DESIGN RECORD TEMPLATE

Modified for use in support of the Australian Code of Practice for the Design, Construction, Survey and Operation of Autonomous and Remotely Operated Vessels

Prepared by Frazer-Nash Consultancy for Trusted Autonomous Systems

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Based on Frazer-Nash Consultancy Document No.: 52988R, Issue No. 2
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1 Introduction

This document acts as a record for assessing the design of Autonomous and Remotely Operated Vessels (AVs) and their ability to operate compliantly with the Australian Code of Practice, and more specifically with COLREGs. Design elements captured in this record include the operational context, communication systems, and the specifications of the sensor used to obtain data. These may then be used for navigational decisions and collision avoidance actions. The record consists of the following sections:

- **Vessel operational context:** A query and response table to establish where operational and COLREGs compliant decision making occurs, the duration of operation, and planned operating activities.
- **Communication systems:** Completed to capture the communication systems used to relay data and decisions between the vessel and the remote operations centre.
- **Sensor capabilities: COLREGs Part B (Steering and Sailing Rules).** Captures the types of sensors and hardware used by the vessel. These are mapped to the capabilities identified in the Enabling Framework[1] using a matrix.
- **Physical characteristics: COLREGs Part C (Lights and shapes).** A checklist to be completed to confirm that the type and shapes of lights present on the vessel are compliant with the applicable Rules stated in Part C.
- **Signalling: COLREGs Part D (Sound and Light Signals).** A checklist to be completed to confirm the vessel has suitable equipment onboard to produce the necessary sound signals.

[1] Refer to Annex A of the Australian Code of Practice for Autonomous and Remotely Operated Vessels. https://tasdcrc.com.au/wp-content/uploads/2021/11/Draft-Australian-Code-of-Practice-for-Autonomous-and-Remotely-Operated-Vessels-for-public-consultation-2021.pdf

2 Vessel Operational Context

Vessels are equipped with hardware and sensors to fulfil a function. Operating context determines whether the specifications, quantity, and type of sensors and hardware fitted on the vessel are sufficient. Operating context refers to the type of conditions the vessel will operate in, and the amount of human operator oversight needed for safe operation of the vessel.

Table 1: Operating Context Definition

Query	Response
What is the length of the vessel in metres?	(metres)
Where does the decision-making capability for the vessel reside?	Onboard the vessel (uncrewed)[2] ☐ Onboard the vessel (crewed)[3] ☐ Remotely by an onshore operator ☐ Remotely by an offshore operator ☐ A combination of the above (ticked above) ☐
Will the vessel be operating in or near restricted visibility or at night?	Yes ○ No ◉
What is the usual mission duration of vessel operation?	(Hours / Days / Weeks / Months)
What is the maximum mission duration of vessel operation?	(Hours / Days / Weeks / Months)
What is the usual operating range from point of deployment?	(kilometres)
Maximum operating range from point of deployment?	(kilometres)
What activities can the vessel conduct?	
In what areas will the vessel be operated?	
Additional comments	

[2] Uncrewed refers to no sufficiently qualified personnel on the vessel to make decisions or take control.
[3] Crewed refers to sufficiently qualified personnel available on the vessel to make decisions or take control.

3 Communication Systems

Communication systems are used to wirelessly transmit data for monitoring and control of the vessel. Specifications of the communication system used should be proportionate to the volume and size of transmitted and received data, as recorded by the respondent in Table 2.

Table 2: Data Transmission Requirements Record

Data source	Compression rate	Single file/image size (kB)	Update rate/latency (Hz)	Transmitted bit rate (kbps)
i.e radar/AIS plot	$\frac{Bits\ before\ compression}{Bits\ after\ compression}$	*375*	*0.4*	*100*
Additional comments:				

Table 3: Communication System Summary

Parameter	Detail
Brand/Manufacturer	
Model	
Quantity	
Position on vessel	
Network type Defines the type of network (i.e Satellite, Wi-Fi, High Altitude Platform)	
Network coverage Defines the range/area covered by the network.	
Network bandwidth	
Expected drop-out rate	
Frequency range (Hz)	
Operating temperature range (°C)	
Data speed uplink (kbps)	
Data speed downlink (kbps)	
Data encoding efficiency	
Data security method used	
Redundancy method If the main communication system fails, what redundancy methods are available to maintain a communication link between the vessel and the remote operator?	
Recovery method If main and redundant communication systems fail, what methods are available for locating the AV for recovery purposes?	

