of Operations (ConOps) including but not limited to the following information as applicable:

(a) Primary and secondary functions;
(b) UMS mass;
(c) Means of propulsion;
(d) Means of buoyancy control;
(e) Means of navigation and collision avoidance;
(f) Means of power generation;
(g) Means of power storage;
(h) Maximum UMS speed, *see* 4.1.10;
(i) Maximum operational sea state;
(j) Maximum operational depth;
(k) Maximum endurance;
(l) Level of autonomy;
(m) Reversionary modes of operation (including recovery);
(n) Means of monitoring health of on-board systems;
(o) Methods of communications/remote operation;
(p) Means of determining position;
(q) Details of modularisations/configurations;
(r) Means of lifting, launch, recovery and transport;
(s) Launch and recovery environmental limitations; and
(t) Environmental limitations (e.g. sea state, water quality, water temperature, air temperature).

8.1.2 LR may accept alternative documents where these provide the information that would be included within the ConOps. In such cases, the relevant sections providing the information required to provide equivalence with the ConOps are to be identified.

8.1.3 A template for a ConOps is provided at *Annex A Concept of Operations* to this Code.

■ *Section 9*
Level of integrity

9.1 General

9.1.1 The required level of integrity shall be determined for each UMS system. The level of integrity is to be determined by assessing the effect on the UMS, considered as a system of systems, of all reasonably foreseeable system failures and by considering their consequence on the ability of the UMS to achieve the Aim of the Code.

9.1.2 Consequences of reasonably foreseeable system failures on the achievement of the Aim shall be categorised as:

(a) System Safety Consequences;
- To people onboard
- To people/objects in the vicinity
- To the environment

(b) System Operational Consequences;
- To capability
- To resilience

9.1.3 The levels of integrity associated with the system operational consequences shall be determined with reference to the Concept of Operations and the design requirements for the UMS and shall be acceptable to Lloyd's Register.

9.1.4 For each system this shall result in a set of Safety Levels of Integrity (SLoI) and Operational Levels of Integrity (OLoI) which shall be categorised as:

(a) High; a LOI for which the consequence of system failure on the achievement of the aim is not acceptable
(b) Medium; a LOI for which the consequence of system failure on the achievement of the aim is acceptable subject to the presence of mitigating factors; or
(c) Low; a LOI for which the consequence of system failure on the achievement of the aim is acceptable

9.1.5 The highest Level of Integrity for each system shall then be used to define the verification requirements for that system.

9.1.6 The verification activities shall be undertaken according to the Level of Integrity established for each system as defined in *Ch 1, 6.1 General 6.1.3*.

9.1.7 Where it is not possible for a designed system to achieve the required Level of Integrity, or as an alternative to the above method for the determination of Level of Integrity, a full hazard analysis shall be carried out using established techniques acceptable to Lloyd's Register.

Chapter 2 Structure

■ *Section 1*
Scope

1.1 Scope

1.1.1 This Chapter covers all structure required to enable the UMS to operate in all Reasonably Foreseeable Operating Conditions and carry all defined operational global and local loads resulting from its operating environment, installed systems and loads from mission equipment. It includes any appendages or supporting structure required to carry out its operational role.

■ *Section 2*
Goal

2.1 Goal

2.1.1 The structure shall be designed, constructed and maintained with a level of integrity sufficient to enable the UMS to be operated and maintained safely as and when required within its design or imposed limitations in all Reasonably Foreseeable Operating Conditions.

■ *Section 3*
Functional objectives

3.1 Functional objectives

3.1.1 For the defined operational life of the UMS, the structure shall be designed and constructed to:

(a) Enable the UMS to operate in all Reasonably Foreseeable Operating Conditions;

(b) Carry and respond to all foreseen loads in a predictable manner with a level of integrity commensurate with operational and safety requirements;

(c) Meet requirements for watertight, weathertight and fire integrity;

(d) Enable the maintenance and repair in accordance with the maintenance philosophy.

3.1.2 Additional systems or equipment not directly covered by this Chapter, shall not affect the structural integrity.

3.1.3 Operators shall be provided with adequate access, information and instructions for the safe operation of the UMS and maintenance of the structure.

■ *Section 4*
Performance requirements

4.1 General

4.1.1 The UMS shall be designed to operate in all Reasonably Foreseeable Operating Conditions and carry all defined operational loads with a design margin appropriate to the required level of integrity, established by the process in *Ch 1 General*.

4.1.2 Consideration shall be given to the probability of the occurrence of a load and combination of loads occurring outside of the reasonably foreseeable operating conditions during the stated design life.

4.1.3 As a minimum, consideration should be given to the following demands:

(a) Above water: Wind, air temperatures (high and low), ice accretion, solar radiation;

(b) Sea surface: Waves, green seas, ice navigation, ship motions (including slamming);

(c) Below water: Hydrostatic.

4.1.4 The structure shall be designed to carry any defined local and global loads; consideration shall be given to the static and dynamic loads from:

(a) Cradling/docking, launch and recovery, securing or transport;

(b) Permanent weights, solid ballast;

(c) Cargo, fuel and ballast;

(d) Stores and equipment;

(e) Machinery equipment.

4.1.5 Where applicable, the structure shall be capable of withstanding any local and global loads imposed on it when it is suspended from lifting points. This shall include any accelerations or impact loads that may be imposed when lifting is undertaken.

4.1.6 Where applicable, the structure shall be designed to withstand the following loads:

(a) Anchoring, mooring and towing, beaching and grounding;

(b) Loads imposed by mission equipment.

4.1.7 The structure shall be designed considering the following:

(a) Ruggedness;

(b) Structural continuity;

(c) Environmental degradation: corrosion, erosion.

4.1.8 Consideration shall be given to the use or protection of materials that have reduced properties under any of the Reasonably Foreseeable Operating Conditions including:

(a) Maximum and minimum operating temperatures;

(b) Fire;

(c) U.V exposure;

4.1.9 Coatings for the protection of structure shall be properly selected and applied to protect the structure throughout the target-useful-life of the coating.

