Guidelines For Classification And Construction

Part 3 Special Ships

Volume 1

GUIDELINES FOR AUTONOMOUS SHIPS

2020

Biro Klasifikasi Indonesia

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The following Guidelines come into force on 1st January 2021.

Foreword

The Guidelines for Autonomous Ships contains technical requirements and approval process for ships employing automation systems. In addition, this Guidelines also gives technical requirements for onshore supporting control center. The arrangement of sections of this Guidelines is as follows:

- Section 1 - General
- Section 2 - Approval Process and Risk Assessment
- Section 3 - Structure
- Section 4 - Stability
- Section 5 - Navigation Systems
- Section 6 - Machinery Systems
- Section 7 - Electrical Installations
- Section 8 - Control System
- Section 9 - Communication System and Network
- Section 10 - Mooring and Anchoring
- Section 11 - Fire Safety Systems
- Section 12 - Ship Security
- Section 13 - Special Systems
- Section 14 - Reliability of Automation Systems

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Further queries or comments concerning these Guidelines are welcomed through communication to BKI Head Office.

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Section 1 General

A. Scope

1. This Guidelines sets out the main recommendations for the design or the operation of systems which may be used to enhance automation in shipping.

2. The recommendations of this Guidelines are related to the design and operations of ships equipped with automation systems capable, to varying degrees, of making decisions and performing actions with or without human interaction, and their associated remote control centres if any.

3. This Guidelines could be applied to a specific automation system, such as for example a navigating automation system or a remote engine control system, or to a ship as a whole. The level of application will be indicated with special notation which is explained further in E.

4. This Guidelines is mainly focused on surface propelled units. This excludes underwater vehicles and non-manoeuvring units, such as drifting buoys used for scientific research.

5. This Guidelines provides also recommendations on the statutory requirements deemed applicable for ships covered by this Guidelines.

These recommendations are intended as a reference for designers, shipyards, manufacturers, shipowners and Administrations in order to help in the definition of the statutory framework applicable to these ships.

The application of this Guidelines does not relieve the Interested Party from compliance with any requirements issued by Administrations.

B. Application

1. In addition to this first general section, this Guidelines includes 13 specific sections:

- Section 2 is about approval process of the autonomous ship. Risk assessment are also explained in this section
- Section 3 to Section 13 provides guidelines for ensuring a suitable level of functionality for automation systems. These sections use goal-based approach to set a minimum level of functionality for each automation system.
  - Section 3 explains the requirements for hull structure
  - Section 4 explains the requirements for stability
  - Section 5 explains the requirements for navigation system
  - Section 6 explains the requirements for machinery system
  - Section 7 explains the requirements for electrical installation
  - Section 8 explains the requirements for communication system

  - Section 9 explains the requirements for mooring and anchoring
  - Section 10 explains the requirements for ship security
  - Section 11 explains the requirements for fire safety
  - Section 12 explains the requirements for control system
  - Section 13 explains the requirements for special systems such as passenger and cargo management system
- Section 14 provides guidelines for improving the reliability of automation systems.

2. The recommendations of this Guidelines may be adjusted according to the results of the risk and technology assessment, the degree of automation, the degrees of direct control and remote control, the navigation notation, the national regulations of the Administration, the operational limitations, the possibility of external rescue, etc.

3. Likewise, the recommendations of this Guidelines may be adjusted for small units that cannot embark humans on board at any time during operations.

4. In particular, the applicable requirements related to the assignment of the additional class notations as recommended in further sections, and more generally the requirements of the Rules & Regulations as mentioned in G, may be adjusted accordingly, to the satisfaction of the BKI and the Administration.

C. Definitions

1. Terms

1.1 **Administration**: Government of the State whose flag the ship is entitled to fly or the State under whose authority the ship is operating in the specific case

1.2 **Automation system**: system based on one or more devices whose implementation can be adjusted in advance, including, where appropriate, devices whose behaviour depends on unforeseeable factors. An automation system can be composed of various types of devices: mechanical, electrical, digital, electronic, magnetic, hydraulic or other. An automation system may be used, for example, for control, protection, lookout, recording or monitoring functions.

1.3 **Control**: controlling a ship consists in operating devices related to its navigation or its operations. Ships may be controlled either by the crew, or remotely by operators, or by automation systems with or without human interaction.

1.4 **Control station**: single or multiple position including all equipment such as computers and communication terminals and furniture at which control and monitoring functions are conducted (ISO 11064-3).

1.5 **Conventional ship**: ship where most decisions and actions are performed by the crew aboard. A conventional ship may have automation systems to assist the crew by automatically performing some actions, but those systems are always under the control of human aboard.

1.6 **Crew**: all persons carried aboard the ship to provide navigation and maintenance of the ship, its machinery, systems and arrangements essential for propulsion and safe navigation or to provide services for other persons aboard (IMO Resolution MSC.266(84)).

1.7 **Cybersecurity**: preservation of confidentiality, integrity and availability of information in the Cyberspace (ISO/IEC 27032).

1.8 **Cyberspace**: complex environment resulting from the interaction of people, software and services on the Internet by means of technology devices and networks connected to it, which does not exist in any physical form (ISO/IEC 27032).C

1.9 **Essential service**: service necessary for a ship to proceed at sea, be steered or manoeuvred, or undertake activities connected with its operation, and for the safety of life, as far as class is concerned.

1.10 **Ergonomics**: applied science that studies, designs and adapts equipment, work and the environment to meet human capabilities and limitations and to enhance safety and comfort (ISO 14105).

1.11 **Hazard**: any source of potential damage or casualty, or any situation with potential to cause it.

1.12 **Latency**: the time interval between the instant at which an instruction control unit issues a call for data and the instant at which the transfer of data is started (ISO/IEC/IEEE 24765).

1.13 **Lookout**: activity carried out at all times by sight and hearing as well as by all available means appropriate in the prevailing circumstances and conditions so as to make a full appraisal of the situation and of the risk of collision (ISO 8468).

1.14 **Navigation**: all tasks relevant for deciding, executing and maintaining course and speed in relation to waters and traffic (IACS Unified Requirements N1).

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

1.16 **Mission System**: a combination of interacting elements (sub-systems, equipment, components, hardware, software), organised to complete the mission assigned to the ship

1.17 **Monitoring**: act of periodically checking equipment and environment in order to detect any changes (ISO 8468)

1.18 **Operators**: all persons that provide navigation and maintenance of the ship, its machinery, systems and arrangements essential for propulsion and safe navigation to provide services. This definition includes person onboard and in the remote control centre.

1.19 **Reasonably Foreseeable Operating Conditions:** conditions in which the ship can be reasonably foreseen to operate in an intact, degraded, aged and/or damaged state. They are normally defined in the operational limitation. See also Section 2.A.3

1.20 **Reliability**: property of a system and its parts to perform its mission accurately and without failure or significant degradation (ISO/IEC 27036-3).

1.21 **Remote Control**: control of an operation at a point distant from the controlled device, using the transmission of information by telecommunications techniques.

1.22 **Remote Control Centre**: area located onshore or on another ship (conventional ships included) or on an offshore unit from which the monitoring and control the ship is exercised.

1.23 **Remote Control station**: control station located in a Remote Control Centre.

1.24 **Reserve power supply**: back-up power supply to the main electrical power supply.

1.25 **Risk**: concept quantifying a hazard, consisting in a combination of probability or frequency and consequence of the related hazard.

1.26 **Risk analysis**: structured method involving:

– identification of hazards related to the unit, installation or equipment

- estimation of hazard probabilities or frequencies
- estimation of hazard consequences.

1.27 **Risk assessment**: systematic analysis of risks including risk analysis, review of risk acceptability by comparison with agreed criteria and identification of risk reduction measures, when relevant.

1.28 **Sensor**: device that responds to biological, chemical, or physical stimulus (such as heat, light, sound, pressure, magnetism, motion, and gas detection) and provides a measured response of the observed stimulus (ISO/IEC/IEEE 21451-7).

1.29 **Ship**: unless otherwise specified, the term ship refer to a ship equipped with automation systems capable, to varying degrees, of making decisions and performing actions with or without human interaction.

1.30 **System**: combination of interacting elements organized to achieve one or more stated purposes (ISO/IEC 15288).

1.31 **System element**: member of a set of elements that constitutes a system. A system element is a discrete part of a system that can be implemented to fulfil specified requirements. A system element can be hardware, software, data, humans, processes (e.g., processes for providing service to users), procedures (e.g., operators instructions), facilities, materials, and naturally occurring entities (e.g., water, organisms, minerals), or any combination (ISO/IEC 15288).

1.32 **System integrity**: quality of a data processing system fulfilling its operational purpose while both preventing unauthorized users from making modifications to or use of resources and preventing authorized users from making improper modifications to or improper use of resources (ISO/IEC 2382).

1.33 **Technical personnel**: persons temporarily embarked aboard a ship equipped with automation systems for the purpose of its maintenance or time-limited technical intervention.

1.34 **Unmanned ship**: ship having no crew to operate ship systems. An unmanned ship may be remotely controlled or supervised by operators or with full automation. It may have passengers, special personnel according to SPS Code MSC.266(84) or temporarily technical personnel aboard an unmanned ship.

2. Abbreviations

AIS : Automatic identification system

ALARP : As low as reasonably practicable

Ax : Degree of automation of a system (x from 0 to 4), see D.1

CCTV : Closed circuit television

COLREG: IMO Convention on the international regulations for preventing collisions at sea

CRC : Cyclic redundancy check

Dy : Degree of direct control of a system (y from 0 to 3), see D.2

GAx : Global degree of automation of a ship (x from 0 to 4), see D.1

GDy : Global degree of direct control of a ship (y from 0 to 3), see D.2

GNSS : Global navigation satellite system

GPS : Global positioning system

GRz : Global degree of remote control of a ship (z from 0 to 3), see D.2

IACS : International association of classification societies

ILO : International labour organisation

IMO : International maritime organisation

ISM : IMO International safety management code

ISPS : IMO International ship and port facility security code

IT : Information technology

LIDAR : Light detection and ranging

LOS : Line of sight

MARPOL: IMO International convention for the prevention of pollution from ships

MLC : ILO Maritime labour convention

NAS : Navigating automation system

NAVTEX: Navigational telex

RCC : Remote control centre

RCO : Risk control options

Rz : Degree of remote control of a system (z from 0 to 3), see D.2

SOLAS : IMO International convention for the safety of life at sea

STCW : IMO International convention on standards of training, certification and watchkeeping for seafarers

VDR : Voyage data recorder

VHF : Very high frequency

VSAT : Very small aperture terminal

VTS : Vessel traffic services.

D. Automation Level

1. Degrees of Automation

1.1 The degree of automation represents the degree of decision making (authority) deferred from the human to the system.

1.2 The degree of automation should be defined to make a distinction between the role of the human and the role of the system among the various functions of the system. These functions are based on a four-stage model of human information processing and can be translated into equivalent system function:

- information acquisition
- information analysis
- decision and action selection

– action implementation.

The four functions can provide an initial categorisation for types of tasks in which automation can support the human. For a high degree of automation the impact of a system error will be predominant, whereas for a low degree of automation, the impact of an human error will be predominant.D

1.3 A degree of automation Ax (x from 0 to 4) should be defined for each automation system.

1.4 Several different degrees of automation could be considered for the duration of a single voyage. Change in degrees of automation shall be made with BKI permission.

1.5 Degrees of automation Ax (x from 0 to 4) considered in this Guidelines are described below and in Table 1.1:

- Degree A0 - Human operated:
  - The system or ship can perform information acquisition, but cannot analyse information, take decisions and execute operations on behalf of human.
  - Human makes all decisions and controls all functions.
  - Human (operators) is located aboard.
- Degree A1 - Human directed:
  - The system or ship can perform information acquisition, information analysis and suggest actions but cannot take decisions and execute operations on behalf of human.
  - Human makes decisions and actions.
  - Human (operators) can be located aboard or remotely outside the ship in a remote control centre.
- Degree A2 - Human delegated:
  - The system or ship can perform information acquisition, information analysis, take decisions and initiate actions, but requests human confirmation. System invokes functions waiting for human confirmation.
  - Human can reject decisions.
  - Human (operators) can be located aboard or remotely outside the ship in a remote control centre.
- Degree A3 - Human supervised:
  - The system or ship can perform information acquisition, information analysis, take decisions and execute operations under human supervision. System invokes functions without expecting human confirmation.
  - Human is always informed of the decisions and actions, and can always take control.
  - Human (operators) can be located aboard or remotely outside the ship in a remote control centre.
- Degree A4 - Full automation:
  - Self-operating system or ship at defined conditions and in specific circumstances.
  - The system or ship can perform information acquisition & analysis, take decisions and executes operations without the need of human intervention or supervision. System invokes functions without informing the human, except in case of emergency.
  - Human can always take control.
  - The supervision can be done aboard or remotely, outside the ship from a remote control centre.

