BUREAU VERITAS MARINE & OFFSHORE

RULE NOTE

SHIPS EQUIPPED WITH **SMART SYSTEMS**

NR675 R04

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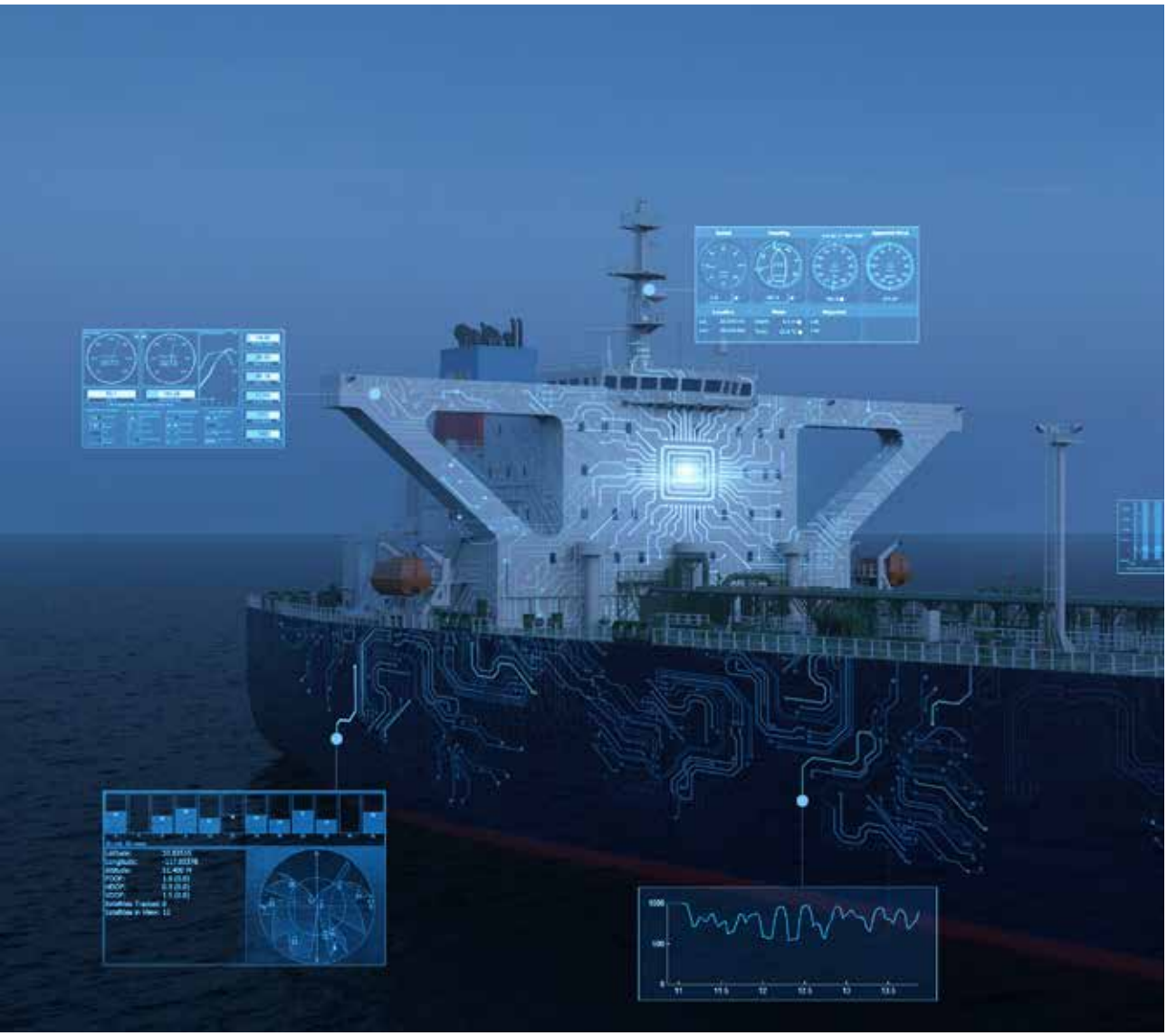

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These rules are provided within the scope of the Bureau Veritas Marine & Offshore General Conditions, enclosed at the end of Part A of NR467, Rules for the Classification of Steel Ships. The latest version of these General Conditions is available on the Bureau Veritas Marine & Offshore website.

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Section 1 General Requirements

1 General

1.1 Application

1.1.1 This Rule Note provides requirements for ships equipped with smart systems. Smart systems are digital solutions designed to achieve sustainable, efficient and safe ship operations by processing ship's data and providing decision support information.

1.1.2 Digital solutions depend on two components:

- Supporting computer-based system.
- Software designed to perform a smart function.

1.2 Definitions

1.2.1 The following definitions are used in this Rule Note:

- Company is defined as per the IMO International Safety Management Code (ISM Code) as: "Owner of the ship or any other organization such as the manager, or the bareboat charterer, who has assumed the responsibility for operation of the ship from the Owner of the ship and who on assuming such responsibility has agreed to take over all the duties and responsibilities imposed by the International Safety Management Code."
- Company interface: refers to the company based software provided by the smart system supplier allowing for remote decision-support and monitoring.
- Decision support: aid to decision-making with specific actions recommended to the users, e.g. intervention into a process, spare part replacement, route modification.
- Digital solution: computer-based system that incorporates functions for collection, transmission, analysis and visualisation of data.
- Event records: collection of time-stamped messages produced by a monitoring function of a system, e.g. alarms, alerts, notifications.
- Expert-in-the-loop services: services in which a digital solution needs a regular input from a shore operator, other than the intended user of the smart function, to produce conclusive results.
- Function: defined objective or characteristic action of a system or component (as per ISO/IEC/IEEE 24765:2017 Systems and software engineering - Vocabulary).
- Hardware: physical elements of a device, system or equipment which support the computation and/or data access for the software; hardware is a component of a smart system. Examples include computers, display units, alarm and monitoring units, miscellaneous electronic devices (switches, PLC, data loggers, routers, ship's server, etc.), purposely installed sensors.
- Non-essential consumer: on-board energy consumer other than consumers contributing to the provision of functions essential for propulsion, steering, safety of life and safety of the ship.
- Permanent data acquisition: automatic collection of data from sensors, monitoring devices, control systems and collection systems which are permanently installed on board and connected to a smart system.
- Raw data: data acquired directly from its source and existing in its original form before subsequent processing (as per ISO 5127:2017 Information and documentation - Foundation and vocabulary); in the present Rule Note, raw data is the original input into the smart system before subsequent processing, e.g. data directly transmitted from sensors.
- Remote monitoring: provision of data descriptive of the state of a system, equipment or a device to a data consumer which is not located on board for checking the measured or calculated states against a specific reference.
- Smart function: characteristic function of a smart system.
- Software: program code with associated data stored and executed in the hardware; software is a component of a smart system.
- Time series: time-stamped states of a system indexed in time order.