4.1.10 Where stability calculations are carried out in accordance with *Ch 3 Stability*, including damage conditions, the internal structure, which is required to maintain watertight integrity, shall be designed to withstand the damage load.

4.1.11 The structure shall be designed to provide foundations for the attachment of fittings and equipment including masts, propulsion systems and mission systems. Consideration shall be given to any rigidity requirements for sensors and communication equipment.

4.1.12 The structural arrangement shall enable safe access for the purpose of maintaining the structure and fitted equipment and systems.

4.1.13 Information and instructions shall be supplied to the Operator to ensure the safe operation under all Foreseeable Operating Conditions.

4.1.14 Information and instructions shall be available to enable the safe repair and maintenance of the UMS.

Chapter 3 Stability

■ *Section 1*
Scope

1.1 Scope

1.1.1 This Chapter covers the provision of buoyancy, stability, and watertight and weathertight integrity required to enable the UMS to operate in all Foreseeable Operating Conditions.

■ *Section 2*
Goal

2.1 Goal

2.1.1 The buoyancy, stability, watertight and weathertight integrity shall be sufficient to enable the UMS to be operated and maintained safely as and when required within its design or imposed limitations in all Reasonably Foreseeable Operating Conditions.

■ *Section 3*
Functional objectives

3.1 Functional objectives

3.1.1 The UMS shall be designed and constructed to:

(a) Provide an adequate reserve of buoyancy in all Reasonably Foreseeable Operating Conditions, in the environment in which it is to be operated;

(b) Provide adequate stability to avoid capsizing in all Reasonably Foreseeable Operating Conditions, in the environment in which it is to be operated;

(c) Prevent unintended ingress of water;

(d) Enable the maintenance and repair in accordance with the maintenance philosophy.

■ *Section 4*
Performance requirements

4.1 General

4.1.1 Watertight boundaries shall be provided, where required, to prevent ingress of water from hydrostatic loads for all Reasonably Foreseeable Operating Conditions.

4.1.2 Weathertight boundaries shall be provided, where required, to prevent ingress of water from spray and rain for all Reasonably Foreseeable Operating Conditions.

4.1.3 Where required, reserve buoyancy of the UMS in a damaged state shall be provided by sub-division or an equivalent method.

4.1.4 Penetrations in watertight boundaries, including those required to maintain residual buoyancy in the damaged state, shall have fittings designed to prevent the ingress of water for all Reasonably Foreseeable Operating Conditions.

4.1.5 Penetrations in weathertight boundaries shall have weathertight fittings.

4.1.6 The UMS shall, in any Reasonably Foreseeable Operating Conditions:

(a) Adequately resist roll, heel or list to meet the requirements of all control, electrical, propulsion and manoeuvring and mission systems;

(b) Return to upright from a roll, heel or list caused by a disturbance subsequent to the removal of the disturbance.

4.1.7 The UMS shall have a margin of buoyancy and stability appropriate for all Reasonably Foreseeable Operating Conditions to meet the required level of integrity established by the process in *Ch 1 General*.

4.1.8 Means shall be provided to determine displacement, heel and trim.

4.1.9 A displacement check, swamp test and inclining or simplified stability assessment shall be conducted as appropriate at the completion of construction to validate the design assumptions.

4.1.10 The seakeeping velocities and accelerations of the hull for all Reasonably Foreseeable Operating Conditions shall consider the requirements of all control, electrical, propulsion and manoeuvring and mission systems. Where seakeeping is dependent upon a stabilising system, it shall meet the required level of integrity.

4.1.11 Consideration shall be given to the removal of any water that may accumulate in the UMS to maintain a margin of buoyancy and stability.

4.1.12 All materials shall comply with the requirements defined in *Ch 1, 7 Materials*.

4.1.13 The subdivision and arrangement of watertight and weathertight fittings shall enable safe access for the purpose of maintenance.

4.1.14 Information and instructions shall be supplied to the Operator to ensure the safe operation under all Reasonably Foreseeable Operating Conditions.

Chapter 4 Control System

■ *Section 1*
Scope

1.1 Scope

1.1.1 This Chapter covers all equipment and components related to the control system and the hazards that these create. The control system includes any systems on board the UMS and any off-board facility that performs a monitoring and/or control function of propulsion, manoeuvring and navigation systems and the transmission of data to carry out these functions. It does not include monitoring and/or control of auxiliary and mission systems.

■ *Section 2*
Goal

2.1 Goal

2.1.1 The control system shall be designed with a level of integrity sufficient to enable the UMS to be operated and maintained safely as and when required within its design or imposed limitations in all Reasonably Foreseeable Operating Conditions.

■ *Section 3*
Functional objectives

3.1 Functional objectives

3.1.1 The UMS shall be able to monitor and control all systems required for propulsion, manoeuvring and navigation.

3.1.2 The control system shall be designed and constructed to:

(a) Enable its operation in all Reasonably Foreseeable Operating Conditions;

(b) Operate in a predictable manner with a level of integrity commensurate with operational and safety requirements;

(c) Meet requirements for watertight, weathertight and fire integrity;

(d) Minimise the risk of initiating fire and explosion;

(e) Enable maintenance and repair in accordance with the maintenance philosophy.

3.1.3 Additional systems or equipment not directly covered by this Chapter, shall not affect the control system.

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

■ *Section 4*
Performance requirements

4.1 General

4.1.1 The control system shall be designed and arranged to meet the required level of integrity established by the process in *Ch 1 General*, considering the Autonomy Level, equipment failure rates and the effects of flood or fire.

4.1.2 The UMS shall be fitted with sensors, systems and equipment to provide feedback to the Operator or autonomous control system of the operating state and potential hazards. The feedback should be appropriate for the Autonomy Level, and operating state and environment of the UMS.

4.1.3 Ambient conditions shall be controlled, where required, to suit the operating environment and the control system requirements.

4.1.4 All aspects (on-board and off-board) of the Control System shall be designed with consideration of the human-system interface.