4 Sensor Capabilities

There are a wide range of sensors that may be used on autonomous vessels, with such hardware often used to fulfil multiple functional capabilities concurrently. The sensor capability matrix shown inTable 5 provides a means of capturing the key sensory hardware which a given vessel is equipped with, thus allowing these to be mapped across high-level functional capabilities required by COLREGs.

Directions for use:

1. For each sensor, place a tick in the adjacent cells to indicate where this hardware is used to fulfil (wholly or partially) any of the functional capabilities listed across the corresponding columns. If a sensor is not used, place a hyphen in the “Number of capability groups addressed by each hardware item” column for that sensor row.
2. If the vessel being considered is fitted with sensory hardware not listed in the matrix, additional hardware items can be specified in the appropriate sensor category (or ‘Other’ if a suitable category does not exist).
3. Further information about the functional capabilities can be obtained from the COLREGs rule references provided.
4. Once the matrix has been completed, count the number of ticks in each row and column and record these in the grey-shaded totals cells. The final count per row is an indication of the number of capabilities that could be fulfilled by the sensor type in that row. The final count per column is an indication of how many different sensors are used to fulfil each capability. These final counts are used as indication of the coverage and robustness of sensors to fulfil the capabilities stated in COLREGs.
5. For each hardware item that fulfils at least one capability, complete the technical data proforma in the corresponding subsection, which can be accessed through the “Section” column.

The capability matrix to be completed by the respondent is provided in Table 5.

Completed matrix example:

A completed example of a vessel equipped with a range of sensors is provided overleaf inTable 4. For this example vessel, the matrix was completed by considering the capability use case for each sensor type used to achieve COLREGs compliance.

This vessel’s camera system is utilised across the functional capability groups: own vessel state and operations; other vessel characterisation; state and range of visibility; operating environment boundaries; and existence of separation scheme. The corresponding boxes are ticked to indicate this. It is recorded in the rightmost column that 5 capability groups are addressed by this vessel’s camera system.

This process is repeated for each sensor type that is onboard the vessel for the purposes of COLREGs compliance. A design record must then be completed in the corresponding Section for each identified sensor type. Use the ‘additional’ section for sensors used by the vessel that are not defined in this document.

This matrix not only identifies the vessel’s reliance on a particular sensor – indicated by the total in the righthand column – but also identifies the vessel’s sensor complexity in addressing COLREGs – indicated by the total across the bottom row.

Table 4: Completed Example - Sensor Capability Matrix

Sensors			High-level capabilities aligned with COLREGs – Sense & Perceive							Number of capability groups addressed by each hardware item
			Group	VESSELS		CONDITIONS		OPERATING ENVIRONMENT		EXTERNAL STIMULI
			Capability	Own vessel state and operations	Other vessel characterisation (appearance, type, size, manoeuvrability)	State and range of visibility	Ocean conditions / sea state	Operating environment boundaries	Existence of separation schemes	Detection of sound signals
			COLREGs rule reference	5, 6, 7, 8, 9, 10, 12, 13, 14, 15, 17, 18	3, 5, 7, 8, 9, 10, 12, 13, 14, 15, 17, 18	6	6	9, 10	10	5, 9, 10	
ID	Name	Section								
Situational Awareness										
1	Camera System	4.1		☒	☒	☒	☐	☒	☒	☐	5
2	Thermal Infrared	4.2		☒	☒	☐	☐	☐	☐	☐	2
3	LiDAR	4.3		☐	☐	☐	☐	☐	☐	☐	-
4	RADAR	4.4		☒	☒	☐	☐	☐	☐	☐	2
5	AIS	4.5		☐	☒	☐	☐	☒	☒	☐	3
6	Sound reception – microphones	4.6		☐	☐	☐	☐	☐	☐	☒	1
7	Sound reception - hydrophones	4.7		☐	☐	☐	☐	☐	☐	☐	-
8	Sonar / echo sounder	4.8		☒	☐	☐	☐	☐	☐	☐	1
Navigation and Positioning											
9	Speed Log	4.9		☒	☐	☐	☐	☐	☐	☐	1
10	GNSS	4.10		☒	☐	☐	☐	☒	☒	☐	3
11	Inertial Navigation System	4.11		☒	☐	☐	☒	☐	☐	☐	2
Environmental Conditions											
12	Anemometer	4.12		☐	☐	☐	☒	☐	☐	☐	1