Table 1.1 Degrees of Automation

Degree of automation		Manned	Definition	Information Acquisition	Information Analysis	Decision making	Action initiation
A0	Human operated	Yes	– Automated or manual operations are under human control – Human makes all decisions and controls all function	– System – Human	Human	Human	Human
A1	Human directed	Yes/No	– Decision support: system suggests action – Human makes decisions and actions	System	– System – Human	Human	Human
A2	Human delegated	Yes/No	– System invokes functions – Human must confirm decisions – Human can reject decisions	System	System	Human	System
A3	Human supervised	Yes/No	– System invokes functions without waiting for human reaction – System is not expecting confirmation – Human is always informed of the decisions and actions	System	System	System	System
A4	Full automation	Yes/No	– System invokes functions without informing the human, except in case of emergency – System is not expecting confirmation – Human is informed only in case of emergency	System	System	System	System

2. Degreees of Control

2.1 The degree of control represents the degree of availability of human (operator) operating the ship aboard or remotely outside the ship from a remote control centre.

2.2 A degree of direct control Dy (y from 0 to 3) and remote control Rz (z from 0 to 3) should be defined for each automation system.

2.3 Several different degrees of control could be considered for the duration of a single voyage.

2.4 Degrees of direct control Dy (y from 0 to 3) and remote control Rz (z from 0 to 3) considered in this Guidelines are described below and in Table 1.2:

- Degree D0 - No direct control

  There are no crew to monitor and control the system or ship, nor to take control in case of warning or alert from the system.
- Degree D1 - Available direct control

  The crew is available aboard, ready to take control in case of warning or alert from the system, but they may be not at the control station (e.g. periodically unmanned bridge).

- Degree D2 - Discontinuous direct control

  The system or ship is monitored and controlled by the crew from the control station aboard (bridge or engine control room). But monitoring and control may be discontinuous during a short period. The crew is always available at the control station aboard, ready to take control in case of warning or alert from the system.

- Degree D3 - Full direct control

  The system or ship is actively monitored and controlled at any time by the crew from the control station aboard (bridge or engine control room).

- Degree R0 - No remote control

  There are no operator in a remote control centre outside the ship to monitor and control the system or ship, nor to take control in case of warning or alert from the system.

- Degree R1 - Available remote control

  Operators are available in a remote control centre outside the ship, ready to take control in case of warning or alert from the system, but they may be not at the control station (e.g. periodically unmanned remote control station).

- Degree R2 - Discontinuous remote control

  The system or ship is monitored and controlled by operators from a remote control station outside the ship. But monitoring and control may be discontinuous during a short period. Operators are always available at the remote control station, ready to take control in case of warning or alert from the system.

- Degree R3 - Full remote control

  The system or ship is actively monitored and controlled at any time by operators from a remote control station outside the ship.

Table 1.2 Degrees of Control

Degree of control			Human presence	Location of control station
Direct control	D0	No direct control	No crew available to monitor and control the system, nor to take control in case of warning or alert.	(1)
	D1	Available direct control	Crew available aboard, ready to take control in case of warning or alert. But they may be not at the control station	Aboard
	D2	Discontinuous direct control	Monitoring and control may be discontinuous during a short period. Crew always available at the control station, ready to take control	Aboard
	D3	Full direct control	System is actively monitored and controlled at any time	Aboard
Remote control	R0	No remote control	No operator available to monitor and control remotely the system, nor to take control in case of warning or alert.	(1)
	R1	Available remote control	Operators available in the RCC, ready to take control in case of warning or alert, but they may be not at the remote control station	RCC
	R2	Discontinuous remote control	Remote monitoring and control may be discontinuous during a short period. Operators always available at the remote control station, ready to take control	RCC
	R3	Full remote control	System is actively monitored and controlled remotely at any time	RCC
(1) See also F.8.3: there may not be any integrated control station				

E. Notation

1. General

1.1 Ships that complies with the requirements of this Guidelines will be given the additional notation **AS (...)**

1.2 The **(...)** part reflects the degree of automation, the degree of control and scope of application of this Guidelines (whole ship or individual system)

2. Notation for Individual System

2.1 Any system covered by the Guidelines should be characterised by:

– a degree of automation **Ax**
  (x from 0 to 4), see D.1
– a degree of direct control **Dy**
  (y from 0 to 3), see D.2
– a degree of remote control **Rz**
  (z from 0 to 3), see D.2
– system to which the Guidelines is applied. The systems and the section which hold the requirements for the corresponding system are described in Table 1.3

Table 1.3 Automation Systems

System	Corresponding section
Navigation	Section 5, and Section 8
Machinery	Section 6, Section 7, Section 8, and Section 11
Passenger Management	Section 13
Cargo Management	Section 13
Mooring and Anchoring	Section 8, and Section 10

2.2 For example, a "human supervised" Navigating Automation System (see D.2) with available direct control and no remote control (see D.3) would be characterized by the following notation:

AS (Navigation - A3 D1 R0)

2.3 For individual system which consists of multiple sub-systems, each with individual degree of automation, the overall degree of automation of the system should correspond to the lowest degree of automation of the sub-systems

3. Notation for Whole Ship

3.1 Any system covered by the Guidelines should be characterised by:

– a degree of automation **Ax**
  (x from 0 to 4), see D.1
– a degree of direct control **Dy**
  (y from 0 to 3), see D.2
– a degree of remote control **Rz**
  (z from 0 to 3), see D.2
– a qualifier that shows that the Guidelines is applied to the whole ship:
  Global

3.2 Degree of automation and control designated to the ship should correspond to the lowest degree of automation and control covering essential services

3.3 For example, a "human delegated" unmanned ship (see D.2) with no direct control and discontinuous remote control (see D.3) would be characterized by the following notation:

ASV (Global - A2 D0 R2)

F. Design Principles

1. General

1.1 Any ship covered by this Guidelines should provide at least the same degree of safety, security and protection of the environment as provided by a conventional ship having the same purpose or design.

1.2 To achieve this minimum degree of safety, security and protection of the environment, the general principles behind the recommendations contained in this Guidelines are given in 2 to 12.

1.3 During operations, a ship should not be a source of danger to itself, to the other ships around (conventional ships included), to the maritime infrastructures and to the marine environment.

1.4 New threats may arise from the reduction or absence of crew and from the use of remote control.

1.5 The risk management is transferred from the crew to sensors and software, and to operators in the remote control centre if any.

2. Main ship capabilities

2.1 Guidelines for ensuring a suitable level of functionality of systems associated with essential services of a ship are provided in Section 3 - 13.

2.2 In particular, any ship covered by this Guidelines should be capable of:

- managing a predefined voyage plan and updating it in real-time if relevant
- navigating according to the predefined voyage plan and avoid collisions with obstacles coming from the traffic or unexpected objects
- keeping a sufficient level of manoeuvrability and stability in various sea states
- withstanding unauthorized physical or virtual trespassing
- complying with all relevant international and local regulations

2.3 The possibility for the crew or remote operators to regain control of a ship in case of emergency or system failure should always be possible.

2.4 The possibility to activate an automation system or regain control should be granted to authorized and qualified personnels only (crew or operators). Specific attention should be paid in particular aboard ships carrying passengers.

2.5 When a ship is operated remotely, the crew should always be able to regain control of the ship in priority to the remote operator.

3. Operational limitations

3.1 The operational limitations of a ship are parameters to which the crew or operators must refer for the monitoring and control of the ship.

3.2 It is the designer, shipyard, manufacturer and/or shipowner responsibility to specify these limitations in order to define the conditions under which the ship is to be operated.

3.3 The operational limitations should at least refer to the following parameters:

- reasonably foreseeable operating conditions
- degree of automation
- degree of control
- range of service
- Administration's national regulations, if any
- local legislation, if any
- traffic conditions, if any
- deadweight and assigned freeboard
- stability information
- minimum ballast draught
- maximum service speed
- design loads on decks, hatch covers and double bottom
- density of cargoes
- situational awareness system characteristics
- navigation system characteristics
- communication system characteristics
- control system characteristics
- machinery system characteristics
- cargo management system characteristics
- passenger management system characteristics
- distributions of roles and responsibilities.

4. Identification

4.1 The identification of a ship should be based on the following standards and regulations:

- IMO A.1117(30) IMO Ship Identification Number Scheme
- ISO 10087 Small craft - Craft identification - Coding system.
- Administration's national regulations, if any
- Local legislation, if any

4.2 Any ship covered by this Guidelines should be marked by explicit distinguishing marks in order to be easily identified, in particular for ships with high degrees of automation (e.g. degree A3 or A4).

The size of the marking must be adapted to the size of the ship so that it can be easily read by an external observer. For the same purpose, these ships should be painted with light colours (e.g. yellow or orange), in order to be as visible as possible from afar on the sea and recognizable by other ships (conventional ships included) operating in their vicinity.

4.3 Any ship should be equipped with an Automatic Identification System (AIS), encoded as far as possible according to the local regulations of the waters in which they are intended to operate.

5. Interactions

5.1 Interactions with other ships (conventional ships included) should be taken into consideration during the design and the operation.

5.2 Any ship covered by this Guidelines should not interfere with other ships (conventional ships included) operating in their vicinity.

5.3 Any ship covered by this Guidelines should be able to respond at any usual request (e.g. identification, position) from other ships (conventional ships included) by means of radio communications or visual signals

5.4 Port and coastal authorities should be able to communicate with any ship covered by this Guidelines in order to be informed about the voyage plan and to be able to regulate the traffic.

Specific communication protocol should be established if necessary.

5.5 Specific attention should be paid to the protection of third parties who could be confronted with any ship covered by this Guidelines in the event of grounding or collision, in particular in the case of an unmanned ship.

For example, it is recommended to protect all moving parts and to provide automatic power breakers.

An appropriate marking indicating the level of danger incurred in the event of attempted disassembly (degassing, overpressure, electrical voltage, etc.) and the contact details of the operators is also recommended.

6. Responsibilities

6.1 There should be a responsible party defined at all times and in all circumstances for all operations of any ship covered by this Guidelines, even if that person is not aboard.

6.2 The following distributions of roles and responsibilities should be clearly defined and described in the operational limitations:

- aboard, between automation systems and the crew
- at the remote control center, between automation systems and remote operators
- between the crew and remote operators.

7. Remote control

7.1 The Remote Control Centre (RCC) should be considered as an extension of the ship. To prevent that unexpected events on the RCC could have consequences on the ship (e.g. fire, earthquake), mitigation measures should be integrated in the design and operations of the RCC.

7.2 Those measures should not interfere with land-based regulations (e.g. lockdown during manoeuvre and procedure for fire escape) which may differ from one country to the other depending on where the RCC is located.

7.3 The RCC, including facility and manning, should be designed with regard to each ship it supervises. When the RCC is used for an additional ship, this design should be reassessed and potentially upgraded accordingly.

7.4 When a ship operates in sensitive or restricted area (e.g. military fleet), and depending on its degree of automation, it could be necessary to have more stringent measures for the protection of the RCC (e.g. to avoid terrorist attack).

7.5 Before taking control of a ship from the RCC, remote operators should first ensure that they have an accurate situational awareness and that all devices to control the ship remotely are available and operational.

7.6 Refer also to Section 13 providing guidelines for ensuring a suitable level of functionality for RCC.

8. Direct control

8.1 All operations for which a ship has to be directly controlled or may be remotely operated should be clearly defined within the operational limitations, according to the results of the risk and technology assessment, the degree of automation, the degrees of direct control and remote control, the navigation notation, and depending on local regulations and traffic.

8.2 Regardless of the possibility of a remote control, a ship should be designed to authorize a human to come aboard or in their vicinity for controlling the ship, for example when a critical situation arises (e.g. fire, flooding, loss of propulsion).

8.3 Any ship covered by this Guidelines should be designed to be controlled aboard by an integrated control station, or at least by a portable device (e.g. laptop) for small units.

8.4 For sea trials, surveys in service, flag or port state control inspections and technical personnel intervention, any ship should be designed to accept the presence of a human aboard (or at least in their vicinity for small units).

8.5 Due to size or design, a ship may not have the capacity to carry a human aboard and may only be controlled remotely or by automation systems.

In this case, the recommendations of this Guidelines may be adjusted: for example, the provisions relating to the life-saving appliances (e.g. presence of lifejackets or lifeboats) may be simplified.

These specific arrangements should be considered on a case-by-case basis by BKI and approved by the Administration.

9. Reliability

9.1 Compared to a conventional ship, a ship covered by this Guidelines may have less or even no crew to rely on for maintenance operations and corrective tasks due to system failure. Consequently, the systems should be designed to be as resilient as possible to failure (e.g. fault tolerant) and to have extended maintenance intervals (see Section 14).

9.2 Highest reliability should be achieved by introducing for example efficient diagnostics and predictive algorithms for controlling the risk of failures and pre-scheduling maintenance operations that should be performed in harbour (e.g. by using a condition-based maintenance).

9.3 The usage of intensive remote monitoring and control of the status of equipments should be considered in order to prevent failures.