1.3 Classification notations

1.3.1 Ships equipped with a smart system and assigned an additional class notation **SMART( )** as defined in NR467, Pt A, Ch 1, Sec 2, [6.8] are to comply with the requirements of this Rule Note.

Note 1: NR467 refers to the Rules for the Classification of Steel Ships.

1.3.2 The following equipments and related functions supporting smart systems are outside the scope of this Rule Note:

- For cybersecurity reference is made to NR659 Rules on Cybersecurity for the Classification of Marine Units
- For data infrastructure reference is made to NR467, Pt F, Ch 4, Sec 4 (additional class notation **DATA-INFRA**)
- For communication systems reference is made to NR467, Pt F, Ch 4, Sec 3 (additional class notation **ASYNC-COM**)

1.3.3 This Rule Note does not cover systems and functions that enable autonomous or remote operations for which reference is made to NI641 Guidelines for Autonomous Shipping.

1.3.4 The additional class notation **SMART( )** is to be completed between brackets by at least one of the following notations indicating the scope of application of the smart function:

- **Hx** for Hull when the requirements given in Sec 3 are complied with
- **Mx** for Machinery when the requirements given in Sec 4, [2] are complied with
- **MHx** for Machinery Health monitoring when the requirements given in Sec 4, [3] are complied with
- **Nx** for Navigation when the requirements given in Sec 5 are complied with
- **EnEx** for Energy Efficiency when the requirements given in Sec 6 are complied with
- **Lx** for Electronic Logbook when the requirements given in Sec 7 are complied with
- **Xx** for Special smart function when the requirements given in Sec 8 are complied with.

The notation **EnEx** may be complemented by one or by a combination of the following complementary notations: **-Em**, **-T**, **-LIT**,**-S**, **-W** and **-CII**.

Where **x** indicates the smart group designation following an incremental logic and can take one of the following values in accordance with Sec 2:

- **1** for Computer-based system connected to the ship's data infrastructure
- **2** for Connected system operating with ship-shore communication capabilities
- **3** for Augmented system provided with a company interface or supported by expert-in-the-loop services.

Each smart system with a distinctive smart function may be assigned the smart group **1**, **2** or **3**.

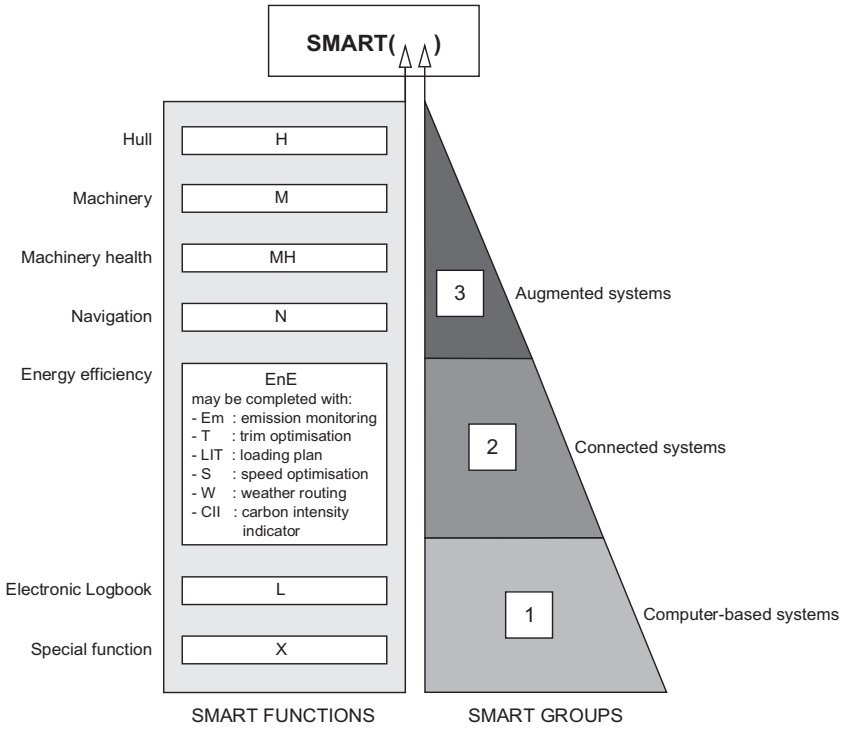
Examples:

- **SMART(H1)** indicates compliance with the requirements for smart function Hull and smart group 1.
- **SMART(MH2,N1,EnE3-W)** indicates compliance with the requirements for:
  - smart function Machinery Health monitoring and smart group 2
  - smart function Navigation and smart group 1
  - smart function Energy Efficiency with complementary notation Weather Routing and smart group 3.

1.3.5 When more than one smart system is considered within the scope of a notation listed in [1.3.4], the smart group assigned is the highest designation among those systems. (e.g. a ship fitted with one system complying with **SMART(M1)** and another complying with **SMART(M3)** is assigned the notation **SMART(M3)**).

1.3.6 The structure of the notation **SMART ( )** is illustrated in Fig 1.

Figure 1 : Structure of smart notations



2 General requirements for the additional class notations SMART( )

2.1 Application

2.1.1 This article provides general requirements for the assignment of the additional class notation **SMART( )**. Additional requirements to be complied with respect to specific smart groups and smart functions are given in Sec 2 to Sec 8.

2.1.2 The assignment of the additional class notation **SMART( )** may be subject to prerequisites such as the assignment of other additional class notations. A summary of the prerequisites additional class notations is provided in Tab 2.

2.2 Documentation to be submitted

2.2.1 The general documentation to be submitted for ships to be assigned the additional class notation **SMART( )** is listed in Tab 1.

The additional documentation to be submitted for specific smart group or smart functions is given in the relevant Sections of this Rule Note.

Table 1 : General documentation to be submitted

No.	A/I **(1)**	Documentation	Particulars
1	I	List of computer-based systems involved in smart functions	For each system the list is to include: • functional designation • supplier
2	A/I	Documentation for the computer-based systems used within the smart system	For information or approval as per NR467, Pt C, Ch 3, Sec 3, [1.6]
3	A	Analysis of consequences of single failures in the form of a Failure Mode and Effect Analysis (FMEA)	For Cat III computer-based systems defined in NR467, Pt C, Ch 3, Sec 3, which are designed to demonstrate redundancy
(1) A = to be submitted for approval; I = to be submitted for information			

2.3 Electromagnetic susceptibility

2.3.1 Electronic type components of a smart system are to comply with the requirements covering electromagnetic susceptibility as defined in NR467, Pt C, Ch 2, Sec 2, [3].

2.4 Hardware testing

2.4.1 Before a new installation, or before any alteration or addition to an existing installation is put into service, the electrical equipment of a smart system is to be tested in accordance with the requirements as defined in NR467, Pt C, Ch 2, Sec 15 to the satisfaction of the Surveyor, where the type approval for components is required as per Tab 2.

