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REVIEW OF PERFORMANCE STANDARDS FOR RADAR EQUIPMENT

Submitted by Germany, Norway and the United Kingdom

SUMMARY

Executive summary:	This paper presents a Preliminary Draft revision of Performance Standards for Radar Equipment. This revision is intended to consolidate and replace a number of current documents which cover the subject. Key background issues are summarised and areas for further development are highlighted.
Action to be taken:	Paragraph 15
Related documents:	MSC.64(67), Annex 4, A.820(19), A.823(19), A.917(22), COMSAR 5/14, NAV 47/8/2, NAV 47/13, NAV 48/19, MSC 75/22/4, MSC 75/24 and SN/Circ.217

Introduction

1 MSC has instructed the NAV Sub-Committee to undertake a review of the performance requirements for radar to include a study of:

.1 minimum range and range discrimination;

.2 detection of Search and Rescue Transponders (SARTs) and Radar Beacons (RACONs);

.3 target detection including performance under anomalous propagation and clutter conditions;

.4 probability of detection and false alarm rate;

.5 hazard and acceptable risk of interference to maritime radar;

.6 the provision of hazard warning of fixed and floating objects; and

.7 maximum range.

2 This paper proposes a revision to the Performance Standards for Radar and associated plotting and tracking aids taking into account the above aspects of performance, amongst others.

Background

3 For the foreseeable future, radar will remain a primary tool for safe navigation as the ship borne radar sensor performs its function totally independently of externally-generated signals. Whilst recently developed systems such as AIS have significant potential to complement information provided by radar, they cannot replace it as they are heavily dependant on signals and information from sources external to own ship.

4 All SOLAS radar equipment is mandated to have a plotting aid and it appears logical to include that requirement within the main body of future Performance Standards for the radar itself. It is also considered that the determination of risk of collision can best be done by automatic target tracking (rather than manual plotting). The increase in the speed of many ships is a further driving factor and therefore greater emphasis must be placed on tracking capability. With modern advancements in technology it is not foreseen that this will result in any significant additional cost.

5 Automatic Identification System (AIS) equipment is now a mandatory carriage requirement for SOLAS vessels although a graphical display of targets reported by AIS is not. It must be recognised, however, that graphical display of such information to the Officer of the Watch (OOW) offers significant potential to enhance collision avoidance. The most logical display for indicating graphically AIS information from other ships is the radar display. Radar tracking information can be significantly enhanced by incorporating information available from AIS, the display of AIS reported targets and association of these reported targets with radar tracked targets. The proposed Performance Standards include this facility as a highly desirable additional feature. It is suggested that the NAV Sub-Committee give serious consideration to recommending that this feature becomes a requirement for all future radar displays for the following reasons:

.1 the display of target information on dedicated, 'stand-alone' AIS equipment separated from radar-derived target information does not readily assist the OOW in assessing if risk of collision exists using "all available means" (COLREGs, Rule 7(a));

.2 alpha–numeric display of AIS information is difficult to interpret and could lead to misinterpretations when viewing radar separately; and,

.3 the option of interfacing the display of AIS and radar – derived target information on the radar will improve evaluation by the OOW of risk of collision, reduce workload and possible misinterpretations.

IEC TC 80 WG 01 has already developed an interim test standard IEC 60936-5 for the display of AIS on radar taking into account the IMO guidelines for the on board operational use of shipborne automatic identification systems (resolution A.917(22)) and the interim guidelines for the presentation and display of AIS target information (SN/Circ.217).

6 Display of selected System Electronic Navigational Chart (SENC) information, including a layering facility, on the radar display is also seen as highly beneficial to the OOW facilitating a better awareness of the navigational situation and providing a simple method of checking the integrity of Electronic Position Fixing System (EPFS) data against positional information available from radar. The proposed Performance Standards again include this facility as a highly desirable optional feature.