9.4 A partial or full redundancy are some solutions to improve the availability for critical systems such as communication infrastructure or machinery.

9.5 Redundancy is easiest to achieve with electrical propulsion. Generators producing electricity for recharging batteries or additional emergency batteries should be considered as a simple and cost-effective way to improve the propulsion and steering reliability.

10. Human factors

10.1 The multiple sensors used for monitoring and control increase a lot the amount of information provided to crew and operators. In order to avoid the risk of overload of information that may reduce the accuracy of the actual ship situation, a fusion of the data collected by the sensors should be proposed to crew and operators.

10.2 The ergonomics of monitoring and control systems should take into account the human vigilance that could be reduced during extended periods of remote control or when several ships which are in different situations are managed by only one operator.

10.3 The remote operators should be aware of the latency due to the communication that cause a delay between his/her action and the actual ship reaction. The latency should be continuously displayed during the operations (e.g. manoeuvring) and a warning should be issued when the latency is over pre-defined limits.

11. Cybersecurity

11.1 The usage of information and communication technologies makes possible virtual unauthorized or malicious actions to ships (e.g. virus infection). Data communication between ship and control centre or GPS signal could be intentionally disturbed or changed in order to hijack the ship or cause severe damages.

11.2 Amongst the best practices for the usage of information and communication technologies, measures should be adopted to provide the highest level of confidence for data (e.g. protection, encryption) and for user access (e.g. password authentication).

11.3 For cybersecurity reference is made to Section 14.

12. Cargo

12.1 Cargo on any ship covered by this Guidelines should be carefully loaded, stowed and monitored at all times and for all operations.

12.2 The stowage of cargo aboard should be ensured at port, since the ship could have few means (less or no crew and equipment) for ensuring a proper cargo securing at sea.

12.3 For cargo management system reference is made to Section 13.

13. Failures and Malfunctions

13.1 Fail-safe sequences

13.1.1 In the event of failure or malfunction of one or more automation systems, fail-safe sequences should be defined.

13.1.2 The purpose of these fail-safe sequences is to recover a safe situation for the ship itself, for people, for other ships and for the environment.

13.1.3 These fail-safe sequences should be defined depending on the automation system concerned, the degree of automation and the operating mode (e.g. manoeuvring in harbour or at sea).

13.1.4 At least two different fail-safe sequences should be available at all times and under all circumstances during normal operations of the ship.

13.1.5 The crew or operators should be able to select and prioritise potential fail-safe sequences during the preparation of the voyage plan.

13.1.6 For example, in case the connection between ship and RCC or between ship and shore is unavailable for a period of time, the ship should enter into a fail-safe sequence to be defined depending on the degree of automation.

This fail-safe sequence could include for instance the following options to be considered with regard to the risk assessment, considering that at least two of these options should be available:

- crew attempts to take a manual control
- ship slows down to the next waypoint and waits for the crew, the operators or the system to regain control
- ship stops and stays at the current position, waiting for the crew, the operators or the system to regain control
- ship sails back to the previous waypoint and waits for the crew, the operators or the system to regain control

13.2 Minimum communication link

13.2.1 A minimum communication link between the ship and the RCC should be maintained at all times and under all circumstances with, for example, a simplified radio or satellite link, in order to be able to exchange a regular status report specifying the status of the ship (for instance that there are no incidents in progress and no alarms triggered).

13.2.2 Similarly, ship automation systems associated with essential services such as for example navigation, communication, machinery, cargo management and passenger management systems should receive this status report so that they can react accordingly in the event of an incident or an alarm being triggered. If no action is taken at the RCC, the ship should be able to enter into a failure sequence on its own.

13.2.3 In the case of remote control, it is the responsibility of remote operators to ensure that the ship remains within the range of its means of communication at all times and under all circumstances. When a ship is no longer within the range of its means of communication allowing its control, this ship should be able to enter into a failure sequence on its own.

13.3 Degraded modes

13.3.1 When the communication link between the RCC and the ship is degraded or interrupted for a significant period of time identified in the risk analysis, the ship should be monitoring and controlled by the crew and/or by automation systems capable of performing the following functions:

- navigation monitoring and control including location, speed regulation, heading and manoeuvring control, buoyancy and stability control
- monitoring and prevention of collisions at sea
- visual and audible signalling
- damage detection
- alert to any persons on board in the event of damage
- receive distress signals and relay them to the relevant search and rescue authorities
- initiate fail-safe sequences

13.3.2 In the event of a situation that could present a risk to navigation, such as partial or complete loss of manoeuvrability or persistent loss of communication between the RCC and the ship, the crew or operators should be able to report this situation by urgent notification to other ships (conventional ships included) operating in the vicinity and by an appropriate visual or audible alert. This limitation should be also reported by AIS.

13.3.3 Any ship covered by this Guidelines should be fitted with towing arrangement that can be used in case of emergency to assist the ship and in compliance with the requirements of Rules for Hull (Pt.1, Vol.II) Sec.18.

13.3.4 In case of loss of manoeuvrability, the possibility of anchoring (or using a floating anchor for small units) may be considered in order to limit drift.

13.3.5 For unmanned ship, it should be possible to perform towing and anchoring operations remotely or automatically.

G. Rules and Regulations

1. General

1.1 Any ship covered by this Guidelines should be compliant with BKI Rules as defined in 2 and all relevant regulations from applicable international conventions, Administration's national regulations or local legislation if any.

1.2 Where appropriate, exemptions or equivalent solutions should be explicitly approved by the Administration.

2. BKI Rules

2.1 The following classification Rules should be applied as far as practicable, depending on the type and the service of the ship:

–
– Part 1 : Seagoing Ships
– Part 2 : Inland Waterway
– Part 3 : Special Ships
– Part 5 : Offshore Technology
– Part 6 : Statutory
– Part 9 : Naval Ships Technology

3. IMO Codes and Conventions

3.1 In addition to 1, the following codes and conventions as amended should be given special attention and should be applied as far as practicable:

– International Convention for the Safety of Life at Sea (SOLAS)
– International Convention for the Prevention of Pollution from Ships (MARPOL)
– International Regulations for Preventing Collisions at Sea (COLREG)
– International Saftey Management (ISM) Code
– International Ship and Port Facility Security (ISPS) Code
– International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW)
– Maritime Labour Convention (MLC)
– ICLL

4. National Regulation

For ships sailing in Indonesian waters, national regulations should be applied as applicable.

5. Ship Recycling Regulation

The requirements of Ship Recycling Regulation should be considered as a basis for proactive approach to safety and environmental protection in ships recycling, with a major focus on management of hazardous materials.

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Section 2 Approval Process and Risk Assessment

A. Approval Process

1. General

When new operational concepts enabled by novel technology are introduced, the solutions may not meet existing regulations and technical requirements. The technology may also be intended to perform a function that is traditionally performed by humans, and for which no performance requirements to the technology have been developed.

To support development and introduction of such new operational concepts and novel technology in ship designs, both class rules and statutory regulations provide guidelines on processes to follow for obtaining approval of alternative designs in general. The objective of these processes is to document that a new concept with its enabling technology will provide a level of safety equivalent or better compared to a conventional ship designed and operated in accordance with existing rules and regulations.

2. Process Overview

This section provides further descriptions of processes that may be followed to obtain the approvals. Three processes are described :

– Approval of conventional technology

  Applicable to conventional technology used in conventional ways. Refer to BKI Rules.

– Technology qualification

  Applicable to novel technology related to automation system and remote control of ship functions. The technology qualification process has the objective to document properties of a system and to ensure safe implementation of the technology with respect to any negative effects on the respective vessel functions. Technology qualification uses risk assessment method.

3. Document to be Submitted

At the request of the designer, shipyard, manufacturer and/or shipowner, BKI may review the design of a ship according to the content of this Guidelines. For this purpose, the documents that should be submitted in the scope of this review are listed in Table 2.1.

Table 2.1 Document to be submitted

Topic	Plans and documents to be submitted
Classification	Plans and documents to be submitted according to BKI Rules in the scope of the classification of the ship and relevant to the service notation applied for
Additional class notations	Plans and documents to be submitted according to BKI Rules in the scope of the additional class notations as specified in this Guidelines
Operational limitations	Details of parameters to which the crew or operators must refer for the control of the ship
Identification	Details of provisions for identification, see Section 1.F.4
Interactions	Details of provisions for interactions, see Section 1.F.5

Table 2.1 Document to be submitted (*continued*)

Topic	Plans and documents to be submitted
Automation systems	Detailed specification of all automation systems, including: • Specification of the Navigation system, see Section 5 • Specification of the Machinery system, see Section 6 • Specification of the Communication network and system, see Section 8 • Specification of the Mooring and anchoring, see Section 9. • Specification of the Ship Security, see Section 10. • Specification of the Control System, see Section 12. • Specification of the Cargo management system, see Section 13.A • Specification of the Passenger management system, see Section 13.B • Plan of the failsafe sequence for all automation system, see Section 1.F.13 These specifications should clearly specify for each function the distribution of roles and responsibilities between the human and the system, and also include the maintenance information.
Risk assessment	Detailed risk assessment report including: • Groups of functions considered, see Section 2.B.2.2 • List of hazards considered, see Section 2.B.2.3 • Risk analysis outcome, see Section 2.B.2.4 • Risk Control Options considered, see Section 2.B.2.6
Reliability	Details of provisions for improving the reliability of systems including: • General system design, see Section 14.B • Human machine interface, see Section 14.C • Network and communication, see Section 14.D • Software quality assurance, see Section 14.E • Data quality assurance, see Section 14.F • Cybersecurity, see Section 14.G This document is mandatory for ship with high degree of automation (A3, A4).
Testing	Detailed tests specifications and reports, including: • Software tests, see Section 14.H.1 • Simulation tests, see Section 14.H.2 • Full scale tests, see Section 14.H.3 All tests reports should include the targeted objective, the followed procedure, the expected results and the outcome achieved

B. Risk Assessment

1. General

The risk assessment is qualitative assessments which is the most appropriate for dealing with novel technology that may be used for any ship covered by this Guidelines.

1) The risk-based approach considers a ship as a model of several different interconnected systems aboard and onshore.

2) The measures to mitigate the risks should be founded on prescriptive requirements already existing in the Rules or in other standards or guidance notes from the industry or regulatory bodies.

3) The risk assessment should be carried out by persons (ideally an independent and appropriate third party) who have documented knowledge and experience of the relevant methodology used and who have the necessary knowledge of the systems to be assessed. Their role and skills should be documented. The risk assessment report should be submitted to the BKI for information.

2. Risk assessment

2.1 Methodology

2.1.1 References

The process for the risk assessment should be based on the techniques available in the following documents:

- ISO/IEC 31010 Risk management - Risk assessment techniques
- ISO/IEC 27005 Information technology - Security techniques Information security risk management.

2.1.2 Stages

The risk assessment should be performed according to the following stages :

- ship model formalisation see 2.2
- hazard identification see 2.3
- risk index calculation considering frequency and severity of the hazardous event see 2.4
- risk evaluation considering risk acceptance criteria see 2.5
- risk control options determination, when relevant see 2.6

2.2 Ship Model

At the first stage of the risk assessment, all main systems of a ship, including Remote Control Centre (RCC), should be split into several groups of functions covering essential services.

As a guidelines, a list of typical groups of functions is given below :

- voyage
- navigation
- detection
- communication
- ship integrity, machinery and systems
- cargo and passenger management
- remote control
- security.

2.3 Hazard identification

2.3.1 Principles

The hazard identification should cover all possible sources of hazards potentially contributing to undesirable events or accidents.

The consideration of a functional failure associated with the consequence of an accident scenario should be governing the process of identification. As a guidelines, a list of typical hazards for ships covered in this section.

2.3.2 Voyages

Typical hazards that should be considered for voyage purpose are given in Table 2.2.

Table 2.2 Hazards for the Voyage

Hazard	Consequence
Human error in input of voyage plan	Collision Grounding Sinking
Failure of update (e.g. of nautical publications, weather forecasts)	Loss of localisation Collision Grounding Sinking
Failure in position fixing (due to e.g. GPS selective availability)	Loss of localisation Collision Grounding Sinking

2.3.3 Navigation

Typical hazards that should be considered for navigation purpose are given in Table 2.3.

Table 2.3 Hazards for the Navigation

Hazard	Consequence
Heavy traffic	Collision Sinking
Heavy weather or unforeseeable events (e.g. freak wave)	Grounding Sinking
Low visibility	Collision Grounding Sinking
Collision with other ships or offshore infrastructures	Collision Sinking
Collision with floating objects	Collision Sinking
Collision with marine wildlife (e.g. whales, squids, carcasses)	Collision Sinking
Collision with onshore infrastructures or failure in mooring process	Collision Grounding Sinking
Loss of intact stability due to unfavorable ship responses (e.g. to waves)	Sinking
Loss of intact stability due to icing	Sinking

2.3.4 Detection

Typical hazards that should be considered for detection purpose are given in Table 2.4.