2.4.2 Onboard integration tests (including wireless network testing) are to be witnessed by the Surveyor.

Table 2 : Smart functions and notations requiring type approved components

Smart function	Pre-requisite notations described in NR467	Type Approved components are required	
		Hardware	Software
H	**LI-S3** or **LI-S4** or **LI-HG-S3** or **LI-HG-S4**	No	No
	MON-HULL	Yes	No
M	**ULEV**	No	No
	AUT-IMS	Yes	Yes
	CLEANSHIP-CEMS	Yes	Yes
	CLEANSHIP SUPER( )-CEMS	Yes	Yes
	CBM	Yes	Yes
	ELECTRIC HYBRID()	Yes	Yes
N	**DYNAPOS**	Yes	Yes
	SYS-IBS	Yes	Yes
MH	–	No	Yes
EnE completed by **-CII**	**REALTIME(CII)**	No	Yes
EnE completed by: **-Em**, **-T**, **-LIT**, **-S** or **-W**	–	No	Yes
L	–	No	Yes
X	–	No	No

2.5 Components type approval

2.5.1 When required as per Tab 2, software components forming a part of the smart system are to be of a type approved by the Society in accordance with NR467, Pt C, Ch 3, Sec 3, [2.2].

2.5.2 When required as per Tab 2, hardware components forming a part of the smart system are to be of a type approved by the Society in accordance with NR467, Pt C, Ch 3, Sec 6 [2.2] and are to comply with the requirements of the pre-requisite notations.

Note 1: Only the hardware installed on board the ship is considered in the scope of the present Rule Note.

2.5.3 Case by case approval of hardware and software may also be accepted at the discretion of the Society, based on submission of adequate documentation and subject to the satisfactory outcome of any required tests.

Section 2 Smart Groups

1 General

1.1 Application

1.1.1 In accordance with Sec 1, [1.3] and Sec 1, [2], this Section provides the requirements for the assignment of a smart group:

- For smart group **1**, see [2.1]
- For smart group **2**, see [2.1] and [2.2]
- For smart group **3**, see [2.1] to [2.3].

2 Requirements

2.1 Smart group 1: computer-based system

2.1.1 Smart group 1 applies to smart functions implemented in computer-based systems installed on board and connected to the ship's data infrastructure. Decision support information and processed data are to be available for onboard application.

2.1.2 The design, construction, commissioning and maintenance of computer-based systems where they depend on software for the proper achievement of the smart functions are to comply with the requirements of NR467, Pt C, Ch 3, Sec 3 and are to comply at least with the requirements for Category I systems.

2.1.3 The additional documentation listed in Tab 1 is to be submitted for the assignment of smart group **1**.

2.1.4 Onboard functional tests of the software modules are to be witnessed by the Surveyor.

Table 1 : Additional documentation to be submitted for smart group 1

No.	A/I **(1)**	Documentation	Particulars
1	I	List of the decision support functions	
2	A	Templates of dashboards and reports generated	
3	I	List of alerts and notifications generated for onboard users	
(1) A = to be submitted for approval; I = to be submitted for information			

2.2 Smart group 2: connected system

2.2.1 In addition to the requirements of [2.1], the requirements given in this sub-article are to be complied with.

2.2.2 Smart group 2 applies to smart functions implemented in smart systems installed on board and connected to the ship's ship-shore communication systems. Decision support information and processed data are to be readily available for use for other shore-based applications beyond the scope of the considered smart system (e.g. navigation data transmitted for noon report; ECDIS route exhanges).

2.2.3 The additional documentation listed in Tab 2 is to be submitted for the assignment of smart group **2**.

2.2.4 The smart system is to demonstrate its data exchange capability using the ship's data infrastructure and ship-shore communication systems. Examples of data-sharing methods include, but are not limited to: cloud services, automatically generated emails, and Application Programming Interface (API).

2.2.5 Deployment of a smart system self-standing communication device (e.g. extra satellite antenna) is not permitted unless otherwise agreed by the Society, once the absence of interference with existing communication systems and ship's superstructures has been demonstrated.

2.2.6 The smart system is neither to be connected to, nor use or interfere with the distress communication systems covered by SOLAS Chapter IV.

2.2.7 The smart system uplink/downlink requirements are not to exceed the ship's connectivity capacity. If available, the satellite communication service level agreement is to be taken as reference.

2.2.8 The smart system is to demonstrate its capability to stop data sharing upon end-user manual request in any special circumstances (e.g. cargo operations; authorities' request).

Table 2 : Additional documentation to be submitted for smart group 2

No.	A/I **(1)**	Documentation	Particulars
1	I	Description of the communication systems between ship and shore	Including uplink/downlink requirements
2	I	Satellite communication service level agreement	If available
(1) A = to be submitted for approval; I = to be submitted for information			

2.3 Smart group 3: augmented system

2.3.1 In addition to the requirements of [2.1] and [2.2], the requirements given in this sub-article are to be complied with.

2.3.2 Smart group 3 applies to smart functions implemented in smart systems installed on board and provided with a company interface and/or supported by a smart service supplier delivering expert-in-the-loop services.

The company interface enables remote monitoring from shore of processed data and decision-support information delivered for sustainable, efficient and safe ship operations.

2.3.3 Where a smart function requires expert-in-the-loop services to produce decision-support outputs, the service supplier is to be approved by the Society as a smart service supplier as per the Rule Note NR533 "Approval of service suppliers". Expert-in-the-loop services are not to cover supply or deployment of software updates.

2.3.4 The additional documentation listed in Tab 3 is to be submitted for the assignment of smart group **3**.

2.3.5 A smart system processing ship's data and providing decision support may be designed to be used only by the Company and not provided for onboard users. In that case, the digital user interface is to be available only from the company interface.

2.3.6 Unless otherwise indicated in Sec 1, Tab 2 the software of the company interface is to be of a type approved by the Society in accordance with the requirements of NR467, Pt C, Ch 3, Sec 3.

2.3.7 During an initial test witnessed by a Surveyor, the user manual is to be provided and the company interface is to be operated by a representative of the company to demonstrate:

- transfer of data between ship and shore, with results checked in the company interface.
- visualisation and reporting features.

Table 3 : Additional documentation to be submitted for notations of smart group 3

No.	A/I **(1)**	Documentation	Particulars
1	I	List of the decision support functions of the company interface	
2	I	Type approval certificate of the company interface	If required
3	I	Description of the company interface	Including: • functional diagrams • data flow • process description • location of the hosting servers
4	I	Table listing the types of user accounts with corresponding access rights	
5	A	Templates of dashboards and reports generated from the company interface	
6	I	List of alerts and notifications generated for the company interface users	
7	I	Service agreement between the applicant and the approved smart service supplier for the provision of expert-in-the-loop services	If applicable
(1) A = to be submitted for approval; I = to be submitted for information.			

Section 3 Hull Smart Functions

1 Notations SMART(Hx)

1.1 Application

1.1.1 In accordance with Sec 1, [1.3] and Sec 1, [2], the requirements for the assignment of the notation **SMART(Hx)** are given in [1.2] and [1.3].