7 It is perceived that the requirement to trigger SARTs and RACONs of current designs imposes constraints on radar design. These constraints, when coupled with future International Telecommunications Union (ITU) requirements to restrict spurious and out of band emissions, may result in increased costs and complexity of equipment. Whilst compatibility with SARTs at X band must remain until a replacement beacon is mandated by IMO, it is considered that the requirement to operate with RACONs at S band can be removed from the mandatory performance requirements and thus allow innovative design of radar operating in this band.

Proposed revision of the Performance Standards

8 A preliminary draft revision of the Performance Standards for Radar is given at annex. It is proposed that these revised Performance Standards should supersede:

.1	MSC.64 (67), annex 4	Performance Standards for Radar Equipment.
.2	A.823(19) (ARPAs).	Performance Standards for Automatic Radar Plotting Aids
.3	A.820(19)	Performance Standards for Navigational Radar Equipment for High-Speed Craft

combining the requirements of all three existing documents into a single comprehensive document applicable to all ships subject to radar carriage requirements. The revision also takes account of the information currently contained in resolution A.917(22) and SN/Circ.217.

9 These revised standards consolidate all aspects of radar system performance and include:

.1 addressing the changing needs of users, including reducing the workload, as reflected in user surveys;

.2 embracing new technology to benefit the user and enhance safety at sea;

.3 recognising the user's need for higher detection performance, particularly relating to target detection in difficult conditions and faster moving targets;

.4 combining and harmonising current radar and plotting IMO Standards, including IMO guidelines for the use and display of AIS;

.5 embracing the new proposed IMO Performance Standards for the 'Presentation and Display of Navigational Related Information' covering harmonisation of display and presentation aspects;

.6 enhancing equipment to be compatible with System Integration (Integrated Navigation System / Integrated Bridge System);

.7 consideration of frequency spectrum and emission requirements of the ITU.

10 These standards apply to stand-alone radar, radar combining the display of AIS and/ or charts or as part of an integrated navigation system.

Further work

11 Further work is required on the preliminary draft before finalising the draft revision. This should include:

.1 confirmation of the Radar Cross Section (RCS) of relevant targets and calculations to confirm the detection ranges that are practically achievable against these targets, both in clear and in clutter conditions. This work must be based on the user expectations and cost-effective technology expected to be available at the time when the new Performance Standards enter force;

.2 consideration of the harmonisation of design and certain important operational controls; and

.3 further studies of the relative virtues of sea and ground stabilisation of the radar display.

12 Deliberations continue within the ITU regarding radar spectrum issues. Concerns persist that further restrictions to the spectrum will restrict enhancement of small target detection and it may be necessary to take further note of these before finalising the draft revision.

13 Certain features proposed in the revised Performance Standards are perceived to offer significant benefits to the Mariner but may incur an element of extra cost. An initial consideration of these costs has led to the assessment that they are not excessive but further work is required to confirm this.

14 Certain requirements regarding the capability of radar equipment performance are contained within Chapter V of SOLAS. Minor changes to these may need to be considered at the next opportunity for routine revision of this chapter.

Action requested of the Sub-Committee

15 The Sub-Committee is invited to consider the above and the proposed preliminary draft revision of the Performance Standards at annex and decide accordingly.

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ANNEX

DRAFT PROPOSED NEW RADAR PERFORMANCE STANDARDS

1 Scope of Equipment

The radar equipment should assist in safe navigation and in avoiding collision by providing an indication, in relation to own ship, of the position of other surface craft, obstructions and hazards, navigation objects and shorelines.