4.1.5 The control system shall record the sensor output for all sensors on which the control system is dependent and all propulsion and manoeuvring system activities at appropriate intervals over the duration of the mission. This data shall be protected from loss or damage and readily recoverable in all Reasonably Foreseeable Operating Conditions.

4.1.6 The control system is to respond in a timely, accurate and predictable manner commensurate with the equipment limitations and manoeuvring capability of the UMS.

4.1.7 The control system shall ensure that any serious malfunctions of UMS systems providing manoeuvring, control, alarm or safety functions shall automatically initiate corrective actions via a high integrity system to put the UMS into a safe state to minimise the risk to people, environments or assets.

4.1.8 The energy source for the control system shall also meet the required level of integrity as for the control system.

4.1.9 An audible and visual alert shall be provided to the Operator in the event of failure of the energy source.

4.1.10 The control system shall recover automatically in a safe manner after restoration of the energy source.

4.1.11 An emergency manual control enacted through a high integrity independent system is to be provided in a prominent position on all primary and secondary Operator consoles to activate a safe state.

4.1.12 An alert system shall be provided to inform Operators as soon as reasonably practicable of deviations from normal or expected operation of UMS systems.

4.1.13 Alerts for systems providing manoeuvring, control, alarm or safety functions shall be presented with priority over other information in every operating mode of the system and shall be clearly distinguishable from other information.

4.1.14 The production of software shall be managed so that the safety risks arising from the software production are reduced to an acceptable level commensurate with the required level of integrity.

4.1.15 The level of resilience of the control system to Operator programming errors, hardware faults, incorrect sensor inputs, security of communications and security of data is to be defined and justified.

4.1.16 A failure or unspecified behaviour of the software shall not result in:

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

4.1.17 The control system shall be protected against:

- unauthorised access;
- unintended change.

4.1.18 A management of change process shall be applied to safeguard against unexpected consequences of modifications or changes to settings.

4.1.19 Programs and data held in the system shall be protected from corruption due to loss of power.

4.1.20 The control system shall not be affected by any reasonably foreseeable EMC interference and shall not cause interference to other systems.

4.1.21 Any penetrations in boundaries required for the control system shall be designed to meet the watertight, weathertight and fire integrity requirements for that boundary as applicable.

4.1.22 Where applicable, protection arrangements from the ingress of solids, dusts, liquids and gases shall be provided for control equipment and distribution systems.

4.1.23 Where alternative control locations are available:

- It shall only be possible to control UMS from one control station at any one time;
- Clear indication showing the location of the control shall be provided;
- Changeover of control stations or systems shall be indicated at all appropriate stations;

- Automatic changeover shall initiate alert at all appropriate stations;
- Transfer between control stations without altering the control set points shall be provided;
- Integrity of alternative control locations shall be commensurate with the required level of integrity.

4.1.24 Operators shall be provided with adequate information and instructions for the safe and effective control of the UMS. These shall be presented in a language and format that can be understood by the Operator in the context in which it is required.

4.1.25 It shall be possible to disable and isolate the control system to allow inspection and maintenance tasks to be safely performed on the UMS.

4.1.26 System diagrams and instructions shall be provided for maintenance of the control system in a language and format that can be understood.

4.2 Remotely controlled control system

4.2.1 The control panel shall be designed using human factors methodology. The controls are to be easily identifiable and are to be arranged in a logical way to reflect their function, means of operation and hierarchy of importance.

4.2.2 The Operator is to be alerted if the UMS is approaching operating range limit. If the UMS exceeds the operating range limit, it shall automatically return into a safe state alerting the Operator.

4.3 Autonomous control system

4.3.1 The autonomous control system shall carry out the programmed mission in an accurate and timely manner with an appropriate level of integrity.

4.3.2 The autonomous control system shall react to changes in its environment including other vessels and moving objects.

4.3.3 It shall be possible within a timeframe appropriate for the operational profile of the UMS to override the autonomous control system to initiate a corrective action or activate a safe state.

4.3.4 The UMS shall fail to a safe state in the event of deviation from normal operation and initiate a system to facilitate location and recovery.

4.3.5 The link between the autonomous control system and the Operator is to be as far as reasonably practicable maintained at all times.

Chapter 5 Electrical Systems

■ *Section 1*
Scope

1.1 Scope

1.1.1 This Chapter covers all equipment and components relating to the electrical system and the hazards that these create. This includes all generation, storage and distribution, including the supply of power to portable and mission specific equipment. It does not include any electrical systems within portable and mission specific equipment. It includes the supply of power to on-board and off-board control systems but does not include the control system itself, which is covered in *Ch 4 Control Systems*.

■ *Section 2*
Goal

2.1 Goal

2.1.1 The electrical system shall be designed with a level of integrity sufficient to enable the UMS to be operated and maintained safely as and when required within its design or imposed limitations in all Reasonably Foreseeable Operating Conditions.

■ *Section 3*
Functional objectives

3.1 Functional objectives

3.1.1 The electrical system shall be designed and constructed to:

(a) Operate in all Reasonably Foreseeable Operating Conditions;

(b) Operate in a predictable manner with a level of integrity commensurate with operational and safety requirements;

(c) Meet requirements for watertight, weathertight and fire integrity;

(d) Minimise the risk of initiating fire and explosion;

(e) Enable the maintenance and repair in accordance with the maintenance philosophy.

3.1.2 Additional systems or equipment not directly covered by this Chapter, shall not affect the electrical system.

3.1.3 Operators shall be provided with adequate access, information and instructions for the safe operation and maintenance of all electrical systems.

■ *Section 4*
Performance requirements

4.1 General

4.1.1 The electrical system shall be designed and arranged to meet the required level of integrity, considering equipment failure rates and the effect of flood or fire.

4.1.2 Sufficient power shall be provided to supply all UMS consumers with an appropriate margin and level of redundancy corresponding to the required level of integrity established by the process in *Ch 1 General* .

4.1.3 Ambient conditions shall be controlled, where required, to suit the operating environment and the electrical system requirements.