1.2 Applicable requirements

1.2.1 The additional class notation **SMART(Hx)** may be assigned when the ship complies with the requirements for the assignment of at least one of the following notations defined in NR467:

a) hull smart functions dedicated to operation:
LI-S3, **LI-S4**, **LI-HG-S3** or **LI-HG-S4**

b) hull smart functions dedicated to hull monitoring:
MON-HULL.

1.3 Additional documentation to be submitted

1.3.1 The assignment of the smart function **H** is subject to the submission of the documentation listed in Tab 1, in addition to the documentation to be submitted for the applicable notation listed in [1.2.1].

Table 1 : Documentation to be submitted for smart function H

No.	A/I **(1)**	Documentation	Particulars
1	A	List of components of the monitoring system	Including, as applicable: • sensors for hull strains and acceleration • sensors for the draught and loading status
(1) A = to be submitted for approval; I = to be submitted for information.			

Section 4 Machinery Smart Functions

1 Application

1.1 General

1.1.1 In accordance with Sec 1, [1.3] and Sec 1, [2], the requirements for the assignment of the notations **SMART(Mx)** for machinery smart functions and **SMART(MHx)** for machinery health smart functions are given in Articles [2] and [3] respectively.

2 Notations SMART(Mx)

2.1 Applicable requirements

2.1.1 The additional class notation **SMART(Mx)** may be assigned when the ship complies with the requirements for assigning at least one of the following notations defined in NR467:

a) machinery smart functions dedicated to operation:
AUT-IMS
or
ULEV in the case of electronically controlled engines
or
CLEANSHIP-CEMS or **CLEANSHIP SUPER()-CEMS**

b) machinery smart functions dedicated to machinery maintenance:
CBM or **CBM-P** (see also [2.1.2])

c) machinery smart functions dedicated to energy storage systems (ESS):
ELECTRIC HYBRID() (see also [2.1.3])

2.1.2 For ships for which the additional service feature **CBM** or **CBM-P** is assigned, the Computerised Maintenance Management System (CMMS) used to program and maintain the Planned Maintenance System (PMS) is to be approved by the Society in accordance with the requirements of the Rule Note NR496 "Approval of Computerized Maintenance Management Systems used on board Ships".

2.1.3 For ships for which the additional class notation **ELECTRIC HYBRID()** is assigned, the following additional requirements are to be complied with:

a) smart system is to include a digital user interface for monitoring at least 1 year of the operational data for the ESS including state of charge (SOC), state of health (SOH) and cell health status;

b) smart system is to provide recommendations for optimising the use of the ESS to meet the target battery lifetime.

2.2 Additional documentation to be submitted

2.2.1 The assignment of the smart function **M** is subject to the submission of the documentation listed in Tab 1 in addition to the documentation to be submitted for the applicable notation listed in [2.1.1].

Table 1 : Additional documentation to be submitted for smart function M

No.	A/I **(1)**	Documentation	Particulars
1	I	Approval certificate of the Computerised Maintenance Management System (CMMS)	When applicable
2	A	List of machinery items surveyed under a Condition Based Maintenance scheme	When applicable
(1) A = to be submitted for approval; I = to be submitted for information.			

3 Notations SMART(MHx)

3.1 Applicable requirements

3.1.1 The additional class notation **SMART(MHx)** may be assigned when the ship is fitted with a smart system that provides monitoring of the state of health and operating conditions of machines and onboard systems in compliance with the requirements in [3.4] and [3.5].

3.1.2 The list of equipments to be considered in the scope of the additional class notation **SMART(MHx)**, with the list of the corresponding parameters monitored by the smart system are to be specified by the Applicant in the documents submitted as described in Tab 2.

3.1.3 The output and functionalities covered by the additional class notation **SMART(MHx)** are not to be used to modify the scope and/or frequency of in-service surveys.

The requirements for the assignment of the additional class notation **SMART(MHx)** are to be considered separately from the requested assessment and workflow for the assignment of the additional service feature **CBM** or **CBM-P**.

3.2 Definitions

3.2.1 The following definitions are used in the present Article:

- Failure: termination of the ability of an item to perform a required function.
- Parameter: a characteristic value describing a state of a system.
- Descriptor: data item derived from raw or processed parameters or from event records.
- Baseline data: descriptor or group of descriptors which provide a criterion of the normal behaviour of equipment under various process states.

3.3 Additional documentation to be submitted

3.3.1 The assignment of the smart function **MH** is subject to the submission of the documentation listed in Tab 2.

Table 2 : Additional documentation to be submitted for smart function MH

No.	A/I **(1)**	Documentation	Particulars
1	I	Diagrams and functional schemes describing the equipment covered by the smart system	
2	I	Description of the machinery health monitoring functionality	Including the principles of the algorithm and data manipulation
3	I	Description of the measured parameters	Including: • characteristics of time series including the source equipment ID, value ranges, units of measurement • ID, characteristics and location of sensors, if any, or other means of permanent data acquisition
4	I	Description of alarm and event data, if received by the smart system from the machinery	Including: • typical message format • message text template • description of the triggering conditions • priority, limits, deadband
(1) A = to be submitted for approval; I = to be submitted for information.			

3.4 Required functionalities

3.4.1 The smart system is to provide a digital user interface for the management of:

a) descriptors including a visualisation of historical trends

b) baseline data.

3.4.2 The digital user interface is to provide dashboards for equipment health parameters presented with:

a) measured or calculated values

b) baseline value ranges

c) safe operational ranges

d) distinctive colour coding for values within and exceeding the relevant ranges.

3.4.3 The smart system is to generate condition reports. The condition report is to include:

- a summary of the equipment status;
- results of anomaly detection or diagnostics consisting of the examination of symptoms to determine the nature of faults or failures
- running hours (if available).

3.4.4 Means of testing the health monitoring functionality are to be provided, such as a software test mode with a simulated introduction of incipient failures. Such simulations are to be related to the results pre-calculated by the manufacturer of the smart system as a test case. The test is to result in an alert generated within the digital user interface.

Note 1: The test cases should focus on the early detectable degradation, i.e. the manifestations occurring within the first 25% of the mean time span between the potentially detectable fault and the functional failure of the equipment as per the recommendations from the OEM (Original Equipment Manufacturer).

3.4.5 The smart system is to generate alerts based on the data where the equipment is running outside of the safe operational limits.

3.4.6 The raw data time series, alarm and event records from equipment are to be stored for a minimum period of 30 days.

3.4.7 The time series derived from the raw data and event records produced by the smart system are to be automatically recorded and stored for at least 5 years. The storage may be on board or on shore if the onshore storage is accessible for the smart system on board.

3.5 Onboard testing

3.5.1 During the onboard test witnessed by a Surveyor, the user manual is to be provided and the smart system is to be operated to:

a) generate a list of time series with uptime history metrics, identification of the source equipment, status of the sensors calibration, if the calibration is required by the manufacturer of the sensor or of the smart system

b) generate a report providing statistics of equipment alarms received by the smart system, if any

c) generate a condition report for the list of equipment considered in the scope of the notation

d) generate a condition report in a test mode with a simulated introduction of incipient failures and compare the results to the corresponding test case

e) compare the consistency of parameter trends with the recent operation of the equipment by demonstrating alarm-based descriptors and baseline data acquired during the equipment commission tests.