Additional										
13	Name:	4.13	☐	☐	☐	☐	☐	☐	☐	-
14	Name:		☐	☐	☐	☐	☐	☐	☐	-
15	Name:		☐	☐	☐	☐	☐	☐	☐	-
16	Name:		☐	☐	☐	☐	☐	☐	☐	-
17	Name:		☐	☐	☐	☐	☐	☐	☐	-
18	Name:		☐	☐	☐	☐	☐	☐	☐	-
19	Name:		☐	☐	☐	☐	☐	☐	☐	-
20	Name:		☐	☐	☐	☐	☐	☐	☐	-
Number of hardware items addressing each capability			7	4	1	2	3	3	1	

Table 5: Sensor Capability Matrix

Sensors			High-level capabilities aligned with COLREGs – Sense & Perceive							Number of capabilities addressed by each hardware item
		Group	VESSELS		CONDITIONS		OPERATING ENVIRONMENT		EXTERNAL STIMULI	
		Capability	Own vessel state and operations	Other vessel characterisation (appearance, type, size, manoeuvrability)	State and range of visibility	Ocean conditions / sea state	Operating environment boundaries	Existence of separation schemes	Detection of sound signals	
		COLREGs rule reference	5, 6, 7, 8, 9, 10, 12, 13, 14, 15, 17, 18	3, 5, 7, 8, 9, 10, 12, 13, 14, 15, 17, 18	6	6	9, 10	10	5, 9, 10	
ID	Name	Section								
Situational Awareness										
1	Camera System	4.1	☐	☐	☐	☐	☐	☐	☐	
2	Thermal Infrared	4.2	☐	☐	☐	☐	☐	☐	☐	
3	LiDAR	4.3	☐	☐	☐	☐	☐	☐	☐	
4	RADAR	4.4	☐	☐	☐	☐	☐	☐	☐	
5	AIS	4.5	☐	☐	☐	☐	☐	☐	☐	
6	Sound reception – microphones	4.6	☐	☐	☐	☐	☐	☐	☐	
7	Sound reception - hydrophones	4.7	☐	☐	☐	☐	☐	☐	☐	
8	Sonar / echo sounder	4.8	☐	☐	☐	☐	☐	☐	☐	
Navigation and Positioning										
9	Speed Log	4.9	☐	☐	☐	☐	☐	☐	☐	
10	GNSS	4.10	☐	☐	☐	☐	☐	☐	☐	
11	Inertial Navigation System	4.11	☐	☐	☐	☐	☐	☐	☐	
Environmental Conditions										
12	Anemometer	4.12	☐	☐	☐	☐	☐	☐	☐	

Additional											
13	Name:	4.13	☐	☐	☐	☐	☐	☐	☐		
14	Name:		☐	☐	☐	☐	☐	☐	☐		
15	Name:		☐	☐	☐	☐	☐	☐	☐		
16	Name:		☐	☐	☐	☐	☐	☐	☐		
17	Name:		☐	☐	☐	☐	☐	☐	☐		
18	Name:		☐	☐	☐	☐	☐	☐	☐		
19	Name:		☐	☐	☐	☐	☐	☐	☐		
20	Name:		☐	☐	☐	☐	☐	☐	☐		

Number of hardware items addressing each capability							

4.1 Camera System

Cameras may be used for a range of detection capabilities including object and vessel detection.

Table 6: Camera System Summary

Question	Response
Total number of cameras	
Combined field of view – Horizontal (°)	
Combined field of view – Vertical (°)	
Bearing of blind spots (if any)	

Table 7: Camera specifications

	Camera 1	Camera 2	Camera 3	Camera 4
Brand/Manufacturer				
Model				
Quantity				
Position on vessel				
Expiration date of sensor calibration certificate				
Anti-fouling method				
Compression rate				
Bit depth				
Fixed or movable (e.g. pan/tilt head)?				
Field of View (FoV) – Horizontal (°)				
Field of View (FoV) – Vertical (°)				
Articulation				
Focal length				
Resolution				
Frame rate				
Output format				
Dynamic range				

	Camera 1	Camera 2	Camera 3	Camera 4
Low light / night vision capability				
Operating temperature range (°C)				
Operating humidity (%)				
Additional Information:				

4.2 Thermal Infrared

Thermal infrared sensors may be used by vessels to detect the proximity of other vessels, wildlife, or navigational hazards.