Table 2.4 Hazards for the Detection

Hazard	Consequence
Failure in detection of small objects (wreckage)	Collision Sinking
Failure in detection of collision targets	Collision Sinking
Failure in detection of navigational marks	Loss of localisation Collision Grounding Sinking

Table 2.4 Hazards for the Detection (*continued*)

Hazard	Consequence
Failure in detection of ship lights, sounds or shapes	Collision Grounding Sinking
Failure in detection of semi-submerged towed or floating devices (e.g. seismic gauges, fishing trawls)	Collision Sinking
Failure in detection of discrepancy between charted and sounded water depth (e.g. wreckage)	Grounding Sinking
Failure in detection of discrepancy Between weather forecast and actual weather situation	Grounding Sinking
Failure in detection of slamming or high vibration	Hull or machinery damage Sinking

2.3.5 Communication

Typical hazards that should be considered for Communication purpose are given in Table 2.5.

Table 2.5 Hazards for the Communication

Hazard	Consequence
Reduction of communication performance (e.g. insufficient bandwidth)	Loss of localisation Collision Grounding Sinking
Communication failure (e.g. with RCC, with relevant authorities, with ships in vicinity)	Loss of localisation Collision Grounding Sinking
Communication failure with an other ship in distress (e.g. message reception, relay, acknowledgment)	Loss of localisation Sinking of the ship in distress
Failure in data integrity (e.g. error in data transmission)	Loss of localisation Collision Grounding Sinking

2.3.6 Ship integrity, machinery and systems

Typical hazards that should be considered for Ship integrity, machinery and systems purpose are given in Table 2.6.

Table 2.6 Hazards for the Ship integrity, machinery and systems

Hazard	Consequence
Water flooding due to structural damage or watertightness device failure	Sinking
Fire	Sinking
Sensor or actuator failure	Loss of localisation Collision Grounding Sinking
Temporary or permanent loss of electricity (e.g. due to black-out)	Loss of localisation Collision Grounding Sinking

Table 2.6 Hazards for the Ship integrity, machinery and systems (*continued*)

Hazard	Consequence
Propulsion or steering failure	Collision Grounding Sinking
Failure of ship's IT systems (e.g. due to bugs	Loss of localisation Collision Grounding Sinking
Failure of ship's IT infrastructure (e.g. due to fire in the server room)	Loss of localisation Collision Grounding Sinking
Failure of anchoring devices when drifting	Collision Grounding Sinking

2.3.7 Cargo and passenger management

Typical hazards that should be considered for Cargo and passenger management purpose are given in Table 2.7.

Table 2.7 Hazards for the Cargo and passenger management

Hazard	Consequence
Too much cargo or too many passengers aboard (overload)	Sinking
Loss of intact stability due to shift and/or liquefaction of cargo or due to cargo overboard	Sinking
Passenger overboard	Human injury or fatality
Passenger illness	Human injury
Passenger injured during arrival or departure	Human injury or fatality
Passenger interfering in an aboard system	Loss of localisation Collision Grounding Sinking

2.3.8 Remote control

Typical hazards that should be considered for Remote control purpose are given in Table 2.8.

Table 2.8 Hazards for the Remote control

Hazard	Consequence
Unavailability of RCC (fire, environmental phenomenon...) or of operators (faintness, emergency situation, etc.)	Loss of localisation Collision Grounding Sinking
Human error in remote monitoring and control (e.g. through situation unawareness, data misinterpretation, RCC capacity overload)	Collision Grounding Sinking
Human error in remote maintenance	Loss of localisation Collision Grounding Sinking

2.3.9 Security

Typical hazards that should be considered for security purpose are given in Table 2.9.

Table 2.9 Hazards for the Security

Hazard	Consequence
Willful damage to ship structures by others (e.g. pirates, terrorists)	Sinking
Attempt of unauthorised ship boarding (e.g. pirates, terrorists, stowaways, smugglers)	Illegal actions Hijack Loss of localisation
Jamming or spoofing of AIS or GPS signals	Loss of localisation Collision Grounding Sinking
Jamming or spoofing of communications, Hacker attack, also on RCC (e.g. In case of pirate or terrorist attack)	Loss of localisation Collision Grounding Sinking
Failure in data confidentiality (e.g. data interception by unauthorized 3rd party)	Illegal actions
Cyber virus spread from port facilities	Illegal actions Hijack Collision Grounding Sinking

2.4 Risk index calculation

2.4.1 Principles

The risk for a given accident scenario due to a hazard is estimated with a risk index as a combination of the frequency of the cause and the severity of the consequence.

2.4.2 Frequency index

The frequency is estimated by the number of occurrences of an event to occur per ship year, in a fleet of several ships having the same operating mode. Examples of frequency index (F) are given in Table 2.10.

Table 2.10 Frequency index (F)

Definition	Definition	Per ship year	F
Frequent	Likely to occur once per month on one ship	10	7
Common	Likely to occur once per year on one ship	1	6
Reasonably	Likely to occur once per year in a fleet of 10 ships, i.e. likely to occur a few times during the ship's life	0.1	5
Possible	Likely to occur once per year in a fleet of 100 ships	10^{-2}	4
Remote	Likely to occur once per year in a fleet of 1000 ships, i.e. likely to occur in the total life of several similar ships	10^{-3}	3
Unlikely	Likely to occur once in the lifetime (20 years) of a fleet of 500 ships	10^{-4}	2
Extremely unlikely	Likely to occur once in the lifetime (20 years) of a world fleet of 5000 ships	10^{-5}	1

2.4.3 Severity index

The severity is estimated according to the impact on human, ship and environment. Examples of severity index (S) are given in Tables 2.11 to Tables 2.13.

Table 2.11 Severity index (S) for human

Definition	Human	Equivalent fatalities	S
Negligible	No damage to human	10^{-3}	1
Minor	Light injuries to human	10^{-2}	2
Severe	Serious injuries to human	0.1	3
Critical	One fatality, or less than 10 on-site permanent disabling injuries	1	4
Catastrophic	Multiple fatalities, and/or 10 or more on-site permanent disabling injuries also outside the event area	10	5

Table 2.12 Severity index (S) for ship

Definition	Ship	Equivalent fatalities	S
Negligible	No damage: safety functions fully available	10^{-3}	1
Minor	Local equipment damage: local damage to safety functions	10^{-2}	2
Severe	Severe equipment damage: large local damages to safety functions	0.1	3
Critical	Critical damage: impairment of safety functions	1	4
Catastrophic	Total loss: total impairment of safety functions	10	5

Table 2.13 Severity index (S) for environment

Definition	Environment	Equivalent fatalities	S
Negligible	Non significant spill, minor environment impact No off-site impact/damage	< 0.1 t	1
Minor	A few barrels of pollution to sea. Moderate environment impact Minor off-site impact	0.1 – 1 t	2
Severe	A few tonnes of pollution to sea. Significant environmental impact, situation manageable Moderate off-site impact limited to property damage or minor health effects	1 – 100 t	3
Critical	Serious environment impact. Significant pollution demanding urgent measures for the control of the situation and/or cleaning of affected areas Significant off-site property damage or short term health effects to public	100 – 10000 t	4
Catastrophic	Extensive environment impact. Major pollution with difficult control of situation and/or difficult cleaning of affected areas Extensive off-site property damage, fatalities or short term health effects to public	> 10000 t	5

2.4.4 Risk index

The risk index (R) is calculated before any mitigation measure and is obtained on a logarithmic scale by adding the frequency index (F) defined in 2.4.2 and the severity index (S) defined in 2.4.3 :

Risk index (R) = Frequency index (F) + Severity index (S)

A risk index matrix may be formalised.

2.4.5 Risk index calculation

For each hazard, the risk index should be calculated in order to rank the risks by considering separately the impact on human, ship and environment.

Example of risk index calculation is given in Table 2.14.

Table 2.14 Risk index (R)

Hazard	Consequence	Frequency Index (F)	Severity index (S)			Risk index (R)		
			Human	Ship	Environment	Human	Ship	Environment
Failure of ship's IT systems (e.g. due to bugs)	Loss of localisation	4	1	2	1	5	6	5
Failure in position fixing (due to e.g. GPS selective availability)	Grounding	5	2	3	3	7	8	8
Low visibility	Collision	7	3	4	3	10	11	10
Fire	Sinking	3	4	5	4	7	8	7

2.5 Risk evaluation

2.5.1 Principles

The acceptability of the risks identified by the risk index calculation should be reviewed in comparison with agreed risk acceptance criteria.

2.5.2 Risk acceptance criteria

It is the designer, shipyard, manufacturer and/or shipowner responsibility to specify the risk acceptance criteria. The risk acceptance criteria should at minimum consider the following risks:

- risk to human (risk of injury, loss of lives)
- risk to the environment (risk of pollution)
- risk to the ship (risk of damage).

Specific requirements about risk acceptance criteria may be defined by the Administration and / or other Authorities. The risk acceptance criteria considered for the risk assessment are to be submitted to BKI for information.

BKI reserves the right to reject risk acceptance criteria that would be considered to provide higher risks levels than the implicit ones in BKI Rules for conventional ships having the same purpose or design.

2.6 Risk Control Options (RCO)

2.6.1 Principles

Considering the results of the risk evaluation, risk control options (RCO) may be defined. The RCO should be determined to prevent the occurrence or to mitigate the consequences of an accident scenario.

2.6.2 Risk reduction measures

The RCO should be categorised by considering one or more, but not limited to, of the following attributes:

- preventive: when reducing the frequency of the event through better design, procedures, organisation policies, training, etc.
- mitigating: when reducing the severity of the outcome of the event

The following categorisation should also be considered:

- inherent: when choices are made in the design concept that restrict the level of potential risk
- engineering: when safety features (either built in or added on) are within the design
- procedural: when crew or operators control the risk by behaving in accordance with defined procedures.

As a general guidance, the risk control options selection process should focus on preventive rather than mitigating measures and inherent or engineering rather than procedural measures. Typical RCO for ships covered in Table 2.15.

Table 2.15 Risk Control Options

Category	Risk Control Option
Unmanned ship and Remote Control Centre	Design of RCC for a proper control and monitor Suitable RCC manning as well as training of operators
	Ship should be directly controlled in heavy or complex traffic
	A ship without accommodation is easier to secure against stowaways
Unmanned maintenance and technical operations	Design of aboard systems for easy maintenance and accurate monitoring of maintenance state Must also be fast to repair
	Need redundant power generation, distribution, propulsion and steering
	Automated fire extinguishing systems are required in all relevant areas Note that no crew makes this simpler as areas are smaller and that CO can be used more safely
	Improved cargo monitoring and planning is required.
Heavy weather	Software are to be able to avoid heavy or otherwise dangerous weather – use of weather routing.
	Restricted navigation notation
Sensors systems	Need good sensor and avoidance systems. Selected systems must also be redundant so that a single failure does not disable critical functions identified during the risk assessment.
Cybersecurity	Cybersecurity measures are important, including alternative position estimation based on non-GPS systems. The RCC may be particularly vulnerable. Data communication links must also have sufficient redundancy.

Section 3 Structure

A Scope

This Section covers all structure required to enable ship 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.

B. Goal

The structure shall be designed, constructed and maintained to enable ship to be operated and maintained safely as and when required within its design or imposed limitations in all reasonably foreseeable operating conditions.

C. Functional Objectives

1. The structure shall be designed and constructed to:

1) Enable the ship to operate in all reasonably foreseeable operating conditions;
2) Carry and respond to all foreseen loads in a predictable manner commensurate with operational limitation and safety requirements;
3) Meet requirements for watertight, weathertight and fire integrity;
4) Enable the maintenance and repair in accordance with maintenance information.

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

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

D. Performance Requirements

1. The ships shall be designed to operate in all reasonably foreseeable operating conditions and carry all defined operational loads in accordance with operational limitation.

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.

3. As a minimum, consideration should be given to the following demands, as applicable:

1) Above water: Wind, air temperatures (high and low), ice accretion, solar radiation;
2) Sea surface: Waves, green seas, ice navigation, ship motions (including slamming);
3) Below water: Hydrostatic.

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:

1) Cradling/docking, launch and recovery, securing or transport;
2) Permanent weights, solid ballast;
3) Cargo, fuel and ballast;
4) Stores and equipment;
5) Machinery equipment.

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.

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

1) Anchoring, mooring and towing, beaching and grounding;
2) Loads imposed by mission equipment.

7. The structure shall be designed considering the following:

1) Ruggedness;
2) Structural continuity;
3) Environmental degradation: corrosion, erosion.

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:

1) Maximum and minimum operating temperatures;
2) Fire;
3) U.V exposure;

9. All materials shall comply with the requirements defined in BKI Rules for Materials (Pt.1, Vol V).

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

11. Where stability calculations are carried out in accordance with Section 4, including damage conditions, the internal structure, which is required to maintain watertight integrity, shall be designed to withstand the damage load.

12. 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.