Section 5 Navigation Smart Functions

1 Notations SMART(Nx)

1.1 Application

1.1.1 In accordance with Sec 1, [1.3] and Sec 1, [2], the requirements for the assignment of the notation **SMART(Nx)** are given in [1.2] and [1.3].

1.2 Applicable requirements

1.2.1 The additional class notation **SMART(Nx)** may be assigned when the ship complies with the requirements for assigning at least one of the following notations defined in NR467:

a) **DYNAPOS** (for DP Class 1, 2 or 3)

b) **SYS-IBS**

and

the ship is to be equipped with an Integrated Navigation System (INS) in accordance with the requirements of IMO.MSC.252(83) "Adoption of the revised performance standards for Integrated Navigation Systems (INS)".

1.3 Additional documentation to be submitted

1.3.1 The assignment of the smart function **N** is subject to the submission of the documentation listed in Tab 1, in addition to the documentation to be submitted for the applicable notation listed in [1.2.1].

Table 1 : Documentation to be submitted for smart function N

N°	A/I **(1)**	Documentation	Particulars
1	A	Description of the Integrated Navigation System	When applicable
(1) A = to be submitted for approval; I = to be submitted for information.			

Section 6 Energy Efficiency Smart Functions

1 Notations SMART(EnEx)

1.1 General

1.1.1 In accordance with Sec 1, [1.3] and Sec 1, [2], the requirements for the assignment of the notation **SMART(EnEx)** and the applicable complementary notations **-Em**, **-T**, **-LIT**, **-S**, **-W** and **-CII** are given in Articles [1] to [7].

1.2 Application

1.2.1 The additional class notation **SMART(EnEx)** may be assigned when the ship is equipped with a smart system that provides monitoring of energy consumption and emissions in relation to the operating conditions of the ship and to the geographical area. The relevant data acquisition and reporting may include, but is not limited to, the operational status of the ship and its onboard consumers. The additional requirements to be complied with in addition of this Article for the assignment of the relevant complementary notation are detailed in Articles [2] to [7].

1.3 Documentation to be submitted

1.3.1 Documentation to be submitted for assignment of the notation **SMART(EnEx)** and for the complementary notations **-Em**, **-T**, **-LIT**, **-S**, **-W** and **-CII** is listed in:

- Tab 1 for general documentation to be submitted for smart function **EnE**
- Tab 2 for complementary notation **-Em**
- Tab 3 for complementary notation **-T**
- Tab 4 for complementary notation **-LIT**
- Tab 5 for complementary notation **-S**
- Tab 6 for complementary notation **-W**
- Tab 7 for complementary notation **-CII**.

Table 1 : Documentation to be submitted for smart function EnE

No.	A/I **(1)**	Description	Particulars
1	I	Characteristics of time series for each measured parameters	Including the source equipment ID, value ranges, units of measurement
2	I	ID, characteristics and location of sensors for each measured parameters	If any
3	I	Templates of reports generated	• As in [1.6.1] items a), b) and c) • In consistency with SEEMP and Engine International Air Pollution Prevention Certificate (EIAPP)
4	I	Power balance	Taking into account the achievable configurations for energy production and distribution
(1) A = to be submitted for approval; I = to be submitted for information			

1.4 Data inputs

1.4.1 Means of monitoring and recording the following data are to be available on board with inputs to the smart system:

a) operational parameters of the active propulsion directly impacting the forces applied on the hull, e.g. pitch, rpm, rudder angle

b) propulsion power

c) engine speed and shaft torque

d) fuel intakes for engines, oil-fired boilers

e) state of charge of Energy Storage Systems (ESS), if fitted.

1.4.2 Means of monitoring and recording the following navigation related data are to be available on board with inputs to the smart system:

a) Ship's geographic position

b) Speed Over The Ground

c) Speed Through the Water

d) Wind direction and speed

e) Under Keel Clearance from echo sounder

f) Ship’s heading.

1.4.3 Where the inputs listed in [1.4.1] and [1.4.2] are not automatic, a manual entry interface may be accepted at the discretion of the Society, e.g. electronic log entries.

1.4.4 Where wind propulsion systems, as defined in NR206, or other energy saving systems are available, means of monitoring and recording the available effective power delivered by the specified system are to be provided on board with inputs to the smart system.

Note 1: NR206 refers to the Rules for the Wind Propulsion Systems.

1.4.5 Where a shore power supply is intended to be regularly used to sustain operations, means of monitoring and recording the power consumed from the shore grid are to be available on board with inputs to the smart system.

1.4.6 Means of monitoring and recording the electric current per group of non-essential consumers are to be available on board with inputs to the smart system, if all the items below are applicable:

a) electrical load balance tables indicate at least one set of non-essential consumers

b) the sets of consumers are defined by the grouping in the electrical distribution system to distinct switchboard elements, and more than a single group can be identified

c) the total maximum electrical load from the non-essential consumer(s) is above 30% of the total power plant output.

1.5 Calculated parameters

1.5.1 The smart system is to calculate and record the following information:

a) CO2 emissions

b) hull resistance

c) ship’s draught

d) operational status of the ship (ocean transit, moored, manoeuvring, etc.)

e) equipment operational status, e.g. running, stopped

f) fuel consumption based on the manufacturer's design information, e.g. Specific Fuel Oil Consumption, if applicable

g) steam consumption in heaters, evaporators, accommodation heating, based on heat transfer equations

h) energy transfer within waste heat recovery systems, if fitted, based on heat transfer equations

i) active power per group of consumers.

1.6 Required functionalities

1.6.1 The smart system is to present functionalities for database management, continuous analytical processing, visualisation and reporting to generate:

a) reports of the Energy Efficiency Operational Indicator (EEOI) and Carbon Intensity Indicator (CII), as applicable according to the Ship Energy Efficiency Management Plan (SEEMP) as estimated for voyages, regular intervals and user defined periods

b) estimated performance profiles for the ship for typical and representative ship's operating configurations based on the collected data

c) recommended performance profiles for the ship based on typical operating configurations

d) alerts for exceeding selected performance ranges for energy consumption

e) simulations of energy consumption for the ship based on typical operating configurations.

1.6.2 The raw data time series are to be stored for a period of at least 30 days.

1.6.3 The time series derived from the raw data are to be automatically recorded and stored for at least 5 years. The storage may be on board or on shore if the onshore storage is accessible for the smart system on board.

1.7 Onboard testing

1.7.1 During the onboard test witnessed by a Surveyor, the smart system is to be operated to:

a) generate reports as in [1.6.1] items a), b) and c) in consistency with SEEMP, Power Balance report and EIAPP certificates

b) generate a list of time series with uptime history metrics, identification of the source equipment, status of the sensors calibration, if the calibration is required by the manufacturer of the sensor or of the smart system

c) generate recommended performance profile for realistic conditions, e.g. a laden voyage typical for the ship's trade

d) simulate energy consumption for the typical operational configurations, including at least an ocean passage and a loading or unloading activity in port.