Table 8: Anemometer Specifications

Parameter	Detail
Brand/Manufacturer	
Model	
Quantity	
Position on vessel	
Expiration date of sensor calibration certificate	
Thermal sensitivity	
Spectral range	
IR resolution	
Focus	
Field of View (FoV) – Horizontal (°)	
Field of View (FoV) – Vertical (°)	
Automatic image adjustment	
Operating temperature range (°C)	
Operating humidity (%)	
Atmospheric transmission correction	
Additional Information:	

4.3 LiDAR

LiDAR may be used by vessels for nearby detection of objects and vessels.

Table 9: LiDAR Specifications

Parameter	Detail
Brand/Manufacturer	
Model	
Quantity	
Position on vessel	
Expiration date of sensor calibration certificate	
Type (spindle/solid-state/other)	
Revolutions per second	
Refresh rate (Hz)	
Acquisition Time (ms)	
Wavelength (nm)	
Operational range (m)	
Field of view (°)	
Resolution	
Accuracy (m)	
Laser eye safety classification	
Operating temperature range (°C)	
Operating humidity (%)	
Additional Information:	

4.4 RADAR

RADAR may be used by vessels for nearby detection of objects and vessels.

Table 10: Radar Specifications

Parameter		Detail
Brand/Manufacturer		
Model		
Quantity		
Position on vessel		
Expiration date of sensor calibration certificate		
Transmit peak power (W)		
Transmit average power (W)		
Frequency (MHz)		
Pulse length (µs)		
Pulse repetition rate (Hz)		
Maximum operational range (Nm)		
Rotation rate (rpm)		
Antenna length (mm)		
Antenna gain (db)		
Beamwidth to -3 dB (°)	**horizontal**	
	vertical	
Operating maximum wind speed (Kts)		
Operating temperature range (°C)		
Operating humidity (%)		
Additional Information:		

4.5 Automatic Identification System (AIS)

AIS may be used for detection of nearby vessels and navigational aids. It may also be used to transmit own vessel data.

Table 11: AIS Specifications

Parameter	Detail
Brand/Manufacturer	
Model	
Quantity	
Position on vessel (VHF antenna)	
Expiration date of sensor calibration certificate	
Type	Class B
Receiver sensitivity (dBm)	
Transmit peak power (W)	
GPS receiver	Internal
Position accuracy (m)	
Operating temperature range (°C)	
Operating humidity (%)	
Additional Information:	

4.6 Sound Reception – Microphones

A sound reception system may be used to detect sound signals and their source of origin relative to the vessel.

Table 12: Microphone Specifications

Parameter	Detail
Brand/Manufacturer	
Model	
Quantity	
Position on vessel	
Expiration date of sensor calibration certificate	
Power source and consumption	
Input sensitivity (dB/Pa)	
Impedance (Ω)	
Signal-to-Noise ratio (dB)	
Compass safety distance (m)	
Relative distance between microphones (if quantity >1)	
Frequency range (Hz)	
Operating temperature range (°C)	
Operating humidity (%)	
Additional Information:	

4.7 Sound Reception - Hydrophones

Hydrophones are passive underwater devices that may be used to detect, and record ocean sounds from all directions.

Table 13: Hydrophone Specifications

Parameter	Detail
Brand/Manufacturer	
Model	
Quantity	
Position on vessel	
Expiration date of sensor calibration certificate	
Linear frequency range (kHz)	
Usable frequency range (kHz)	
Transducer sensitivity (dB)	
Preamplifier gain (dB)	
Effective sensitivity (dB)	
SPL equiv. Noise at 1 kHz (dB)	
RMS overload acoustic pressure (dB)	
Output impedance (Ω)	
Maximum operating depth (m)	
Operating temperature range (°C)	
Additional Information:	

SPL = Sound Pressure Level
RMS = Root Mean Square

4.8 Sonar / Echo Sounder

Sonar is an active method that may be used for detecting submerged or navigational hazards.