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

14. Information and instructions shall be supplied to the Operator to ensure the safe operation under all reasonably foreseeable operating conditions.

15. Information and instructions shall be available to enable the safe repair and maintenance of ship.

Section 4 Stability

A. Scope

This Section covers the provision of buoyancy, stability, and watertight and weathertight integrity required to enable ship to operate in all reasonably foreseeable operating conditions.

B. Goal

The buoyancy, stability, watertight and weathertight integrity shall be sufficient to enable ship to be operated and maintained safely as and when required within its design or imposed limitations in all reasonably foreseeable operating conditions.

C. Functional Objectives

The ship shall be designed and constructed to:

1) Provide an adequate reserve of buoyancy in all reasonably foreseeable operating conditions, in the environment in which it is to be operated;
2) Provide adequate stability to avoid capsizing in all reasonably foreseeable operating conditions, in the environment in which it is to be operated;
3) Prevent unintended ingress of water;
4) Enable the maintenance and repair in accordance with maintenance information.

D. Performance Requirements

1. Watertight boundaries shall be provided, where required, to prevent ingress of water from hydrostatic loads for all reasonably foreseeable operating conditions.

2. Weathertight boundaries shall be provided, where required, to prevent ingress of water from spray and rain for all reasonably foreseeable operating conditions.

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

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.

5. Penetrations in weathertight boundaries shall have weathertight fittings.

6. The ship shall, in any reasonably foreseeable operating conditions:

- Adequately resist roll, heel or list to meet the requirements of all control, electrical, propulsion and manoeuvring and mission systems;
- Return to upright from a roll, heel or list caused by a disturbance subsequent to the removal of the disturbance.

7. The ship shall have a margin of buoyancy and stability appropriate for all reasonably foreseeable operating conditions in accordance to operational limitation.

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

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.

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 requirement stated in operational limitation.

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

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

13. Information and instructions shall be supplied to the Operator to ensure the safe operation under all reasonably foreseeable operating conditions.

Section 5 Navigation System

A. Scope

This Section covers the systems required for safe navigation of the ship. This includes systems for the identification and avoidance of navigational hazards.

B. Goal

The goal of the Navigating Automation System (NAS) is to be able to navigate a ship safely and efficiently along a predefined voyage plan taking into account of traffic and weather conditions in all Reasonably Foreseeable Operating Conditions.

C. Functional Objectives

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

2. The NAS should deal with all matters related to navigation, including voyage planning, docking and undocking, mooring and unmooring, navigation, anchoring and assistance in distress situations.

3. The NAS should include also RCC communication capabilities for remotely controlled or remotely supervised operations

4. The NAS should be aware of traffic and weather conditions and should be able to make a modification of the navigation path accordingly while keeping the ship on the pre-defined voyage plan.

5. The docking, undocking, mooring, unmooring and anchoring operations, as well as the harbour navigation or port approach and the assistance in distress situations should be controlled or remotely supervised in case the degree of automation does not allow a full automation for these operations.

6. The NAS shall be designed and constructed to:

– Enable their operation in all Reasonably Foreseeable Operating Conditions;
– Operate in a predictable manner commensurate with operational limitation and safety requirements;
– Meet requirements for watertight, weathertight and fire integrity;
– Minimise the risk of initiating fire and explosion;
– Enable the maintenance and repair as per manufacturer requirement.

7. Additional systems or equipment not directly covered by this Section, shall not affect the NAS.

8. Adequate access, information and instructions shall be provided for the safe operation and maintenance of the NAS.

D. Performance Requirements

1. Voyage Planning

1.1 The voyage plan describing the full voyage from departure to arrival should be definable and updatable at any time by the crew or remotely by the operators.

1.2 The voyage plan should be defined taking into account the latest updates of charts, weather forecasts and all relevant information relating to the planned area of operations.

1.3 The voyage plan should be established by defining waypoints, headings, turning angles and safe speeds the ship must follow during its voyage.

1.4 In particular, the crew or remote operators should program control points (or appointments) in order to control the progress of the ship.

1.5 Depending on the degree of automation, the NAS should be able to notify the RCC each time the ship is deviating from the planned course and should send an alarm when the deviation is out of specified margins. The tolerance in the deviation should be set in accordance with the context (e.g. in heavy traffic or open sea) in order to avoid overload of information for the supervisor.

2. Navigation

2.1 The data from various ship's sensors should be gathered and evaluated in order to thoroughly determine the location and heading of the ship. Redundant sensors and positioning by multiple sources should ensure a high degree of data accuracy. The current speed and water depth should be monitored as well.

2.2 The data for navigational and weather forecast should be retrieved from combined external sources such as the RCC, AIS transceivers or data providers (Navigational Telex NAVTEX, SafetyNET).

2.3 It should be demonstrated that the NAS is able to identify the COLREG obligation of the ship towards all objects in the vicinity and calculate COLREG-compliant deviation measures for a given traffic conditions.

For path planning, solutions like sampling-based algorithms may be used. For collision avoidance, algorithms like velocity obstacles may be used.

2.4 When the degree of automation requests supervision during operations in harbour (e.g. docking and undocking) or heavy traffic conditions near shore, land-based communication networks should be used to provide a maximum availability and a minimum latency.

2.5 The NAS should also be able to initiate fail-safe sequences as designed, see Section 1.F.13.

3. Docking and undocking

3.1 The docking and undocking procedures should be monitored by sensors (e.g. pressure sensors, radar, etc.) to confirm that there are no obstacles for the safe progress.

3.2 A means should be available to stop the sequence of docking or undocking at any time in the event that the system has not been able to detect a hazardous situation.

4. Lookout

4.1 Any ship covered by this Guidelines should comply with the principles of the Rule 5 of the COLREG as amended by maintaining at all times a proper lookout by sight and hearing as well as by all available means appropriate in the prevailing circumstances and conditions so as to make a full appraisal of the situation and of the risk of collision.

This lookout may be carried out:

- by crew
- by remote operators from the RCC with continuous access to on-board or off-board surveillance and warning systems to prevent collisions
- by an automation system equipped with warning sensors and actuators allowing the ship to react to a collision situation in accordance with international rules (COLREG).

4.2 The ship should independently gather weather data from its own sensors. The accumulated data like wind speed, wave frequencies, should be used for subsequent weather routing and should be also stored and provided to the RCC.

4.3 Navigational sensors aboard the ship should continuously gather data to generate a complete traffic picture of the vicinity of the ship. Objects should be detected, identified and tracked.

See also 8 about collision avoidance and 9 about situational awareness.

4.4 Sensors protection devices should be provided to ensure the good quality of the data transmitted in all weather conditions (high brightness, presence of water, salt, ice,...).

5. Weather routing

5.1 The weather data which have been gathered by the ship should be evaluated in comparison with weather forecasts which have been received from shore via the RCC.

5.2 With this data combination a valid estimation of current and upcoming weather conditions along the navigational and voyage plan of the ship should be made.

5.3 Combined with predefined parameters and taking into account stability and manoeuvrability conditions a route optimization should be conducted under weather routing criteria.

6. Ship status and dynamics

6.1 The ship status data should include position with displacement, draft, trim, ship motions within 6 degrees of freedom and information about propulsion and steering systems. Cargo monitoring should also be part of the ship status.

6.2 The weight distribution aboard the ship should be calculated to determine the ship's buoyancy and to control the stability.

6.3 The dynamics of the ship (velocities and acceleration) should be predicted within a short time frame (less than 5 minutes) based on own ship's characteristics as well as environmental conditions (e.g. wind, wave headings and frequencies).

6.4 It is the crew and remote operators responsibility to load and operate the ship in a proper manner.

In particular, it will be assumed that:

- the draught of the ship in operating conditions will not exceed that corresponding to the freeboard assigned
- the ship will be properly loaded taking into account both its stability and the stresses imposed on its structures

- cargoes will be properly stowed and suitably secured
- the speed and course of the ship are adapted to the prevailing sea and weather conditions according to the normal prudent seamanship.

6.5 Particular attention should be paid by operators to the remote monitoring and control of operations to compensate for impaired situational awareness caused by the absence of certain human senses at the remote control station such as balance, acceleration, smell, temperature, vibrations, etc.

7 Voyage recording

7.1 Data from essential services and any other significant process identified during the risk assessment should be received and stored in the log book or equivalent data recording device. Situational data are similar to what is recorded by a VDR and should be complemented with expected or unexpected events or decisions. Such devices shall be protected against unauthorised access

7.2 Data type regularly submitted to the RCC and their associated intervals and amount should depend on the current ship control mode (e.g. remote or full automation).

7.3 All log book data should be able to be retrieved directly by the RCC at any time.

8. Collision avoidance

8.1 Ship 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 ship is operating and which lights and shapes are being displayed or which sound signals are being broadcast at any time.

8.2 Ship 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 ship is operating and which sound signals are being broadcast at any time

8.2 To navigate the ship safely and to be COLREG compliant a continuous monitoring of the current traffic situation should be performed.

8.3 All traffic-related data should be combined and assessed and possible future scenarios predicted.

8.4 As soon as a potential close quarters situation is identified, appropriate measures should be taken, such as:

- reduce speed
- predict and anticipate the obstacle’s motions
- deviate from the initial ship’s path.

9. Situational awareness

9.1 Relevant input parameters for the process of navigation should be provided by devices (e.g. sensors) to have an accurate situational awareness, which provides the NAS with a perception of the vicinity of the ship, including environmental conditions as well as with target data for detected objects.

This perception should be done for example by using a sensor fusion-based approach where raw sensor data from existing navigational sensors (e.g. data provided by LIDARs, cameras, radars and GNSS) are gathered, processed and correlated among themselves to map a realistic representation of the ship’s environment.

9.2 Special attention should be paid to the limitations due to technical reasons and legal reasons (COLREG). The sensors should be able to detect floating or partly submerged object of standard container size (typically several meters) in a mid-range distance (typically less than one kilometre).

9.3 The sensors should be also capable of detection of a life raft or a person in the water in a short range distance (typically several hundred metres).

9.4 The sensors should be able to detect any limitation in the operating range such as a reduced visibility (e.g. use of Circular Error Probability to detect uncertainties of object position).

10. Operation and Maintenance

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

10.2 It shall be possible to disable and isolate the NAS to allow inspection and maintenance tasks to be safely performed on the ship.

10.3 System diagrams and instructions shall be provided for maintenance of the NAS in a language and format that can be understood.

E. Reference

1. The NAS should be compliant with the applicable requirements related to the assignment of the following additional class notation from BKI Rules as applicable:

- for one man console (**NAV-O** or **NAV-OC**)

  see Guidance for Class Notation (Pt.0, Vol.B) Sec. 3.B.2
- for dynamic positioning with redundancy (**DPx**)

  see Guidance for Class Notation (Pt.0, Vol.B) Sec. 3.B.2

2. The applicable requirements related to the assignment of these additional class notations may be adjusted to the satisfaction of BKI

3. Radionavigation system, GNSS and shipborne Position, Navigation and Timing (PNT) data processing should be compliant with the applicable requirements of the following standards as amended:

- IMO Resolution A.1046(27) Worldwide radionavigation system
- IMO Resolution A.915(22) Revised maritime policy and requirements for a future Global Navigation Satellite System (GNSS)
- IMO Resolution MSC.401(95) Performance standards for multi-system shipborne radionavigation receivers
- IMO MSC.1/CIRC.1575 Guidelines for shipborne Position Navigation and Timing (PNT) data processing

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Section 6 Machinery System

A. Scope

The provision of this section apply to main propulsion machinery , manoeuvring machinery, 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 component for control system, which is covered in Section 8.

B. Goal

The machinery systems shall be designed to enable ship to be operated and maintained safely as and when required within its design limitations in all reasonably foreseeable operating conditions.

C. Functional Objective

1. The machinery system shall be designed and constructed to:

- Enable their operation in all reasonably foreseeable operating conditions;
- Operate in a predictable manner in accordance to operational limitation and safety requirement;
- Meet requirements for watertight, weathertight and fire integrity;
- Minimize the risk of initiating fire and explosion;
- Enable the maintenance and repair in accordance with maintenance information.

2. Additional systems or equipment not directly covered by this section, shall not affect the machinery system.

D. Performance Requirements

1. General

1.1 For all machinery 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.

1.2 Ambient conditions shall be controlled, where required, to suit the operating environment and all machinery system requirements.

1.3 The propulsion systems shall be designed to meet the required operating speed in all reasonably foreseeable operating conditions.

1.4 The manoeuvring system shall be designed to meet the required manoeuvring requirements in all reasonably foreseeable operating conditions.

1.5 Auxiliary systems shall be designed to meet the mission equipment and mission function requirements in all reasonably foreseeable operating conditions.

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

1.7 Any penetrations in watertight and weathertight boundaries due to propulsion and manoeuvring systems shall be designed in accordance with the requirements of Section 4.

1.8 All machinery systems shall be designed such that they will not unduly affect any other system including under failure conditions.

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.