2 Additional requirements for notation -Em (emissions monitoring)

2.1 Application

2.1.1 In accordance with [1.2.1], the smart function **EnE** is completed by **-Em** when ships are fitted with a smart system complying with the requirements of this article. The smart system provides an estimation of the ship's emissions. The additional documentation to be submitted for the complementary notation **-Em** is listed in Tab 2.

Table 2 : Additional documentation to be submitted for the complementary notation -Em

No.	A/I **(1)**	Description	Particulars
1	I	Templates of reports generated for estimation of emissions	As per [2.2.1]
2	I	Description of the methods used for calculating the emissions	
(1) A = to be submitted for approval; I = to be submitted for information			

2.1.2 The smart system is to evaluate and record the following information:

a) SO_x emissions

b) NO_x emissions

c) Greenhouse gas (GHG) emissions, including CO_2, CH_4 and N_2O, or carbon dioxide equivalent CO_{2e}

d) Georeferenced emission performance with respect to the Emission Control Areas (ECAs).

2.2 Required functionalities

2.2.1 The smart system is to present functionalities for database management, continuous analytical processing, visualisation and reporting to generate:

a) reports with performance indicators for GHG, SO_x and NO_x emissions related to the geographic area of operation

b) estimated emission profiles for the ship for typical and representative ship's operating configurations based on the collected data

c) recommended emission profiles for the ship based on typical operating configurations

d) alerts for exceeding selected performance ranges for emissions

e) simulations of emissions for groups of consumers based on typical operating configurations, if the corresponding inputs are available as per [1.4.6].

2.3 Onboard testing

2.3.1 During the onboard test witnessed by a Surveyor, the user manual is to be provided and the smart system is to be operated to:

a) generate reports as in [2.2.1] in consistency with the characteristics of the fuel on board or intended for the next voyage

b) generate recommended emission profile for realistic conditions, e.g. a laden voyage typical for the ship's trade

c) simulate emissions for the typical operational configurations and conditions, including at least an ocean passage and a loading or unloading activity in port.

3 Additional requirements for notation -T (trim optimization)

3.1 Application

3.1.1 In accordance with [1.2.1], the smart function **EnE** is completed by **-T** when ships are fitted with a smart system complying with the requirements of this article. The smart system provides a decision support for trim optimization by graphically plotting the recommended trim for a selected displacement and a voyage speed. The additional documentation to be submitted for the complementary notation **-T** is listed in Tab 3.

Table 3 : Additional documentation to be submitted for the complementary notation -T

No.	A/I **(1)**	Description	Particulars
1	I	Pre-calculated report with the tabulated data for the trim related propulsion power demands	The trim and draughts are to cover the loading conditions as given in the loading manual and the operational range in ballast and laden voyage loading conditions
(1) A = to be submitted for approval; I = to be submitted for information			

3.2 Required functionalities

3.2.1 The smart system is to display draught and trim combinations corresponding to energy consumption and propulsion power demand. The graphic presentation is to unambiguously demonstrate the change in the corresponding energy efficiency for a trim variation.

3.3 Onboard testing

3.3.1 During the onboard test witnessed by a Surveyor, the smart system is to be operated to:

a) calculate the energy consumption relevant to the ship's actual loading condition in transit

b) compare for consistency the estimated power demand and the relevant data in the report defined in Tab 3 for **SMART(EnEx-T)**.

4 Additional requirements for notation -LIT (loading plan optimization)

4.1 Application

4.1.1 In accordance with [1.2.1], the smart function **EnE** is completed by **-LIT** when ships are fitted with a smart system complying with the requirements of this article. The smart system provides a decision support for trim optimization by generating a stowage plan for intact stability. The additional documentation to be submitted for the complementary notation **-LIT** is listed in Tab 4.

4.2 Required functionalities

4.2.1 The ship is to be equipped with a Loading Instrument (LI) which is to be approved by the Society for hull girder and intact stability calculations.

4.2.2 The smart system is to generate a stowage plan, which is optimized for energy efficiency on the pre-calculated set of the draught and trim combinations.

4.2.3 The optimized stowage plan is only to result in loading conditions that meet intact stability and hull girder criteria applicable to the ship concerned.

4.2.4 If the smart system automatically transfers the optimized stowage plan to the ship's LI, the proposed stowage plan is to be subject to an automatic check by the algorithms based on the LI intact stability and hull girder criteria. The output of the automatic check is to be provided to the crew for a manual acknowledgement.

Table 4 : Additional documentation to be submitted for the complementary notation -LIT

No.	A/I **(1)**	Description	Particulars
1	I	Pre-calculated report containing optimized stowage plan for all loading conditions listed in the loading manual	
2	I	Description of the interaction between the LI and the smart system	• If the smart system automatically transfers the optimized stowage plan to the ship's Loading Instrument (LI) • Including data exchange protocols, direction of the data flow, regularity of the communication when an optimized stowage plan is produced and transferred to the LI • The information can be provided as a part of the software and hardware module descriptions required in Sec 1, [2.2]
3	I	Extract from the risk assessment of cyber security	• If the smart system automatically transfers the optimized stowage plan to the ship's Loading Instrument (LI) • Extract from (as applicable): - the risk assessment of cyber security performed in compliance with IMO.MSC.428(98), and being part of ISM Code certification, or - the risk assessment for additional cyber security class notation defined in NR659 • The extract is to cover the risks and mitigations pertaining to the connectivity between the LI and the smart system
(1) A = to be submitted for approval; I = to be submitted for information.			

4.3 Onboard testing

4.3.1 During the onboard test witnessed by a Surveyor in addition to the scope of the tests described in [3.3.1], the smart system is to be operated to generate an optimized stowage plan for one of the loading conditions given in the loading manual. The optimized stowage plan is to comply with the stability and hull girder criteria.

5 Additional requirements for notation -S (speed profile optimization)

5.1 Application

5.1.1 In accordance with [1.2.1], the smart function **EnE** is completed by **-S** when ships are fitted with a smart system complying with the requirements of this article. The smart system provides a decision support for voyage plan optimization including a recommended speed profile. The additional documentation to be submitted for the complementary notation **-S** is listed in Tab 5.

5.2 Required functionalities

5.2.1 The smart system is to be able to use Electronic Navigational Charts (ENCs), Emission Control Area (ECA) positions, sea current and tidal predictions, fuel type and navigational route information.

5.2.2 During the route planning, the smart system is to be able to calculate optimal speed profiles for the minimum energy consumption and for the minimum greenhouse gas (GHG) emissions. The smart system is to provide a waypoint optimization with route and schedule alternatives.

5.2.3 During the route execution, the smart system is to provide a decision support with a recommended speed setpoint, energy consumption and emission status.

5.2.4 If the smart system automatically transfers the optimised route to the ship's Electronic Chart Display and Information System (ECDIS), the proposed route is to be subject to an automatic check by the algorithms based on the ECDIS safety contour. The output of the automatic check is to be provided to the crew for a manual acknowledgement.