Table 14: Sonar / Echo Sounder Specifications

Parameter	Detail
Brand/Manufacturer	
Model	
Quantity	
Position on vessel	
Expiration date of sensor calibration certificate	
Operating frequency (kHz)	
Pulse bandwidth (kHz)	
Pulse types (CW/HFM/LFM)	
Transmission tilt angle range (°)	
Range (m)	
Operating depth (m)	
Transmission modes (°)	
Transmitting beam widths (° @ kHz)	
Number of Rx beams (# and ° covered)	
Receiving beam widths (#, °, kHz)	
Beam stabilisation	
Number of transmitter channels	
Number of receiver channels	
Operating temperature range (°C)	
Additional Information:	

4.9 Speed Log

A speed log is a device that may be used to measure the speed of a vessel with respect to water flow or the seabed.

Table 15: Speed Log Specifications

Parameter	Detail
Brand/Manufacturer	
Model	
Quantity	
Arrangement on vessel (transducer(s))	
Expiration date of sensor calibration certificate	
Type (e.g. electromagnetic, doppler, impeller, pito-meter, acoustic)	
Accuracy	
Speed range	
Depth range (if applicable)	
Beam characteristics (if applicable)	
Operating temperature range (°C)	
Operating humidity (%)	
Additional Information:	

4.10 Global Navigation Satellite System (GNSS)

A Global Navigation Satellite System (GNSS) is a satellite-based radionavigation system used for accurate determination of geographical locations. It is also used to synchronise time.

Table 16: GNSS Specifications

Parameter	Detail
Brand/Manufacturer	
Model	
Quantity (antennas)	
Position on vessel (antenna)	
Expiration date of sensor calibration certificate	
Compatible Global Navigation Satellite Systems (GNSSs) (GPS, GLONASS, Galileo, BeiDou)	
Number of channels	
Position accuracy	
Rate of refresh	
Rate of turn	
Operating temperature range (°C)	
Operating humidity (%)	
Additional Information:	

4.11 Inertial Navigation System (INS)

Inertial Navigation Systems (INS) are devices that may be used to determine the position, orientation and velocity of a vessel. INS can comprise accelerometers, gyroscopes and magnetometers.

Table 17: INS Specifications

Parameter		Detail
Brand/Manufacturer		
Model		
Quantity		
Position on vessel		
Expiration date of sensor calibration certificate		
Range		
Gain stability		
Non-linearity		
Bias stability		
Random walk/noise density		
Bias in-run stability		
VRE		
Alignment error		
Bandwidth		
INS accuracy	**Surge**	
	Heave	
	Sway	
	Heading	
	Position	
	Aiding equipment	
Operating temperature range (°C)		
Operating humidity (%)		
Additional Information:		

4.12 Anemometer

Anemometers may be used by vessels to measure relative wind speed and direction.

Table 18: Anemometer Specifications

Parameter	Detail
Brand/Manufacturer	
Model	
Quantity	
Position on vessel	
Expiration date of sensor calibration certificate	
Wind speed range (knots)	
Speed accuracy (±knots)	
Speed resolution (knots)	
Angle accuracy (±°)	
Angle resolution (°)	
Operating temperature range (°C)	
Operating humidity (%)	
Additional Information:	

4.13 Additional Sensors

Technical data for additional sensors which have been added to the sensor capability matrix are to be provided here.

Table 19: Additional Sensor Specifications

Parameter	Detail
Sensor generic name	
Hardware ID (Table 5: Sensor Capability Matrix)	
Brand/Manufacturer	
Model	
Quantity	
Position on vessel	
Expiration date of sensor calibration certificate	
Physical property sensed	
Sensing technique/method	
Spatial coverage	
Range of sensed values	
Sensitivity	
Accuracy	
Data output	
Operating temperature range (°C)	
Operating humidity (%)	
Additional Information:	

Duplicate table above for additional sensors as required.

5 Physical Characteristics

Complete tables based on vessel type and length. Mark compliance status as Yes/No/Exempt (Y/N/E).

5.1 Lights

Checklist for the position and specification of lights and shapes based on Part C and Annex I of COLREGs. A notation of "Y" followed by a tick signifies that a vessel of a particular length is equipped with the necessary lights specified for vessels of that length.