4.1.4 The Quality of Power Supply (QPS) shall be maintained at the level required by all UMS consumers taking account of all Reasonably Foreseeable Operating Conditions.

4.1.5 Where a reserve power supply is required in the event of failure or loss of the main electrical supply to achieve the required level of integrity, the following shall be considered:

(a) Size of demand;

(b) Speed of transition;

(c) Duration of demand;

(d) Integrity of reserve power supply;

(e) Location and routing of reserve power supply.

4.1.6 Electrical equipment shall be designed for the maximum load for all Reasonably Foreseeable Operating Conditions.

4.1.7 Where applicable, facilities to connect safely to an external electrical power supply shall be provided.

4.1.8 The design of distribution system shall be suitable for the functional requirements of the UMS and portable and mission specific equipment for all Reasonably Foreseeable Operating Conditions.

4.1.9 The design and configuration of the distribution system, including earthing arrangements as necessary, shall minimise the risk to Operators, maintainers and equipment under all Reasonably Foreseeable Operating Conditions.

4.1.10 The electrical system shall not be affected by any EMC interference and shall not cause interference to other systems within the UMS and external to it for all Reasonably Foreseeable Operating Conditions.

4.1.11 Any penetrations in watertight and weathertight boundaries due to the electrical system shall be designed in accordance with the requirements of *Ch 3 Stability*.

4.1.12 Suitable protection arrangements shall be provided for the use of portable and mission specific equipment.

4.1.13 Portable and mission specific equipment shall not have a detrimental effect upon the electrical distribution system.

4.1.14 Exposed metal parts of electrical machines or equipment which are not intended to be live but which are liable under fault conditions to become live shall be earthed.

4.1.15 A means to detect and alert in the case of insulation breakdown with respect to earth within equipment and distribution systems shall be provided.

4.1.16 Equipment is to be designed and installed to minimise the effects of arc flash.

4.1.17 Where applicable, protection arrangements from the ingress of solids, dusts, liquids and gases shall be provided for electrical equipment and distribution systems.

4.1.18 Protection shall be provided against damage to UMS systems from excess current.

4.1.19 Suitable arrangements for the protection of mechanically connected equipment due to the effects of electrical overloads shall be provided.

4.1.20 Suitable arrangements for the protection of electrical equipment due to the effects of mechanical overloads shall be provided.

4.1.21 Electrical equipment and distribution systems shall be suitably protected from mechanical damage.

4.1.22 Suitable security arrangements to prevent unauthorised access to live electrical connections and electrical systems shall be provided.

4.1.23 Suitable protection arrangements for lightning strikes shall be provided.

4.1.24 Suitable arrangements shall be provided to minimise the effects of radiation hazards to personnel on other vessels, Operators and maintainers.

4.1.25 The categorisation of hazardous areas with potentially flammable atmospheres shall be in accordance with a national or international standard.

4.1.26 Where machinery or electrical equipment is required to be fitted in a space with a potentially flammable atmosphere:

(a) it shall be of a type suitable for the environment for which it will be operated;

(b) a means shall be provided to detect and alert the Operator of any abnormal parameters which may lead to ignition of the atmosphere.

4.1.27 The integrity of the boundary of the hazardous area shall not compromise the safety of the adjacent space.

4.1.28 Suitable arrangements for the safe installation, use and maintenance of energy storage devices shall be provided.

4.1.29 Ageing effects on the performance of energy storage devices shall be considered over the lifetime of the UMS.

4.1.30 Where necessary the launch, recovery and stowage system shall ensure the equipotential bond between the UMS and cradle or recovery device.

4.1.31 Electrical power generation required for propulsion and manoeuvring systems are to meet the requirements of *Ch 7 Propulsion and Manoeuvring*.

4.1.32 System diagrams and instructions shall be provided for maintenance of the electrical system in a language and format that can be understood.

4.1.33 To allow inspections and maintenance tasks to be safely performed the following shall be provided:

(a) Suitable arrangements for the isolation and switching of distribution circuits;

(b) Protection from the risk of static electricity;

(c) Indication of the nature of the potential hazards at the entrance(s) to the space, and on the equipment where applicable.

Chapter 6 Navigation Systems

■ *Section 1*
Scope

1.1 Scope

1.1.1 This Chapter covers the systems required for safe navigation of the UMS. This includes systems on board and off-board for the identification and avoidance of navigational hazards and the communication between these, and systems for communication with other vessels to relay intentions. It does not include control of the navigation system itself or the control of systems to carry out avoidance of navigational hazards, which are covered in *Ch 4 Control Systems*.

■ *Section 2*
Goal

2.1 Goal

2.1.1 The navigation system shall be designed with a level of integrity sufficient to enable the UMS to be operated and maintained safely as and when required within its design or imposed limitations in all Reasonably Foreseeable Operating Conditions.

■ *Section 3*
Functional objectives

3.1 Functional objectives

3.1.1 Navigational systems shall identify all navigation hazards, fixed or mobile, and measure and interpret environmental data.

3.1.2 The UMS shall be able to navigate to minimise risk of grounding, collision and environmental impact.

3.1.3 The UMS shall be able to communicate its limitations and navigational intentions to other vessels.

3.1.3 The navigational systems shall be designed and constructed to:

(a) Enable their operation in all Reasonably Foreseeable Operating Conditions;

(b) Operate in a predictable manner with a level of integrity commensurate with operational and safety requirements;

(c) Meet requirements for watertight, weathertight and fire integrity;

(d) Minimise the risk of initiating fire and explosion;

(e) Enable the maintenance and repair in accordance with the maintenance philosophy.

3.1.4 Additional systems or equipment not directly covered by this Chapter, shall not affect the navigation systems.

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

■ *Section 4*
Performance requirements

4.1 General

4.1.1 The navigation system shall be designed and arranged to meet the required level of integrity established by the process in *Ch 1 General*, considering the Autonomy Level, equipment type, function and the effect of flood or fire.