Table 5 : Additional documentation to be submitted for the complementary notation -S

No.	A/I **(1)**	Description	Particulars
1	I	Description of the interaction between the ECDIS and the smart system	• If the smart system automatically transfers the route plan to the ship's Electronic Chart Display and Information System (ECDIS) • Including data exchange protocols, direction of the data flow, regularity of the communication when a route plan is produced and transferred to the ECDIS. The information can be provided as a part of the software and hardware module descriptions required in Sec 1, [2.2]
2	I	Extract from the risk assessment of cyber security	• If the smart system automatically transfers the route plan to the ship's Electronic Chart Display and Information System (ECDIS) • Extract from (as applicable): - the risk assessment of cyber security performed in compliance with IMO.MSC.428(98), and being part of ISM Code certification, or - the risk assessment for additional cyber security class notation defined in NR659 • The extract is to cover the risks and mitigations pertaining to the connectivity between the ECDIS and the smart system
(1) A = to be submitted for approval; I = to be submitted for information			

5.3 Onboard testing

5.3.1 During the onboard test witnessed by the Surveyor, the smart system is to be operated to generate a voyage plan report which includes the speed profiles, energy consumption and GHG emissions. A new voyage plan for an ocean transit is to be generated and optimized for the energy efficiency.

5.3.2 If the smart system automatically transfers the route to the ship's ECDIS, the Surveyor is to witness a functional test for the automatic display of the optimized voyage plan in ECDIS in both planning mode and voyage execution mode. The test is to include an examination of the safety contour alerts produced by the ECDIS in relation to the route.

6 Additional requirements for notation -W (weather routing optimization)

6.1 Application

6.1.1 In accordance with [1.2.1], the smart function **EnE** is completed by **-W** when ships are fitted with a smart system complying with the requirements of this article. The smart system provides a decision support for voyage plan optimization based on the meteorological information, i.e. weather routing. The additional documentation to be submitted for the notation **-W** is listed in Tab 6.

6.2 Required functionalities

6.2.1 The smart system is to be able to use Electronic Navigation Charts (ENCs), electronic surface weather analysis reports and navigational route information.

6.2.2 The smart system is to provide a digital user interface with an overlay of the surface weather analysis charts on the plotted voyage plan as selected from the routing alternatives calculated by the smart system.

6.2.3 A weather routing function is to alert the user in the event of meteorological dangers to navigation requiring an alteration of the initial voyage plan, e.g. tropical storm.

6.2.4 The surface weather analysis reports relevant for the areas where the routes are plotted are to be stored for 1 year.

6.2.5 If the smart system automatically transfers the route to the ship's Electronic Chart Display and Information System (ECDIS), the proposed route is to be subject to an automatic check by the algorithms based on the ECDIS safety contour. The output of the automatic check is to be provided to the crew for a manual acknowledgement.

Table 6 : Additional documentation to be submitted for the complementary notation -W

No.	A/I **(1)**	Description	Particulars
1	I	Procedure for managing the weather routing information on board	
2	I	Description of the interaction between the ECDIS, the smart system and the means of receiving the meteorological information	• If the smart system automatically transfers the route plan to the ship's Electronic Chart Display and Information System (ECDIS) • including data exchange protocols, direction of the data flow, regularity of the communication when a route plan is produced and transferred to the ECDIS • The information can be provided as a part of the software and hardware module descriptions required in Sec 1, [2.2]
3	I	Extract from the risk assessment of cyber security	• If the smart system automatically transfers the route plan to the ship's ECDIS • Extract from (as applicable): - the risk assessment of cyber security performed in compliance with IMO.MSC.428(98), and being part of ISM Code certification, or - the risk assessment for additional cyber security class notation defined in NR659 • The extract is to cover the risks and mitigations pertaining to the connectivity between the ECDIS, the smart system and the means of receiving the meteorological information
(1) A = to be submitted for approval; I = to be submitted for information.			

6.3 Onboard testing

6.3.1 During the onboard test witnessed by a Surveyor, the smart system is to be operated to

a) Generate a report for an optimized voyage plan which takes into account the meteorological conditions. The report is to provide a new voyage plan for an ocean transit. The relevant information from the surface weather analysis is to be incorporated in the report.

b) Import and display the latest surface weather analysis chart information for the local area.

6.3.2 If the smart system automatically transfers the route to the ship's ECDIS, the Surveyor is to witness a functional test for the automatic display of the optimized voyage plan in ECDIS in both planning mode and voyage execution mode. The test is to include an examination of the safety contour alerts produced by the ECDIS in relation to the route.

7 Additional requirements for notation -CII (carbon intensity indicator)

7.1 Definitions

7.1.1 The following definitions are used in the present article:

- Carbon Intensity Indicator (CII): a ship's performance indicator by which it is possible to measure the carbon intensity of the ship for a calendar year, as defined in the IMO Guidelines on operational carbon intensity indicators and the calculation methods (CII Guidelines, G1).
- Continuous CII: a ship's carbon intensity indicator which is calculated for a period of time between the commencement of a calendar year and the exact time defined by the system or the operator. Continuous CII is based on available IMO DCS data without extrapolation.
- CII Onboard Digital Solution (CII ODS): an onboard computer-based system performing on board the collection of data necessary for the calculation of the Continuous CII. CII ODS is to be available for the onboard users to monitor regularly the Continuous CII and to obtain a relevant decision-support.
- CII Shore Digital Solution (CII SDS): a shore digital solution available for the shore users to monitor regularly the Continuous CII and to obtain a relevant decision support based on the data received from the CII ODS.

7.2 Application

7.2.1 In accordance with [1.2.1], the additional class notation **SMART(EnEx)** may be complemented by the notation **-CII** when the following applies:

a) the ship complies with the requirements for assigning the additional class notation **REALTIME(CII)** as per NR467

b) CII ODS uses the means of permanent automatic data acquisition as inputs in addition to the manual inputs

c) CII ODS and CII SDS comply with the requirements of [7.3].

The documentation to be submitted for the complementary notation **-CII** is listed in Tab 7.

Table 7 : Additional documentation to be submitted for the complementary notation -CII

No.	A/I **(1)**	Description	Particulars
1	I	List of manual data entries in the interface of the CII ODS	
2	A	Description of the methods used for calculating the Continuous CII	
3	A	Description of models used to estimate the fuel consumption based on the automatic inputs	
4	I	Description of the CII ODS and CII SDS architectures	Including functional diagrams, data flow, process description, location of the hosting servers in regard of the automatic data acquisition
5	I	List of alerts generated for onboard and shore users based on the automatic inputs	
(1) A = to be submitted for approval; I = to be submitted for information.			

7.3 Required functionalities

7.3.1 In case of a failure of the permanent automatic data acquisition, the smart system is to produce a notification to the operator on board and is to provide as a fall-back at least the functionalities related to the manual inputs in accordance with NR467, Pt F, Ch 5, Sec 3, [5.1].

7.3.2 The fuel intake sensor data required as per [1.4.1] can be substituted by the inputs from the fuel tank sounding sensors.