Table 20: Rule 22, Visibility of lights

Length	**Light type**	**Visibility range (nautical miles)**	**Y/N/E** Indicate selection using Y, N, or E and ticking the box.
Example			*Y☐N☐E☐*
$L \geq 50$ metres	Masthead light	6	Y☐ N☐ E☐
	Side light	3	Y☐ N☐ E☐
	Stern light	3	Y☐ N☐ E☐
	Towing light	3	Y☐ N☐ E☐
	White, red, green all-round light OR Yellow all-round light	3	Y☐ N☐ E☐
$12 \leq L < 50$ metres	Masthead light	$L < 20$ metres: 3	Y☐ N☐ E☐
		$L \geq 20$ metres: 5	Y☐ N☐ E☐
	Side light	2	Y☐ N☐ E☐
	Stern light	2	Y☐ N☐ E☐
	Towing light	2	Y☐ N☐ E☐
	White, red, green all-round light OR Yellow all-round light	2	Y☐ N☐ E☐
$L < 12$ metres	Masthead light	2	Y☐ N☐ E☐
	Side light	1	Y☐ N☐ E☐
	Stern light	2	Y☐ N☐ E☐
	Towing light	2	Y☐ N☐ E☐

Length	**Light type**	**Visibility range (nautical miles)**	**Y/N/E** Indicate selection using Y, N, or E and ticking the box.
	White, red, green all-round light OR Yellow all-round light	2	Y☐ N☐ E☐
Inconspicuous, partly submerged, or objects being towed	White all-round light	3	Y☐ N☐ E☐
Additional Information:			

5.2 Rule Compliance

Table 21: Part C Rule Compliance

Is the own vessel:	Select option		**Compliance with lights and shapes Rules**
	Yes	**No**	
Power-driven	☐	☐	If yes, comply with Rule 23 ☐
Towing or pushing	☐	☐	If yes, comply with Rule 24 ☐
Sailing or rowing	☐	☐	If yes, comply with Rule 25 ☐
Fishing vessels	☐	☐	If yes, comply with Rule 26 ☐
Vessels not under command or restricted in their ability to manoeuvre	☐	☐	If yes, comply with Rule 27 ☐
Constrained by draught	☐	☐	If yes, comply with Rule 28 ☐
Pilot vessel	☐	☐	If yes, comply with Rule 29 ☐
Anchored or aground	☐	☐	If yes, comply with Rule 30 ☐
Seaplane	☐	☐	If yes, comply with Rule 31 ☐

6 Signalling

6.1 Sound Equipment

Sound equipment is used to indicate the presence of the own vessel to surrounding vessels when operating in or near restricted visibility. For an AV to be COLREGs compliant whilst operating in restricted visibility conditions, it must be able to produce a sound signal. The sound signal can be produced using the sound equipment specified in COLREGs or using an alternative means that satisfies the technical specifications in Annex 3 of COLREGs.

Mark compliance status as Yes/No/Alternative/Exempt (Y/N/A/E).

Table 22: Rule 33 – Equipment for sound signals

Vessel	Sound Device	Y/N/A/E
$L < 12$ meters	Means of making an efficient sound signal	No
$L \geq 12$ metres	Whistle	Yes
$L \geq 20$ metres	Bell or equivalent (in addition to whistle)	Yes
$L \geq 100$ metres	Gong or equivalent (in addition to whistle and bell)	No
All	Comply with specification in Annex III of the COLREGs	Yes

6.2 Speakers

Speakers may be used to transmit sound signals from the vessel to neighbouring vessels.

Table 23: Speaker Specifications

Parameter	Detail
Brand/Manufacturer	
Model	
Quantity	
Position on vessel	
Peak power handling (W)	
Power handling continuous average (W)	
Frequency response range (kHz)	
Nominal impedance (Ω)	
Sensitivity (dB)	
Range (m)	
Directionality	

Parameter	Detail
Operating temperature range (°C)	
Operating humidity (%)	
Additional Information:	

6.3 Signals

Table 24: Part D Rule Compliance

Rule	Type of signal	Can the vessel produce the necessary sound and light signals?
34	Manoeuvring and warning signals	☐ Yes ☐ No
35	Operating in restricted visibility[4]	☐ Yes ☐ No
36	Signals to attract attention	☐ Yes ☐ No
37	Distress signals	☐ Yes ☐ No

[4] Only applicable if operating at night or in or near restricted visibility conditions.

7 Additional comments

Reference any additional comments here:

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