4.1.2 The UMS shall be provided with sufficient sensors and systems to determine, display and record its present time, position, orientation and movement in relation to the earth and the rate of change of the parameters measured at an appropriate interval and accuracy to ensure safe navigation to its required level of integrity.

4.1.3 Ambient conditions shall be controlled, where required, to suit the operating environment and the navigation system requirements.

4.1.4 The UMS shall be provided with appropriate sensors and processing equipment to adequately measure, analyse, assess, display and record fixed and mobile hazards in its physical environment for the conduct of safe navigation.

4.1.5 The UMS shall have a means to measure its depth (where applicable), direction and speed in accordance with *Ch 4 Control Systems*.

4.1.6 The UMS shall have a means to display its manoeuvring limitations.

4.1.7 The UMS shall have a means to control its illuminated appearance.

4.1.8 The UMS shall have a means to communicate with other vessels.

4.1.9 The UMS shall have a means to alert other vessels that it is in distress.

4.1.10 The UMS shall be fitted with systems in order to receive, transmit, record and analyse navigation data, in recognised formats, relevant to safe navigation, for the duration of the mission. These systems shall be protected against unauthorised access.

4.1.11 Surfaced UMS shall be able to exhibit, by day and night, in all weathers, appropriate lights and shapes in order to indicate size, orientation, activity and limitations so as to facilitate the determination of risk of collision by other mariners. The Operator is to be aware of the conditions in which the UMS is operating and which lights and shapes are being displayed at any time.

4.1.12 Surfaced UMS shall be able to generate, by day and night, in all weathers, sound signals, in order to indicate its orientation, activity and limitations to facilitate the determination of risk of collision by other mariners. The Operator is to be aware of the conditions in which the UMS is operating and which sound signals are being broadcast at any time.

4.1.13 The UMS, by day and night, in all weathers, shall be able to detect the presence of nearby vessels, monitor their speed and direction and take measures as required to avoid a collision.

4.1.14 The UMS shall always have sufficient power and a means of manoeuvring available to ensure proper control in accordance with *Cha 7 Propulsion and Manoeuvring*.

4.1.15 Any penetrations in watertight and weathertight boundaries due to the navigation systems shall be designed in accordance with the requirements of *Ch 3 Stability*.

4.1.16 Equipment necessary for the safety of navigation shall be capable of being safely accessed for the purpose of repair and routine maintenance.

4.1.17 Operators shall be provided with adequate information and instructions for the safe and effective navigation of the UMS. These shall be presented in a language and format that can be understood by the Operator in the context in which it is required.

4.1.18 It shall be possible to disable and isolate the Navigation system to allow inspection and maintenance tasks to be safely performed on the UMS.

4.1.19 System diagrams and instructions shall be provided for maintenance of the Navigation system in a language and format that can be understood.

Chapter 7 Propulsion and Manoeuvring

■ *Section 1*
Scope

1.1 Scope

1.1.1 This Chapter covers all equipment and components relating to the propulsion and manoeuvring system and the hazards that these create. This does not include control of the propulsion and manoeuvring system, which is covered in *Ch 4 Control Systems*, and does not include auxiliary systems, which are covered in *Ch 9 Auxiliary Systems*.

■ *Section 2*
Goal

2.1 Goal

2.1.1 The propulsion and manoeuvring systems shall be designed with a level of integrity sufficient to enable the UMS to be operated and maintained safely as and when required within its design or imposed limitations in all Reasonably Foreseeable Operating Conditions.

■ *Section 3*
Functional objectives

3.1 Functional objectives

3.1.1 The propulsion and manoeuvring system shall be sufficient to enable effective control.

3.1.2 The propulsion and manoeuvring systems shall be designed and constructed to:

(a) Enable their operation in all Reasonably Foreseeable Operating Conditions;

(b) Operate in a predictable manner with a level of integrity commensurate with operational and safety requirements;

(c) Meet requirements for watertight, weathertight and fire integrity;

(d) Minimise the risk of initiating fire and explosion;

(e) Enable the maintenance and repair in accordance with the maintenance philosophy.

3.1.3 Additional systems or equipment not directly covered by this Chapter, shall not affect the propulsion and manoeuvring systems.

■ *Section 4*
Performance requirements

4.1 General

4.1.1 The propulsion and manoeuvring system shall be designed and arranged to meet the required level of integrity established by the process in *Ch 1 General*, considering equipment failure rates and the effect of flood or fire.

4.1.2 For all propulsion and manoeuvring systems installed, the choice of materials and components of construction as well as the design, location and installation shall be made according to the environmental, maintenance and operating conditions in order to ensure the continued function of the equipment during all Reasonably Foreseeable Operating Conditions.

4.1.3 Ambient conditions shall be controlled, where required, to suit the operating environment and the propulsion and manoeuvring system requirements.

4.1.4 The propulsion system shall be designed to meet the required operating speed in all Reasonably Foreseeable Operating Conditions.

4.1.5 The manoeuvring system shall be designed to meet the required manoeuvring requirements in all Reasonably Foreseeable Operating Conditions.

4.1.6 The supply of energy source shall be sufficient to meet operational requirements with adequate reserve.

4.1.7 The energy source for the propulsion and manoeuvring system shall also meet the required level of integrity.

4.1.8 Any penetrations in watertight and weathertight boundaries due to propulsion and manoeuvring systems shall be designed in accordance with the requirements of *Ch 3 Stability*.

4.1.9 Pressure vessels and associated piping systems and fittings shall be of a design and construction adequate to safely contain media and safely release pressure. This is to take account of the anticipated internal and external pressure and temperature profiles and the service for which they are intended.

4.1.10 The propulsion and manoeuvring system shall be designed to minimise the risk of initiating a fire, including consideration of the following:

(a) Surface temperatures of systems shall not become a source of ignition in case of flammable fluid leaks;

(b) Failure of a joining arrangement shall not pose a further risk (e.g. due to atomisation of hydrocarbons, leakage of water onto electrical equipment etc.);

(c) Suitable arrangements to prevent the ignition of vapours in a tank shall be provided.