1.10 Safe access shall be provided to all machinery system including means of isolation and access provision in the event of equipment failure or for maintenance.

1.11 Information and instructions shall be supplied to the operator to ensure the safe operation, fault finding and maintenance machinery, under all reasonably foreseeable operating conditions.

2. Maintenance

2.1 Machinery system should be designed to allow an extended period of time without any physical interference in the machinery spaces.

2.2 Based on the condition assessment of the machinery, the system should suggest or take corrective actions for the prevention of machinery failure. Instead of a condition based maintenance, systematic preventive maintenance should also be adopted.

2.3 Information on the need for spare parts that enable ordering in advance should be delivered to the operators.

3. Fire protection

Machinery system shall be designed to minimize the risk of initiating a fire, including consideration of the following :

- Surface temperatures of systems shall not become a source of ignition in case of flammable fluid leaks;
- Failure of a joining arrangement shall not pose a further risk (e.g. due to atomization of hydrocarbons, leakage of water onto electrical equipment etc);
- Suitable arrangements to prevent the ignition of vapours in a tank shall be provided.

Section 7 Electrical Installation

A. Scope

This section 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 Section 8.

B. Goal

The electrical system shall be designed to enable the Ship to be operated and maintained safely as and when required within its design or imposed limitations in all Reasonably Foreseeable Operating Conditions.

C. Functional objectives

1. The electrical system shall be designed and constructed to:

1) Operate in all Reasonably Foreseeable Operating Conditions;
2) Operate in a predictable manner in accordance to operational limitation and safety requirements;
3) Meet requirements for watertight, weathertight and fire integrity;
4) Minimise the risk of initiating fire and explosion;
5) Enable the maintenance and repair as required.

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

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

D. Performance Requirements

1. The electrical system shall be designed and arranged to meet design requirement, considering equipment failure rates and the effect of flood or fire.

2. Sufficient power shall be provided to supply all Ship consumers with an appropriate margin and level of redundancy corresponding to the operational limitation.

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

4. The Quality of Power Supply (QPS) shall be maintained at the level required by all ship consumers taking account of all reasonably foreseeable operating conditions.

5. Where a reserve power supply is required in the event of failure or loss of the main electrical supply, the following shall be considered:

- Size of demand;
- Speed of transition;
- Duration of demand;
- Integrity of reserve power supply;
- Location and routing of reserve power supply.

6. Electrical equipment shall be designed for the maximum load for all reasonably foreseeable operating conditions.

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

8. The design of distribution system shall be suitable for the functional requirements of the Ship and portable and mission specific equipment for all reasonably foreseeable operating conditions.

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.

10. The electrical system shall not be affected by any EMC (Electromagnetic Compatibility) interference and shall not cause interference to other systems within the Ship and external to it for all Reasonably Foreseeable Operating Conditions.

11. Any penetrations in watertight and weathertight boundaries due to the electrical system shall be designed in accordance with the requirements of Section 4.

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

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

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.

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.

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

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

18. Protection shall be provided against damage to ship systems from overcurrent.

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

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

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

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

23. Suitable protection arrangements for lightning strikes shall be provided.

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

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

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

- it shall be of a type suitable for the environment for which it will be operated;
- a means shall be provided to detect and alert the operator of any abnormal parameters which may lead to ignition of the atmosphere.

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

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

29. Ageing effects on the performance of energy storage devices shall be considered over the lifetime of the Ship.

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

31. Electrical power generation required for propulsion and manoeuvring systems are to meet the design requirements.

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

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

- Suitable arrangements for the isolation and switching of distribution circuits;
- Protection from the risk of static electricity;
- Indication of the nature of the potential hazards at the entrance(s) to the space, and on the equipment where applicable.

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Section 8 Control System

A. Scope

This Section 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 ship and any off-board facility (Remote Control Centre) that performs a monitoring and/or control function of propulsion, manoeuvring and the transmission of data to carry out these functions. It does not include monitoring and/or control of mission systems.

B. Goal

The goal of control system shall be designed to enable the ship to be operated and maintained safely as and when required within its design or imposed limitations in all reasonably foreseeable operating conditions.

C. Functional Objectives

1. The ship shall be able to monitor and control all systems required for propulsion, manoeuvring and auxiliary system.

2. The control system shall be designed and constructed to:

– Enable its operation in all reasonably foreseeable operating conditions;
– Operate in a predictable manner in accordance to operational limitation and safety requirements;
– Meet requirements for watertight, weathertight and fire integrity;
– Minimise the risk of initiating fire and explosion;
– Enable maintenance and repair in accordance to maintenance information.

3. The remote control centre shall be design and constructed to :

– Display suitable information, facilitate the decision making process and remote control for the operators.
– Provide means of communications with ships and any other decision centre taking part in the operation of the ships.
– Comply with land-based regulations as applicable.
– Comply with ISM code and ISPS code.

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

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

D. Performance Requirements

1. General

1.1 The control system shall be designed and arranged according to considering the degrees of automation, equipment failure rates and the effects of flood or fire.

1.2 The ship shall be fitted with sensors, systems and equipment to provide feedback to the operator or automation control system of the operating state and potential hazards. The feedback should be appropriate for the degrees of automation, and operating state and environment of the ship.

A visual monitoring should be provided by at least one CCTV system in particular for ships with high degrees of automation (e.g degree A3 or A4).

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

1.4 All aspects (on-board and off-board) of the control system shall be designed with consideration of the human-system interface. see also Section 14.C.

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.

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 ship.

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

1.8 The power source for the control system shall be designed in accordance to control system characteristics explained in operational limitations.

1.9 An audible and visual alert shall be provided to the operator in the event of failure of the power source.

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

1.11 An emergency manual control enacted through an independent system is to be provided in a prominent position on all primary and secondary operator consoles to activate a safe state.

1.12 An alert system shall be provided to inform operators as soon as reasonably practicable of deviations from normal or expected operation of ship systems.

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.

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 according to operational limitation.

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.

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.

1.17 The control system shall be protected against:

– unauthorised access;

– unintended change.

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

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

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

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.

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

1.23 Where alternative control locations are available:

– It shall only be possible to control ship 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;

– Alternative control locations shall be designed according to operational limitation.

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

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 ship.

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

2. Remote Control Centre (RCC)

2.1 Means of communication

2.1.1 The RCC should be linked to the ship, to the Vessel Traffic Services (VTS), to the port authorities or the shipping company by using communication technologies that are available (e.g. GSM, WiMax, VHF or satellite).

2.1.2 With regard to the obligation of assistance (SOLAS Chapter V Reg.33), it should be ensured at a minimum that distress signals are received and relayed by the RCC to the relevant search and rescue authorities.

2.2 Monitoring and control

2.2.1 The RCC should be able to plan and to upload voyage data to the ship.

2.2.2 The RCC operators should be able to easily identify operational abnormalities, unexpected threats and errors efficiently in a highly automated context and then communicate this situation to other stakeholders in the RCC.

2.2.3 The RCC operator is to be alerted if the ship is approaching operating range limit. If the ship exceeds the operating range limit, it shall automatically return into a safe state alerting the operator.

2.2.4 The same RCC may simultaneously monitor and control several ships operating in a coordinated (swarm) or independent manner. In this last case, it is recommended to gather information about essential services on one dashboard for each ship under monitoring and control.

2.2.5 In addition to have a clear visibility around the ship as requested by SOLAS Ch V reg 22 (Navigation bridge visibility), the dashboard should also include sea chart, radar screen and weather chart.

2.2.6 The dashboard should display an information panel summarizing essential services to have a clear view of the situation of the ship with for each of them, a coloured flag indicator:

– green for normal situation

– yellow for warning that require operators attention and verification

– red for alert that require operators immediate corrective actions.

2.2.7 See also Section 14.C.

2.3 Manning

2.3.1 The RCC should be manned with qualified, certified and medically fit personnel, such as operators, supervisors, ship engineers and captains.

2.3.2 The RCC should be appropriately manned in order to encompass all aspects of maintaining safe operations aboard ships remotely monitored and controlled.

2.3.3 Personnel should have sufficient sea-going or in service experiences related to an equivalent ship under control.

2.3.4 Simulator training should be used for practicing of operators and supervisors.

2.3.5 Taking into account the fatigue due to the large time spent on computer’s screen, the proportion between rest and duty periods should be arranged to ensure the efficiency of the watch keeping.

2.3.6 The RCC should be manned for uninterrupted supervision during operations. A chain of RCCs around the world could alternate in monitoring and controlling a ship always making sure the center in control have daylight hours, to avoid night shifts with increased risk of accidents.

3. Automation control system (On Board)

3.1 The automation control system shall carry out the programmed mission in an accurate and timely manner according to operational limitation.

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

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

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

3.5 The link between the automation control system and the operator is to be as far as reasonably practicable maintained at all times.

E. References

1. Control system should be compliant with the applicable requirements related to the assignment of the following additional class notation listed in Guidance for Class Notations (Pt.0, Vol.B,) Sec.3.B, as applicable.

OT, OT-nh, OT-S, OT-F, RC

2. The applicable requirements related to the assignment of those additional class notations may be adjusted to the satisfaction of BKI according to the results of the risk assessment, the degree of automation, the degree of direct control and remote control, the navigation notation, the operational limitations, the possibility of external rescue, etc.

3. The ergonomics and the layout of the RCC should be based on the following international standards:

ISO 11064 (all parts) Ergonomics design of control centres.

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Section 9 Communication System

A. Scope

This section covers the requirements for communication network and system used to transfer data externally and internally.

B. Goal

The goal of the communication network and system is to be available to transfer data externally (ship to RCC, ship to shore, ship to ship) and internally, without compromising their integrity in all reasonably foreseeable operating conditions.

C. Functional Objectives

1. Land-based and space-based communication system should be used for the ship to RCC and ship to shore communications. For ship to ship communications, a line of sight (LOS) communication system should be used.

2. The ship should include an efficient and secure network for communication between systems internally and externally.

3. The communication system should be designed to operate with different level of communication quality and should be resilient to a signal degradation.

4. The communication system shall be designed and constructed to:

- Enable their operation in all reasonably foreseeable operating conditions;
- Operate in a predictable manner commensurate with operational limitation and safety requirements;
- Enable the maintenance and repair according to maintenance information.

5. Additional systems or equipment not directly covered by this Section, shall not affect the communication system.

D. Performance Requirements

1. Type of communication system

1.1 For external communication, in order to maintain a correct level of availability in case of failure, backup arrangement is to be provided for the transmission of critical data. In the event of a failure, an automatic transition between the main and the backup solution should be provided, and an alarm should be triggered.

1.2 Different frequency bands should be used in order to minimize the risks of disturbance of signals due to atmospheric effects (e.g. fading due to heavy rain).

1.3 Line of sight communication systems should be mainly based on AIS or digital VHF systems with a range of at least two kilometres.

3. Performance

3.1 Remotely controlled ship should require more communication bandwidth for operation than a conventional ship and should require several communication channels.

3.2 Bandwidth and latency of the communication network and system should be adequate for the traffic that is mainly oriented from ship to RCC or ship to shore due to the amount of data transmitted by the automation systems.

3.3 Methods for reducing the amount of data to only what is needed for human perception should be considered. Methods such as reduction of the frame-rate, the image resolution or an efficient image compression can be used.

E. References

1. The communication network and system should be compliant with the applicable requirements from IEC 61850-90-4 Network Engineering.

Section 10 Mooring and Anchoring

A. Scope

1. This Section applies to the mode of mooring using mooring lines and mode of anchoring using anchor and chain.

2. When the ship adopts other mooring modes and mooring equipment different from that described in this Section, the risk assessment of mooring and anchoring systems is to be carried out so as to meet the goal set out in this Section.

3. Ship's mooring and anchoring equipment is to be controlled and operated by personnel boarding the ship when needed.

B. Goal

The goal of this Section is to ensure that the ship can safely complete the berthing and departing at the dock or dropping and weighing anchor at the anchorage, and that it can be effectively fastened to the preset position.

C. Functional objectives

1. The mooring and anchoring systems shall be designed and constructed to:

1) ensure the ship berths and departs in safely condition.
2) maintain the ship at preset position.
3) operate in all reasonably foreseeable operating conditions;
4) Enable the maintenance and repair in accordance with maintenance information.

2. Additional systems or equipment not directly covered by this Section, shall not affect the mooring and anchoring operation.

3. Operators shall be provided with adequate access, information and instructions for the safe operation of mooring and anchoring.

D. Performance Requirements

1. Mooring System

1.1 Under the condition of remote control, the ship itself or with the navigation aids of external forces can realize berthing and departing.

1.2 When the ship berths and departs autonomously, the ship is to have sufficient power and maneuvering ability and can safely berth and depart in all reasonably foreseeable operating conditions.