For this purpose, radar should provide the integration and display of radar video, target tracking information, positional data derived from own ship's position (EPFS) and [geo referenced data] [maps]. The integration and display of AIS information [should] [may] be provided to complement radar. The capability of displaying SENC chart information may be provided [and in this case, allowing its use as back up for ECDIS]

- [The radar, combined with [other sensor or] reported information (e.g. AIS), should improve the safety of navigation by assisting in the efficient navigation of ships and protection of the environment by satisfying the following functional requirements: in harbour approaches by giving a clear indication of land and other fixed hazards;

- as a means to provide an enhanced traffic image and situation awareness; and

- in a ship-to-ship mode for aiding collision avoidance of both detected and reported hazards]

2 Application of these standards

These standards supersede all current radar and plotting standards.
These standards apply to stand-alone radar, radar combining the display of AIS with radar and charts with radar, and as a part of an integrated navigation system (INS).

These Performance Standards should apply to all radar installations required by SOLAS independent of the:

- type of ship (HSC or conventional)

- frequency band in use

- type of display

providing that no special requirements are specified in table 1 and that additional requirements for specific classes of vessel (in accordance with SOLAS chapter V and X) are met.

The radar installation, in addition to meeting the general requirements as set out in resolution A.694 (17), should comply with the following performance standards.

Table 1 defines the differences in the performance requirements for various sizes/ categories of ship/craft falling under SOLAS.

TABLE 1

Size of ship	300GT –499GT	500GT –9999GT and HSC	10000GT and above
Minimum effective screen size	180mm	250mm	[320mm]
Auto track targets	Yes	Yes	Yes
Auto acquisition targets	-	-	Yes
Minimum acquired radar target capacity	[20]	[20] [30]	[30] [40]
Minimum activated AIS target capacity	[20]	[20] [30]	[30] [40]
Trial Manoeuvre	-	-	Yes

3 References

See appendix 2 (To be reviewed and completed)

4 Definitions

See appendix 1 (To Be Developed)

5 Operational Requirements for the Radar System

[The design and performance of the radar should be based on user requirements and up-to-date navigational technology. It should provide safe target detection within the safety-relevant environment surrounding ownship and should permit fast and easy situation evaluation.[1]]

5.1 Frequency

.1 Frequency spectrum

The radar should transmit within the confines of the ITU allocated bands for maritime radar and meet the requirements of the radio regulations and applicable ITU-R recommendations.

.2 Radar sensor requirements

Radar systems of both X and S band are covered in these performance standards:

- X band for high discrimination, good detection and tracking performance.
- S band to ensure that detection and tracking capabilities are maintained in varying conditions of fog, rain and sea clutter.

Where both frequency equipment are fitted, the frequency band selected should be indicated.

[1] Refer to MSC/Circ 878 , the Human Element Analysing Process (HEAP)

5.2 [Radar range and bearing accuracy

The radar [system] [sensor] range and bearing accuracy requirements in typical sea conditions are xxx and yyy]

5.3 Detection Performance and Anti-clutter Functions

All available means should be made available to aid the user in detection of targets.

.1 Detection

.1.1 Detection in clear conditions

In the absence of clutter, for long range target and shoreline detection the requirement for the radar system is based on typical propagation conditions and with an antenna height of 15m above sea level.

Based on an indication of the target in [8] out of 10 scans the requirement contained in table 2 should be met.

TABLE 2

Target Description	Target feature or minimum effective target echoing area at			Detection Range at a defined relative target speed.	
	Height above sea level in metres	X band target in (m^2)	S band target in (m^2)	X band	S band
Shorelines	Rising to 6.0	10000	10000	[8.0nm at 70kn]	TBD
Shorelines	Rising to 60	10000	10000	[16nm at 70kn]	TBD
SOLAS vessel (>500 gt)	[5.0]	[100]	[10]	[5.5nm at 140kn]	TBD
Small craft of length (10m min)	[3.0]	[10]	[1.0]	[4.5nm at 140kn]	TBD
Navigation buoy	[2.0]	[5.0]	[0.5]	[3.5nm at 70kn]	TBD

.1.2 Detection at close range

[The short-range detection of the targets under the conditions and relative speeds specified in table 2 – TBD; **Note**: this para has to be harmonised with paragraph 5.4]

.1.3 Detection in clutter conditions

Performance limitations caused by typical precipitation and sea clutter conditions will result in a reduction of target detection capabilities relative to those defined in table 2.