4.1.11 Suitable precautions against the build-up of electrostatic charges shall be provided.

4.1.12 The propulsion and manoeuvring system shall be designed such that it will not unduly affect any other system including under failure conditions.

4.1.13 The propulsion and manoeuvring system shall be protected against damage by fire in accordance with *Ch 8 Fire*.

4.1.14 Safe access shall be provided to the propulsion and manoeuvring system including means of isolation and access provision in the event of equipment failure or for maintenance.

4.1.15 Information and instructions shall be supplied to the Operator to ensure the safe operation, fault finding and maintenance of machinery, under all Reasonably Foreseeable Operating Conditions.

Chapter 8 Fire

■ *Section 1*
Scope

1.1 Scope

1.1.1 This Chapter covers all structure, equipment and components relating to fire safety and the hazards that these create and minimising the risk of ignition. This includes all automated and remotely operated fixed systems and does not include any portable or other fire-extinguishing equipment provided for use by personnel on board.

■ *Section 2*
Goal

2.1 Goal

2.1.1 The fire safety systems shall be designed to detect and extinguish a fire with a level of integrity sufficient to enable the UMS to be operated and maintained safely and to protect the UMS in all Reasonably Foreseeable Operating Conditions.

■ *Section 3*
Functional objectives

3.1 Functional objectives

3.1.1 The UMS shall be designed and constructed to minimise the risk of initiating a fire.

3.1.2 The UMS shall be designed and constructed to detect, contain and extinguish a fire.

3.1.3 Fire safety systems shall be designed to:

(a) Enable their operation in all Foreseeable Operating Conditions;

(b) Operate in a predictable manner with a level of integrity commensurate with operational and safety requirements;

(c) Meet requirements for watertight, weathertight and fire integrity;

(d) Enable maintenance and repair in accordance with the maintenance philosophy.

■ *Section 4*
Performance requirements

4.1 Risk of ignition and growth

4.1.1 Means shall be provided to control leaks of flammable liquids.

4.1.2 Means shall be provided to limit the accumulation of flammable gases, vapours and dust.

4.1.3 The use of combustible materials shall be minimised and consideration shall be given to selecting materials with lower ignitability.

4.1.4 Ignition sources shall be minimised.

4.1.5 Ignition sources shall be separated from combustible materials and flammable liquids.

4.1.6 Storage of flammable liquids and gasses shall be appropriately located and restricted to the minimum.

4.1.7 A margin is to be maintained between the foreseeable maximum ambient temperature of a space, and the minimum flashpoint of flammable liquids contained within the space.

4.1.8 Means shall be provided for the control of air supply and flammable liquids to a space or group of spaces.

4.1.9 Pressure systems for flammable liquids and gasses shall be designed to minimise any potential effects caused by fire.

4.2 Detection and alerts

4.2.1 The fire detection system shall meet the required level of integrity established by the process in *Ch 1 General*.

4.2.2 An effective means of detecting and locating fires and alerting the Operator is to be provided. This shall be designed in accordance with the appropriate Sections of *Ch 4 Control Systems*.

4.2.3 Fire and gas detection systems shall be suitable for the nature of the space, fire growth potential and potential generation of smoke and gases.

4.3 Containment and structural integrity

4.3.1 The structure shall be constructed of non-combustible or fire-resisting materials, or provided with suitable protection from fire or other sources of ignition, to meet the required level of integrity established by the process in *Ch 1 General*.

4.3.2 The primary structure of the UMS, when subjected to fire for a defined period of time and after a fire, shall not:

- Threaten the structural integrity of the UMS through loss of structural members e.g. bulkhead strut or pillar, in or adjacent to a compartment which has a fire;

- Threaten or degrade structure supporting the Propulsion and Manoeuvring System and the Electrical and Control System.

4.3.3 Where required by the Owner, the fire, should not threaten or degrade structure supporting portable and mission specific equipment.

4.3.4 Fittings that preserve external watertight integrity when subject to fire shall remain effective for a defined period of time and after a fire.

4.3.5 Where required to meet the level of integrity established by the process in *Ch 1 General*, the UMS shall be subdivided by thermal and structural boundaries. Active and/or passive containment arrangements may be used.

4.3.6 Fire containment at boundaries shall have due regard to the fire risk of the space, function of the space, and function of adjacent spaces.

4.3.7 The fire integrity of the boundary shall be maintained at openings and penetrations.

4.4 Extinction

4.4.1 For all foreseeable fire hazards there shall be defined effective and proportionate means of extinguishing each such fire.

4.4.2 Fire-extinguishing systems shall be installed, having due regard to the risk of ignition, fire growth potential and operational importance of the protected spaces.

4.4.3 Fire-extinguishing systems are to be suitable for application at the initiation of a fire and for all stages through to the maximum potential escalation.

4.4.4 Control and activation of fire-extinguishing systems shall be designed in accordance with the appropriate Sections of *Ch 4 Control Systems*.

4.4.5 Automatic activation of fire-extinguishing systems shall have due regard for the function of the space and / or equipment protected.

4.4.6 Selection of fire-extinguishing media shall have due regard to potential environmental impact, toxicity of the agent and its fire breakdown products and potential short- and long-term effects on space recovery.

4.4.7 Means shall be provided to safely exhaust spaces and remove combustion products.

4.4.8 Fixed systems shall not endanger stability nor pressurise compartments.

4.4.9 Status of extinguishing systems shall be provided to the Operator.

4.4.10 The fire-extinguishing systems shall have appropriate margin and level of redundancy to meet the required level of integrity established by the process in *Ch 1 General*.

4.5 Maintenance

4.5.1 Safe access shall be provided to the fire safety systems including access provision in the event of equipment failure or for maintenance.

4.5.2 System diagrams and instructions shall be provided for maintenance of the fire safety systems in a language and format that can be understood.