1.3 The mooring control system is to satisfy the following requirements:

- evaluation on whether berthing, mooring and unberthing can be carried out in accordance with the signal and data detected and received on a real-time basis, the limitation of the ship's manoeuvring capability (including navigation aided by external force) and the limitation of the mooring capability;
- a plan of berthing, mooring and unberthing is developed if the capability is sufficient as determined by the evaluation result;
- during the implementation of plan, environmental loads and hawser conditions are monitored on a real-time basis and if necessary, the plan should be adjusted;
- where the ship's safety condition cannot be maintained as determined by the control system, an alarm message is to be sent to the remote control center.

1.4 The mooring equipment is to effectively keep the ship at preset position in all reasonably foreseeable operating conditions.

1.5 The ship is to have the function of mooring line delivery and recovery.

1.6 The mooring line pulling force condition can be monitored and adjusted, to make sure that the remote control center is able to implement the function of monitoring and communication for the dock.

2. Anchoring System

2.1 The anchor handling operations can be carried out under the condition of remote control.

2.2 When the ship is anchoring autonomously, the anchor handling operations can be safely carried out in all reasonably foreseeable operating conditions.

2.3 The anchoring control system is to satisfy the following requirements:

- evaluation on whether anchoring operation can be carried out in accordance with the signal and data detected and received on a real-time basis, and the limitation of the ship's anchoring capability;
- a plan of anchor handling is developed if the capability is sufficient as determined by the evaluation result;
- during the implementation of plan, environmental loads and chain cable conditions are monitored on a real-time basis and if necessary, the plan should be adjusted;
- in the anchoring condition, in case that it is judged by the control system that collision might be caused by the dragging of the anchor of the ship itself or other ships, the ship's manoeuvring system is to be started automatically to adjust the chain cable condition or sail away by hoisting/abandoning anchor;
- where the ship's safety condition cannot be maintained as determined by the control system, an alarm message is to be sent to the remote control center.

2.4 The anchoring system is to effectively keep the ship at preset position in all reasonably foreseeable operating conditions.

2.5 The release length, speed and tension of the anchor chain are to be monitored.

2.6 The anchoring system is to be able to receive the information of anchorage and anchor position, to make sure that the remote control center can monitor the surroundings of the anchorage, and send alarm to remote control center in emergency.

3. Operation and Maintenance

3.1 Operators shall be provided with adequate information and instructions for the safe and effective of mooring and anchoring operations. These shall be presented in a language and format that can be understood by the operator in the context in which it is required.

3.2 It shall be possible to disable and isolate the mooring and anchoring operations to allow inspection and maintenance tasks to be safely performed on the ship.

3.3 System diagrams and instructions shall be provided for maintenance of the mooring and anchoring in a language and format that can be understood

E. Reference

The design and construction of the mooring and anchoring should comply to Rules for Hull (Pt.1, Vol.II) as applicable.

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Section 11 Fire Safety System

A. Scope

The provision of this section apply to all structure, equipment and component relating to fire safety and the hazards that these create and minimizing 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 crew.

B. Goal

The fire safety systems shall be designed to detect and extinguish fire to enable the ship to be operated and maintained safely and to protect the ship in all reasonably foreseeable operating conditions.

C. Functional Objective

1. The ship shall be designed and constructed to minimize the risk of initiating a fire.

2. The ship shall be designed and constructed to detect, contain and extinguish a fire.

3. The fire system shall be designed to:

- Enable their operation in all foreseeable operating conditions;
- Operate in a predictable manner in accordance to operational limitation and safety requirement;
- Meet requirements for watertight, weathertight and fire integrity;
- Enable maintenance and repair in accordance with maintenance information.

D. Performance Requirements

1. Risk of Ignition and growth

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

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

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

1.4. Ignition sources shall be minimized.

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

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

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.

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

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

2 Detection and alerts

2.1 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 Section 8.

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

3. Containment and structural integrity

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.

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

- Threaten the structural integrity of the ship 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.

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

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.

3.5 The ship shall be subdivided by thermal and structural boundaries. Active and/or passive containment arrangements may be used.

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.

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

4. Extinction

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

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.

4.3 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 Control and activation of fire-extinguishing systems shall be designed in accordance with the appropriate Section 8.

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

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.

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

4.8 Fixed systems shall not endanger stability nor pressurise compartments.

4.9 Status of extinguishing systems shall be provided to the operator.

4.10 The fire extinguishing systems shall have appropriate margin and level of redundancy.

5. Maintenance

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

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.

E. Reference

Fire safety system should be comply to BKI Rules, as applicable:

– Rules for Hull (Pt.1, Vol.II) Sec.22
– Rules for Machinery (Pt.1, Vol.III) Sec. 12

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Section 12 Ship Security

A. Scope

This Section covers all equipment and components related to the ship security. This includes the design, installation and operation of the ship security system.

B. Goal

The ship security system is to provide the requirements on the design, installation and operation of the security system in order to prevent unauthorized entry into the ship in all reasonably foreseeable operating conditions.

C. Functional Objectives

1. An effective security system is to be provided by the ship with at least the following functions:

- access control;
- detection, surveillance and alarms;
- security communication.

2. The ship structures and spaces are to be so arranged as to be capable of physically preventing unauthorized access.

3. The remote control centre is to be capable of detecting and identifying a suspected target which follows, approaches and interferes with the ship, and can monitor the entry into the means of access to the ship and into the sensitive spaces in the ship.

4. Where the ship finds the approach of a suspected target, it is to send alarm to the remote control centre.

5. The remote control centre is to be able to automatically receive the security information on the intended navigation routes released by the relevant Authority.

6. The ship is to be able to receive all externally broadcast security information as sea, store and process the security information detected and monitored on board, and transmit the information to the remote control centre.

7. The system shall be designed and constructed to:

- Enable their operation in all Reasonably Foreseeable Operating Conditions;
- Operate in a predictable manner commensurate with operational limitation and safety requirements;
- Enable the maintenance and repair according to maintenance information .

D. Performance Requirements

1. Access control

1.1 The number of openings in the external boundaries of hull, superstructures and deck house are to be minimized to meet the minimum requirements of the intended usage.

1.2 The door to any means of access in the ship is to be capable of automatic closing. The locking arrangement of doors and access (e.g. small hatchways) is to be so designed that they can be only opened from the entry side by a person authorized to enter and can be remotely opened or closed by the remote control centre.

2. Detection, surveillance and alarms

2.1 The range of on board detection and surveillance systems is to cover overboard surrounding areas, means of access to the ship and restricted areas on board. The detection capacity is to be such that a suspected object of at least a standard container size, within a range of 2 nautical miles, as well as its direction of movement and speed, can be identified.

2.2 Ship and its security system are to meet the following requirements:

- The detection system fitted on the ship is to be able to automatically send a warning to the remote control centre once detecting the approach of a suspected object;
- On board spaces and means of access are to be provided with adequate lighting. Detection, surveillance and lighting equipment is able to be controlled by the remote control centre, so as to facilitate remote security patrol.
- The ship is to be installed with a security alert system, so that the remote control centre can send the security warning to the Administration once it judges that the security of the ship is sabotaged.

3. Security communication

3.1 The communication systems of the ship and the remote control centre are to be capable of keeping ship security communication, information and equipment smooth and unimpeded at all times, and security communication records are to be maintained.

3.2 Computer systems and their network design used for all autonomous and remote control operations in the ship and in the remote control centre are to comply with the requirements of Section 14.

3.3 Ship security plans and their implementation as required by the Administrations are to be part of the management system of remote control centre as specified in Section 8.

4. Maintenance

4.1 It shall be possible to disable and isolate the system to allow inspection and maintenance tasks to be safely performed on the ship.

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

Section 13 Special Systems

A. Cargo Management System

1. Scope

1.1 This sub-section covers the systems needed to ensure the safety of the cargo and prevent it from being a danger to the ship or the environment. The responsibility of the system includes monitoring, control and performing loading and unloading.

2. Goal

2.1 The goal of the cargo management automation system is to ensure that cargo does not compromise the safety of the ship or not degrade the environment in all Reasonably foreseeable operating conditions.

3. Functional Objectives

3.1 The cargo management automation system should collect and monitor the main cargo parameters.

3.2 The loading and unloading sequences should be properly handled by the cargo management automation system.

3.3 The system shall be designed and constructed to:

- Enable their operation in all Reasonably foreseeable operating conditions;
- Operate in a predictable manner commensurate with operational limitation and safety requirements;
- Meet requirements for watertight, weathertight and fire integrity;
- Minimise the risk of initiating fire and explosion;
- Enable the maintenance and repair according to maintenance information.

3.4 Additional systems or equipment not directly covered by this Section, shall not affect the cargo management system.

3.5 Adequate access, information and instructions shall be provided for the safe operation and maintenance of the cargo management system.

4. Performance Requirements

4.1 Monitoring

4.1.1 The cargo parameters should be collected and analysed by means of sensors installed in the cargo hold, within the carrying device or directly on the cargo. A visual monitoring should also be provided.

4.1.2 The temperature, the pressure, the gas, the water incoming, the cargo shifting, are the main parameters that should be monitored.

4.1.3 An alarm system able to issue warning or alert to the crew or the operators should be provided for the detection of abnormal values for each cargo parameter.

4.2 Control

4.2.1 Means should be provided to automatically control the cargo parameters, such as for heating, cooling, ventilating or pumping.

4.3 Loading and Unloading

4.3.1 During the loading and unloading sequences, the cargo management automation system should monitor the cargo capacity, the ballast water, the ship's structural strength and the stability (loads induced by the cargo).

4.4 Operation and Maintenance

4.4.1 Operators shall be provided with adequate information and instructions for the safe and effective operation of the system. These shall be presented in a language and format that can be understood by the operator in the context in which it is required.

4.4.2 It shall be possible to disable and isolate the system to allow inspection and maintenance tasks to be safely performed on the ship.

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

5. References

5.1 The cargo management system should be compliant with the applicable requirements related to the assignment of the following additional class notation from BKI Rules listed in Section 1.G.2.1, as applicable:

– for refrigerated cargo

  CRS, **RIC**

  see Guidance for Class Notations (Pt.0, Vol.B), Sec.3.B.3

– for refrigerated cargo in controlled atmosphere

  CA, **CA mob**

  see Guidance for Class Notations (Pt.0, Vol.B), Sec.3.B.3

– for refrigerated container

  RCP x/y

  see Guidance for Class Notations (Pt.0, Vol.B), Sec.3.B.3

– for liquefied gases in bulk

  RI

  see Guidance for Class Notations (Pt.0, Vol.B), Sec.3.B.3

– for loading computer

  LCS

  see Guidance for Class Notations (Pt.0, Vol.B), Sec.3.A.3

5.2 The applicable requirements related to the assignment of these additional class notations may be adjusted to the satisfaction of BKI according to the results of the risk assessment, the degree of automation, the degrees of direct control and remote control, the navigation notation, the operational limitations, the possibility of external rescue, etc.

B. Passenger Management System

1. Scope

1.1 This subsection covers the systems needed to ensure the safety of the passengers for the whole voyage. These includes the function of life-saving and man overboard prevention.

2. Goal

2.1 The goal of the passenger management system is to ensure the safety of passengers during a voyage in all Reasonably foreseeable operating conditions.

3. Functional Objectives

3.1 The passenger management system should prevent any overload due to an exceedance of the ship's capacity.

3.2 During boarding and un-boarding sequences, the passenger management system should prevent any passenger from injury.

3.3 In case of a critical incident (e.g. man overboard), the passenger management system should provide means for alerting and rescuing.

3.4 All systems aboard should be designed to avoid any deliberate or unwilled interference or obstruction by a passenger.

3.5 Passengers should have the possibility to activate an emergency push button in case of critical situation (e.g. passenger overboard, obstacle during docking).

3.3 The system shall be designed and constructed to:

– Enable their operation in all Reasonably foreseeable operating conditions;
– Operate in a predictable manner commensurate with operational limitation and safety requirements;
– Meet requirements for watertight, weathertight and fire integrity;
– Minimise the risk of initiating fire and explosion;
– Enable the maintenance and repair according to maintenance information.

3.4 Additional systems or equipment not directly covered by this Section, shall not affect the passenger management system.

3.5 Adequate access, information and instructions shall be provided for the safe operation and maintenance of the passenger management system.

4. Performance Requirements

4.1 Overload Prevention

4.1.1 In order to prevent the overload, a system should be provided to determine the number of passenger with regard to the capacity of the ship. This system should be arranged prior to the boarding stage of the passengers.

4.1.2 In order to ensure that the ship has sufficient freeboard, an alarm should be installed and triggered when the waterline exceed the load line.

4.1.3 The ship's capacity should be estimated by a maximum number of person and/or approximate weight. This estimation should take into account a safety margin for additional weight per passenger (e.g. due to luggage, bicycle, etc.).

4.2 Life saving

4.2.1 The life saving appliances should be stowed in order to be accessible for all passengers and should be designed to be simple to use. A convenient solution should be for each passenger to wear a life jacket.

4.2.2 In case of a passenger overboard, an alarm should be accessible to the passengers aboard (emergency push button) and/or should be activated by the passenger in the water (radio or water activated) to maintain the ship near the actual position and to alert the rescue team.