7.3.3 Direct CO_2 emission measurement sensors can be used to calculate the CO_2 emissions. If available, the digital interfaces of the CII ODS and CII SDS are to include a comparative trending view of the emissions calculated from the exhaust sensor time series and from other inputs.

7.3.4 Where applicable, the fields for manual entries are to be automatically pre-filled with the values which are calculated from the permanent automatic data acquisition inputs. Such pre-filled entries are to be further modified or digitally signed off “as is” by an onboard user upon verification.

7.3.5 Sensor measurement data and other inputs from the permanent automatic data acquisition are to be sampled and logged at least daily. The sensor measurement data is to be stored for a minimum of 1 year.

7.3.6 The CII ODS and CII SDS are to generate notifications for the discrepancies between the fuel quantities which are estimated from the permanent automatic data acquisition time series and the fuel quantities which are based on the manually reported values.

7.3.7 The digital interfaces of the CII ODS and CII SDS are to include a comparative trending view for the fuel quantities calculated from the permanent automatic data acquisition time series and from the manual input for

a) the total amount of fuel on board

b) amount in each tank monitored, if fuel tank sounding sensors are used

c) amount transferred to a consumer or to a group of consumers, if flowmeters are used.

7.4 Onboard testing

7.4.1 During the onboard test witnessed by a Surveyor, the CII ODS is to be operated to:

a) check the trending view as described in [7.3.7]

b) complete other actions as per the testing scope of the additional class notation **REALTIME(CII)**.

7.5 Remote testing

7.5.1 During the remote test witnessed by a Surveyor, the CII SDS is to be accessed by means of external Internet connection to:

a) check the trending view as described in [7.3.7]

b) complete other actions as per the testing scope of the additional class notation **REALTIME(CII)**.

Section 7 Electronic Logbook Smart Functions

1 Notations SMART(Lx)

1.1 Application

1.1.1 In accordance with Sec 1, [1.3] and Sec 1, [2] the requirements for the assignment of the notation **SMART(Lx)** are given in [1.2], [1.3] and [1.4].

1.2 Applicable requirements

1.2.1 The additional class notation **SMART(Lx)** may be assigned to ships equipped with a type approved smart system for electronic record keeping such as:

a) Computerized Maintenance Management System (CMMS) as per the requirements of the Rule Note NR496 "Approval of Computerized Maintenance Management Systems used on board Ships".

b) electronic record book as per the resolution MEPC.312(74) under the International Convention for the Prevention of Pollution from Ships (MARPOL)

c) electronic record book as per the resolution MEPC.372(80) and MEPC.383(81) under the International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWM Convention)

d) electronic logbook as per a set of requirements of ISO 21745:2019 selected by the Applicant

Note 1: Where the smart system is type approved as per a set of the ISO 21745:2019 requirements, the smart system may be used for a variety of electronic record keeping purposes, including, but not limited to, operational noon reports, bridge and engine logbooks. The set of requirements of ISO 21745:2019 selected by the Applicant is to be specified in the type approval certificate.

1.2.2 Manual entries may provide inputs to the smart system where no measurements can be made automatically.

1.2.3 The additional class notation **SMART(Lx)** may be assigned on a case-by-case basis for electronic record keeping systems which are not in the scope of [1.2.1] at the discretion of the Society.

1.3 Additional documentation to be submitted

1.3.1 The additional documentation to be submitted for smart function **L** is listed in Tab 1.

Table 1 : Additional documentation to be submitted for smart function L

No.	A/I **(1)**	Description	Particulars
1	I	Type approval certificate of the smart system	With regards to the references listed in [1.2.1]
2	I	List of the relevant electronic logbook inputs	Including digital and analogue interfaces and manual entries
3	I	List of the electronic logbook outputs	Including digital user interfaces, application programming interfaces (API) and reports relevant for the onboard process supported by the smart system
4	I	Description of the onboard process supported by the smart function L	With a reference to its interfaces and operational procedures
(1) A: to be submitted for approval; I: to be submitted for information.			

1.4 Onboard testing

1.4.1 During the onboard test witnessed by the Surveyor, the user manual is to be provided and the system is to be operated to:

a) generate records on board

b) check the availability of the newly created records in primary and backup storage

c) confirm the availability of automatic inputs, if any

d) check that the list of the authorised users on board is consistent with the Role Based Access Control defined in the user manual.

Section 8 Special Smart Functions

1 Notations SMART(Xx)

1.1 Application

1.1.1 In accordance with Sec 1, [1.3] and Sec 1, [2], the requirements for the assignment of the notation **SMART(Xx)** are given in [1.2], [1.3], [1.4] and [1.5].

1.2 Applicable requirements

1.2.1 The additional class notation **SMART(Xx)** may be assigned to ships equipped with a smart system providing a dedicated smart function other than the ones covered by Sec 3 to Sec 7, and complying with the requirements of this Section.

1.2.2 The additional class notation **SMART(Xx)** is assigned on a case by case basis, subject to the Society agreement and the demonstration by the Applicant that the dedicated smart function is beyond the existing scopes of notations covered by Sec 3 to Sec 7.

1.2.3 The notation **X** is to be replaced by the name of the smart function which is to be covered by the additional class notation **SMART(Xx)**, e.g. **SMART(Sloshing x)**.

1.2.4 The application of the notation **X** is to be limited to Category I systems as described in NR467, Ch 3, Sec 3.

1.2.5 When granting the additional class notation **SMART(Xx)**, a memorandum is to be endorsed in order to record the list of equipment covered and an overview of the dedicated smart function.

1.2.6 The loss of the smart function which is to be covered by the additional class notation **SMART(Xx)** is not to lead to dangerous situations for human safety, safety of the ship and/or threat to the environment.

1.3 Additional documentation to be submitted

1.3.1 The additional documentation to be submitted for smart function **X** is listed in Tab 1.

Table 1 : Additional documents to be submitted for smart function X

No.	A/I **(1)**	Documentation	Particulars
1	I	List of the relevant inputs of the special smart function	Including digital and analogue interfaces and manual entries
2	I	List of the outputs of the special smart function	Including digital user interfaces, application programming interfaces (API) and reports relevant for the onboard process supported by the digital solution
3	I	Description of the performance indicators for the special smart function	Indications driving the improvement of the process enhanced with the special smart function
4	A	Description of the onboard process supported by the special smart function	With a reference to its interfaces and operational procedures
(1) A = to be submitted for approval; I = to be submitted for information.			

1.4 Data inputs

1.4.1 Monitoring and recording equipment for the relevant time series is to be available on board the ship as inputs to the smart system.

1.5 Onboard testing

1.5.1 During the onboard test witnessed by a Surveyor, the user manual is to be provided and the system is to be operated to:

a) generate a report on data availability with uptime metrics and including identification of the source equipment, including digital and analogue interfaces and manual entries

b) status of the sensors calibration, if the calibration is required by the manufacturer of the sensor or of the smart system

c) generate the output including digital user interfaces, application programming interfaces (API) and reports relevant for the onboard process supported by the digital solution.

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