Chapter 9 Auxiliary Systems

■ *Section 1*
Scope

1.1 Scope

1.1.1 This Chapter covers all auxiliary equipment and components required to support mission equipment and mission functions and the hazards that these create. This does not include equipment and components for Control System, Electrical Systems, Navigation Systems or Propulsion and Manoeuvring Systems, which are covered in *Ch 4 Control System*, *Ch 5 Electrical Systems*, *Ch 6 Navigation Systems*, and *Ch 7 Propulsion and Manoeuvring* respectively.

■ *Section 2*
Goal

2.1 Goal

2.1.1 The auxiliary systems shall be designed to support mission equipment and mission functions with a level of integrity sufficient to meet the operational requirements and be operated and maintained safely as and when required within its design or imposed limitations in all Reasonably Foreseeable Operating Conditions.

■ *Section 3*
Functional objectives

3.1 Functional objectives

3.1.1 The auxiliary systems shall be designed and constructed to:

(a) Enable their operation in all Reasonably Foreseeable Operating Conditions;

(b) Operate in a predictable manner with a level of integrity commensurate with operational and safety requirements;

(c) Meet requirements for watertight, weathertight and fire integrity;

(d) Minimise the risk of initiating fire and explosion;

(e) Enable the maintenance and repair in accordance with the maintenance philosophy.

3.1.2 Additional systems or equipment not directly covered by this Chapter, shall not affect the auxiliary systems.

■ *Section 4*
Performance requirements

4.1 General

4.1.1 The auxiliary systems shall be designed and arranged to meet the required level of integrity established by the process in *Chapter 1 General*, considering equipment failure rates and the effect of flood or fire.

4.1.2 For all auxiliary systems installed, the choice of materials and components of construction as well as the design, location and installation shall be made according to the environmental, maintenance and operating conditions in order to ensure the continued function of the equipment during all Reasonably Foreseeable Operating Conditions.

4.1.3 Ambient conditions shall be controlled where required to suit the operating environment and auxiliary systems requirements.

4.1.4 Auxiliary systems shall be designed to meet the mission equipment and mission function requirements in all Reasonably Foreseeable Operating Conditions.

4.1.5 The supply of energy source shall be sufficient to meet operational requirements with adequate reserve.

4.1.6 The energy source for auxiliary systems shall also meet the required level of integrity.

4.1.7 Any penetrations in watertight and weathertight boundaries due to auxiliary systems shall be designed in accordance with the requirements of *Ch 3 Stability*.

4.1.8 Pressure vessels and associated piping systems and fittings shall be of a design and construction adequate to safely contain media and safely release pressure. This is to take account of the anticipated internal and external pressure and temperature profiles and the service for which they are intended.

4.1.9 Auxiliary systems shall be designed to minimise the risk of initiating a fire including consideration of the following:

(a) Surface temperatures of systems shall not become a source of ignition in case of flammable fluid leaks;

(b) Failure of a joining arrangement shall not pose a further risk (e.g. due to atomisation of hydrocarbons, leakage of water onto electrical equipment etc.);

(c) Suitable arrangements to prevent the ignition of vapours in a tank shall be provided.

4.1.10 Suitable precautions against the build-up of electrostatic charges shall be provided.

4.1.11 Auxiliary systems shall be designed such that they will not unduly affect any other system including under failure conditions.

4.1.12 Where appropriate to meet the defined operational requirement, auxiliary systems shall be protected against damage by fire in accordance with *Ch 8 Fire*.

4.1.13 Safe access shall be provided to the auxiliary systems including means of isolation and access provision in the event of equipment failure or for maintenance.

4.1.14 Information and instructions shall be supplied to the Operator to ensure the safe operation, fault finding and maintenance of machinery, under all Reasonably Foreseeable Operating Conditions.

ANNEX A CONCEPT OF OPERATIONS	<If appropriate, official seal of the Recognised Organisation>

Particulars of the UMS

UMS Name	*(pennant number and name)*
Type e.g. (Surface/Semi/Submarine)	
Date last updated	*(date)*

The Owner

Defines the ship details, role and extreme threat survivability, and agrees the foreseeable damage survivability, maintenance philosophy and environmental conditions.

Signed		
Name		
Position		
Address		
Date of Signature		Official Seal

Primary and secondary roles

Primary Roles	*(high level overview of primary roles in sufficient detail for standards to be selected and the design completed)*

Secondary Roles	*(high level overview of secondary roles in sufficient detail for standards to be selected and the design completed)*

Unmanned System Attributes

Design Life	*(years)*
Level of Autonomy	*e.g. AL3, AL4, AL5 or AL6*
Length Overall	*(m)*
Breadth Overall	*(m)*
Lightweight	*(te)*
Displacement	*(te)*
Minimum Draught	*(m)*
Maximum Draught	*(m)*
Speed (maximum)	*(surface/sub-surface) (knots)*
Endurance	*(surface/sub-surface) (mission length in days)*
Area of Operation	*(restricted by range and range to refuge {links time, speed, sea state}, restricted to sheltered waters, max operating depth)*
Payload	Fluids in tanks: Dry weights: Hazardous materials: *(weights, volumes and locations)*

Required Integrity Levels*

Description of Owners required level of integrity according to *Chapter 1 General*.

	Safety	**Operational**
Structure		

Stability		
Control Systems		
Electrical Systems		
Navigation Systems		
Propulsion & Manoeuvring		
Fire		
Auxiliary Systems		

***Add sub-level systems as required**

Environment

A - Meteorology and climatology (above surface)	
Wind	*(maximum Beaufort Force or speed for operation and for survival)*
Precipitation	*(if specifically required, e.g. Tropical Storm)*
Air temperature – high	*(specify e.g. Maximum mean daily max)*
Air temperature – low	*(specify e.g. Minimum mean daily min)*
Air humidity	*(if not 100 per cent relative humidity at all air temperatures)*
Ice accretion	*(if specifically required)*
Visibility	*(if specifically required, e.g. night operations)*
Atmospheric pressure	*(if specifically required)*
Solar radiation	*(if specifically required, e.g. equatorial)*
Electro-magnetic discharge	*(if specifically required)*
Air quality	*(if specifically required, e.g. operations in coastal waters near deserts)*
Flora and fauna	*(if specifically required, e.g. in waters of known high activity)*
B - Sea surface, Bathymetry and oceanography (below surface)	
Waves	*(Sea State, significant wave height, maximum wave height)*
Waves - other situations	*(if specifically required, e.g. operations in surf, tidal bore)*
Sea temperature – high	*(specify e.g. Maximum mean daily max)*