4.2.3 Any ship should be able to detect the presence of a liferaft or person in the water near the ship and this detection should be reported to the RCC if any.

4.2.4 Sufficient number of survival craft shall be provided.

4.3 Operation and Maintenance

4.3.1 Operators shall be provided with adequate information and instructions for the safe and effective operation of the system. These shall be presented in a language and format that can be understood by the operator in the context in which it is required.

4.3.2 It shall be possible to disable and isolate the system to allow inspection and maintenance tasks to be safely performed on the ship.

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

5. References

5.1 The passenger management system should be compliant with the applicable requirements and regulations of SOLAS as amended, in particular those from Chapter III about Life-saving appliances and arrangements.

Section 14 Reliability of Automation Systems

A. General

1. Scope

1.1 This Section provides guidelines for improving the reliability of automation systems associated with essential services of any ship covered by this Guidelines.

B. General system design

1. References

1.1 Design, construction, commissioning and maintenance of all computer based systems associated to essential services should be in accordance with the requirements of Rules for Electrical Installation (Pt.1, Vol.IV), Sec. 10

1.2 The computerized based system life cycle should be based on the following international standards:

- ISO/IEC/IEEE 15288 Systems and software engineering - System life cycle processes
- ISO/IEC/IEEE 12207 Systems and software engineering - Software life cycle processes
- ISO/IEC 61508 (all parts) Functional safety of electrical/ electronic/programmable electronic safety-related systems.

2. Risk-based design

2.1 A risk-based design approach (failure analysis) should be adopted to identify, evaluate and mitigate the effects of a system failure. The methodology should be based on a Failure Mode Effects and Criticality Analysis (FMECA).

2.2 The boundaries of the system should be clearly identified with all critical components that may affect the safety of operations.

3. Component failure

3.1 The system should be designed in such a way that a failure of one component should not affect the functionality of other components except for those functions directly dependent upon the information from the defective component.

3.2 System and software should be fault tolerant and providing an acceptable level of resilience against unexpected failure.

3.3 This resiliency should be achieved by using an appropriate redundancy on the system’s critical components (e.g. power supply, communication equipment).

4. Network failure

4.1 When the systems are interconnected through a network, failure of the network should not prevent individual system from performing its functions.

5. Power failure

5.1 The system should be arranged with an automatic change-over to a continuously available reserve power supply in case of loss of main power source.

5.2 Refer to Section 7 for the requirement of reserve power supply

C. Human machine interface

1. References

1.1 The ergonomics, the layout and interfaces of the system should be based on the following international standards:

- IMO A.1021(26) Code on alerts and indicators.
- IMO MSC/CIRC.982 Guidelines on ergonomic criteria for bridge equipment and layout
- ISO 9241-210 Ergonomics of human-system interaction Part 210 - Human-centred design for interactive systems
- ISO 8468 Ships and marine technology - Ship's bridge layout and associated equipment - Requirements and guidelines
- ISO 2412 Shipbuilding - Colours of indicator lights.

2. Design

2.1 The human machine interface should be designed to be easily understood in a consistent style. Particular consideration should be given to:

- symbols
- colours
- controls
- information priorities
- layout.

2.2 System’s controls and indicators should be designed with due regard to human. Controls and indicators are to be so constructed that they can be efficiently operated by suitably qualified personnel.

3. Information display

3.1 Continuously displayed information should be reduced to the minimum necessary for safe operation. Supplementary information should be readily accessible.

3.2 Operational information should be presented in a readily understandable format without the need to transpose, compute or translate.

3.3 Displays and indicators should present the simplest information consistent with their function.

3.4 All information required by the user to perform an operation should be available on the current display.

3.5 The human machine interface should use marine terminology.

4. Controls and indicators

4.1 The number of operational controls, their design manner of function, location, arrangement and size should be provided for a simple, quick and effective operation.

4.2 All operational controls should permit normal adjustments to be easily performed and should be arranged in a manner which minimises the possibility of inadvertent operation. Controls not required for normal operation should not be readily accessible.

4.3 Feedback timing should be consistent with the task requirements. There should be clear feedback from any action within a short time. When a perceptible delay in response occurs taking into consideration the communication latency, visible indication should be provided.

4.4 Warning and alarm indicators should be designed to show no light in normal position that is an indication of a safe situation. Colour coding of functions and signals should be in accordance with international standards.

4.5 The management and the prioritisation of warning and alarm indicators should be defined in the operational limitations. Warning and alarm indicators should only be activated when an action is required and should specified the required action.

4.6 Indications, which may be accompanied by a short low intensity acoustic signal, should occur on the user display when an attempt is made to execute an invalid function or use an invalid information.

4.7 In case of an input error, the system is to require human to correct the error immediately.

4.8 The system should indicate default values when applicable.

5. User training

5.1 Training should be provided to the personnel and should be carried using suitable material and methods to cover the following topics:

- general understanding and operation of the system
- mastering of uncommon conditions in the system.

5.2 Reference shall also be made to STCW and Section 8.D.2.3

D. Network and communication

1. References

1.1 The network components and communication equipment should be designed in accordance with the following standards:

- IMO MSC.252(83) Performance Standards for Integrated Navigation Systems (INS).
- IEC 61162 (all parts) Maritime navigation and radio-communication equipment and systems – Digital interfaces

2. Design

2.1 Permanent and reversible communication system between ship, RCC and shore should be available. The network should be designed to enable a permanent collection of data aboard and its availability for subsequent transmission.

2.2 The network components and communication equipment should be type approved products.

2.3 Transmission protocol should be in accordance with a recognised international standard. Satellite communication provider should be recognized by International Maritime Satellite Organisation (IMSO).

2.4 The network should have the capacity to transmit the required amount of data with a margin for overload without compromising the data integrity.

2.5 Wireless data communication should employ recognised international wireless communication system that incorporate the following features:

1) message integrity: fault prevention, detection, diagnosis, and correction so that the received message is not corrupted or altered when compared to the transmitted message
2) configuration and device authentication: shall only permit connection of devices that are included in the system design
3) message encryption: protection of the confidentiality and or criticality the data content
4) security management: protection of network assets, prevention of unauthorised access to network assets.

2.6 The network is to be self-checking, detecting failures on the link itself and data communication failures on nodes connected to the link. Detected failures are to initiate an alarm.

2.7 The network devices should be automatically started when power is turned on, or restarted after loss of power.

3. Performance

3.1 A means of transmission control should be provided and designed so as to verify the completion of the data transmitted (CRC or equivalent acceptable method). When corrupted data is detected, the number of retries should be limited so as to keep an acceptable global response time.

3.2 All data should be identified with a priority level. The transmission software should be designed so as to take into consideration the priority of data.

3.3 Missing or corrupted data transmitted through the network should not affect functions which are not dependent on this data.

3.4 When a hardware or software transmission failure occurs, it should be detected by the transmitter and the recipient which should activate an alarm.

3.5 A means should be provided to verify the activity of transmission and its proper function (positive information).

4. Redundancy

4.1 Except if the availability of the connection can be demonstrated in the event of a failure, all transmission equipment should be duplicated or have a secondary means which is capable of the same transmission capacity, with an automatic commutation from one to the other.

4.2 Functions that are required to operate continuously to provide essential services dependent on wireless data communication links should have an alternative means of control that can be brought in action within an acceptable period of time.

E. Software quality assurance

1. References

1.1 The software quality assurance should be based on the following international standards or industry guidelines:

- IMO MSC.1/CIRC.1512 Guidelines on Software Quality Assurance and Human-Centred Design for E-Navigation
- ISO 10007 Quality management systems – Guidelines for Configuration Management
- ISO/IEC 90003 Software engineering - Guidelines for the application of ISO 9001 to computer software

1.2 The software quality assurance is to comply with the requirements of Rules for Electrical Installation (Pt.1, Vol.IV), Sec. 10.

2. Quality plan

2.1 The software development should be carried out according to a quality plan defined by the software provider and records are to be kept.

2.2 The quality plan should include the test procedure for software and the results of tests should be documented.

3. Testing

3.1 Software should be tested in association with hardware and evidences of testing should be produced according to the quality plan, see H.1.

4. Configuration management

4.1 A software maintenance should be in place to manage failure due to software change and in case of wrong interaction with existing software from other systems.

4.2 Software change should be the responsibility of qualified and authorised member (e.g. chief engineer).

F. Data quality assurance

1. References

1.1 The data quality assurance should be based on the following international standards:

- ISO 8000 Data quality
- ISO/IEC 10181 Information technology - Open Systems Interconnection - Security frameworks for open systems.

2. Data quality assessment

2.1 The data quality assessment should be carried on the following measurements:

- Completeness: all necessary data are recorded
- Uniqueness: no data will be recorded more than once
- Timeliness: the degree to which data represent reality from the required point in time
- Validity: data are valid if it conforms to the syntax (format, type, range) of its definition
- Accuracy: the degree to which data correctly describes the “real world” object or event being described
- Consistency: the absence of difference, when comparing two or more representations of a data item against its definition. It is possible to have consistency without validity or accuracy.

3. Data acquisition

3.1 For the data acquisition, the location and the selection of the sensors should be done so as to measure the actual value of the parameters. Temperature, vibration and electromagnetic interference levels should be taken into account. The sensors should be designed to withstand the local environment.

3.2 Means should be provided for testing, calibration and replacement of sensors. Such means should be designed, as far as practicable, so as to avoid perturbation of the normal operation of the system.

3.3 Low level signal sensors should be avoided. When installed they should be located as close as possible to amplifiers, so as to avoid external influences.

4. Data storage

4.1 The data storage should be suitable for the amount of collected data. In case of overcapacity, a mechanism should be provided to remove unnecessary or obsolete data and to recover to a normal situation.

4.2 When the data storage is based on a network or distributed system (e.g. storage in the cloud), consequences of the outage of the provider should be considered.

4.3 The data storage should have a backup feature (e.g. automatic duplication) and should be fault-tolerant (e.g. due to power failure).

5. Data authentication

5.1 The authentication of data should be possible each time it is requested by the system, by using a mechanism such as a digital signature or a secure protocol.

6. Data integrity

6.1 Data integrity (unaltered data) should be preserved by providing means of protection from unauthorised access, the data should carry an internal data checksum against deliberate or unintentional modifications.

7. Data confidentiality

7.1 Data confidentiality should be maintained by using means of encryption and an adequate level of authorisation for access in consultation of the data storage.

G. Cyber security

1. References

1.1 The cybersecurity should be based on the following international standards:

- IMO MSC-FAL.1/Circ.3
- The Guidelines on Cyber Security Onboard Ships produced and supported by BIMCO, CLIA, ICS, INTERCARGO, INTERTANKO, OCIMF and IUMI.
- ISO/IEC 27001 standard on Information technology – Security techniques – Information security management systems – Requirements. Published jointly by the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC).
- United States National Institute of Standards and Technology's Framework for Improving Critical Infrastructure Cybersecurity (the NIST Framework).

H. Testing

1. Software testing

1.1 The software modules of the application software should be tested individually and subsequently subjected to an integration test. It should be checked that:

- the development work has been carried out in accordance with the quality plan
- the documentation includes the method of testing, the test programs producing, the simulation, the acceptance criteria and the results.

1.2 Software module tests should provide evidence that each module performs its intended function and does not perform unintended functions.

1.3 The behaviour of a machine-learning system is dependent on the training set used during the learning phase of the system. It is recommended to use an extensive training set in order to cover a maximum number of potential situations.

The consistency of the behaviour of a machine-learning system should be tested (repeatability). In particular to be sure that after a long period, the behaviour of the system is not modified and is always responding in the same way. When testing a machine-learning system, the test data should include some exceptional conditions, in order to validate the behaviour of the system and to detect any deviation from the expected behaviour.

1.4 System or subsystem testing should verify that modules interact correctly to perform the functions in accordance with specified requirements and do not perform unintended functions.

1.5 Repetition tests should be required to verify the consistency of test results.

1.6 Faults should be simulated as realistically as possible to demonstrate appropriate software fault detection and software response.

2. Simulation testing

2.1 The aim of the simulation tests is to demonstrate by virtual means (simulation) the safe operations of any ship covered by this Guidelines and associated RCC if any.

2.2 Tests should be defined in order to cover all expected operating scenarios and should address the following topics:

- Functionality: All functionalities of systems associated to essential services should be tested.
- Performance: Performance assessment criteria should be defined beforehand.
- Failure resiliency: All hazards identified in the risk assessment (see Section 2.B) should be simulated in order to confirm the resiliency of systems associated to essential services.

2.3 Hardware-in-the-loop (HWIL) testing could be considered for checking proper working of any embedded control systems.

3. Full scale testing

3.1 The results of all simulation tests as specified in 2 are to be verified as far as feasible by full scale testing during sea trials.

3.2 Full scale testing should be done in a specific tests area approved by the Administration.

3.3 See also IMO Interim Guidelines for MASS trials MSC.1/Circ.1604.