Sea temperature – low	*(specify e.g. Minimum mean daily min)*
Tide	*(range (height) and maximum speed (relevant to berthing))*
Green seas and spray	*(area affected, frequency)*
Ice navigation	*(if specifically required, e.g. icebreaking)*
Sea surface quality (floating objects, pollution)	*(if specifically required, e.g. operations in estuaries)*
UMS motions	Maximum from equilibrium / Period Roll degrees seconds Pitch degrees seconds Yaw degrees seconds Heave metres seconds Surge metres seconds Sway metres seconds Submerged Roll degrees seconds Pitch degrees seconds *(design values for deviations from the static position)*
Vibration	*(motion induced and wave induced)*
Pressure (depth)	*(for specific features in head of sea water)*
Ocean currents	*(if specifically required, e.g. drift)*
Water quality	*(salinity/visibility) (if specifically required, e.g. operations in estuaries)*
Flora and fauna	*(if specifically required, e.g. in waters of know high activity)*
D – Geotechnical	
Bottom/Ground conditions	*(if specifically required)*
Banks (including canals)	*(dimensions, bottom conditions if specifically required)*
E – Human Caused Environment	
Berthing	*(maximum speed of contact)*

Beaching	
Shipping/Storage	
Towing and salvage	
Acoustic fields	*(if specifically required)*
Electro-magnetic fields	*(if specifically required)*
Launching and recovery	*(assumptions for build)*
Noise and vibration	

Operating philosophy

Modes of Operation	Occasionally Manned Semi-Autonomous Fully-Autonomous Remotely Operated
Restrictions and limitations	Cargo restrictions: Loading restrictions: Structural limitations: Other: *(including all restrictions and limitations that are acceptable under the role of the UMS)*
Role Specific Operations	*(requirements relating to the specific role of the vessel, e.g. cargo handling, requirement for low flashpoint fuels including their stowage etc.)*
Anchoring and mooring	*(frequency of use, limitations due to sea conditions)*
Towing (other than for emergencies)	

	(requirement for / being towed, operational scenarios, etc.)
Lifting, launch and recovery, and Transport	*(how will the UMS be deployed, etc.)*
Management of hull strength	*(approach to management of structure, etc.)*
Buoyancy and stability	*(approach to management of stability, e.g. stability information book approval, loading instrument, damage control philosophy)*
Machinery and Electrical systems	Operating Philosophy:
	Equipment: Propulsion system: Manoeuvring system: Buoyancy and stability systems: Other machinery systems: Electrical storage systems Electrical generation system: HV power supply & distribution: LV power supply & distribution: Control systems: Communications systems Navigation systems Auxiliary Systems *(description of major equipment and systems)*

Fire safety	Fuel Payload Fuel in tanks Fuel cells Batteries Cargo Payload Fluids in tanks Mission equipment Operating Activities Anchoring Mooring Towing Other Situational Awareness Fire detection equipment Management Training Survey and Maintenance Containment Prosecution Fire-extinguishing equipment Recovery Damage extent (fire) Re-configuration and redundancy Post damage capability External Assistance Shore Connection Ship-to-UMS Connection
Navigation	*(operational requirements for navigation equipment and workstations, mission functionality, DP, ACP, Navigation and operational lighting)*
Carriage of dangerous goods	
Recoverability	*(means of recovering the UMS following system failure)*

Survey, Maintenance and Disposal philosophy

Survey philosophy	*(overview of survey and inspection philosophy)*
Survey schedule	*(survey cycle and scope of survey)*
Maintenance philosophy	*(overview of maintenance philosophy)*
Maintenance schedule	*(maintenance cycles and depth of planned maintenance)*
Disposal philosophy	*(overview of disposal philosophy)*

ANNEX B VERIFICATION METHODS

Verification Method Requirements (Draft)

LEVEL OF INTEGRITY / PROCESS	HIGH	MEDIUM	LOW
DESIGN REVIEW	• System plans are to be appraised by LR	• System plans are to be reviewed by LR	• Statements of Compliance are to be issued by the Designer
COMPONENTS (all major components and items of equipment)	• Statement of Compliance* issued (or validated) by an independent inspection authority (LR)	• Statement of Compliance* issued (or validated) by an independent QC department or 3rd Party	Manufacturers Statement of Compliance*
	*Certification formats and levels to be agreed in accordance with the requirements of the reference standards used and required Level of Integrity.		
HULL CONSTRUCTION	• To be constructed under LR survey in accordance with plans approved by LR and agreed Inspection & Test Plan	• To be audited whilst under construction by LR • Statement of Compliance to be issued by the Manufacturer	• Construction premises and processes are to be audited by LR • Statement of Compliance to be issued by the Manufacturer
SYSTEM INSTALLATION	• To be installed under survey in accordance with plans approved by LR and agreed Inspection & Test Plan	• Final inspection of installed components in accordance with plans reviewed by LR	• Final inspection of installed components.
TRIALS	• To be tested in accordance with specified performance criteria	• To be tested under normal working conditions	• To be tested under normal working conditions
IN SERVICE	• Subject to survey by LR in accordance with the agreed periodic survey requirements.	• Subject to survey by LR in accordance with the agreed periodic survey requirements.	• General examination by LR in accordance with the agreed periodic survey requirements.
MODIFICATIONS	• Details of modifications are to be approved by LR • Construction, installation and trials are to be carried out under survey	• Details of any modifications are to be reviewed by LR • Construction, installation and trials are to be carried out under survey	• Details of any modifications are to be recorded to enable review by LR • Modifications are to be reviewed to ensure they do not change the LoI of the system

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