[Precipitation should not reduce the detection performance of more than [50%] with [XX mm/h] rain].
or
[Precipitation will reduce the range detection performance. For example rain may result in a reduction of no more than [XX] under typical rain conditions.]
or
[The reduction in the range of detection due to precipitation should be quantified. TBD]

[Sea clutter will result in a reduction in detection probability. For example for a navigation buoy as defined in table 2 at [0.5nm] the number of indication's may reduce to no less than [Y] out of 10 scans in typical adverse sea states.]
or
[The reduction in detection probability due to sea clutter should be quantified. TBD]

Note. Any degradation in performance due to weather, a long transmission line, different antenna height or any other factor, should be clearly stated in the installation and user's manual.

.2 Anti-clutter Functions

.2.1 Means should be provided for the suppression of unwanted echoes, including sea clutter, rain and other forms of precipitation, clouds, sandstorms and interference from other radars.

.2.2 Effective manual and automatic anti-clutter functions should be provided.

.2.3 A combination of automatic and manual anti-clutter functions is permitted.

.2.4 There should be a clear and continuous indication of the status for all anti-clutter functions.

.3 Signal Processing

.3.1 Means should be available to enhance target visibility on the display screen.

.3.2 The picture update period should not be greater than [3secs] and at least sufficient to ensure that the target detection and vessel speed criteria in Table 2 is met.

.3.3 The equipment manual should explain the basic concept, features and limitations of any signal processing.

.4 Operation with SARTs and Radar Beacons

.4.1 At least the X band radar system should be capable of detecting SARTs and radar beacons that are compatible with the system from which radar signals are being transmitted/received.

.4.2 All radars in the X band should be capable of operating at least in the horizontally polarised mode. If other polarisation modes are available, an indication of the mode should be indicated.

.4.3 [It should be possible to switch off those signal processing functions which might prevent a radar beacon or SART from being detected and displayed.]

5.4 Minimum Range

.1 With own vessel at zero speed and an antenna height of 15m above the sea, the navigational buoy specified in Table 2 should be detected at a minimum horizontal range of [40m] from the antenna position and up to a range of [1nm],

without changing the setting of control functions, other than the range scale selector.

.2 Means should be provided to correct any range error due to the transmitter antenna transmission line. The compensation for each selected antenna should be automatically applied.

5.5 Discrimination

The discrimination performance should apply at a range between 50% and 100% on the 1.5nm [or lower] range scale.

.1 Range

The radar system should be capable of displaying two point targets on the same bearing, separated [by 40m] in range, as two distinct objects.

.2 Bearing

The radar system should be capable of displaying, as two distinct separate objects, two point targets at the same range, and separated in bearing by [2.5°] for both X and S band.

5.6 Roll, Pitch [and Yaw]

The target detection performance of the equipment [at ranges up to 10nm] should not be substantially impaired when own vessel is rolling, pitching or yawing up to +/-10°.

5.7 Radar Tuning

.1 Manual tuning should be provided and additionally, automatic tuning may be provided.

.2 An indication should be provided, in the absence of targets, to ensure that the system is correctly tuned.

5.8 Performance Monitor

[Means should be available, while the equipment is operational, to determine a significant drop in performance relative to a calibrated standard established at the time of installation.]

or

[Means should be provided to monitor and alert the operator immediately if the detection performance of the radar has deteriorated relative to a calibrated standard established at the time of installation.]

5.9 Radar Availability

The radar equipment should be fully operational within 4 minutes after switch ON from cold. A standby condition [where there is no radar transmission] should be provided and the radar should be fully operational within 15 seconds from the standby condition.

5.10 Radar Measurements – Common Reference Position

.1 Measurements from ownship (e.g. range-scale, range rings, target range and bearing, cursor, tracking data) should be made with respect to the ship's common reference position (e.g. conning position). If the position of the radar antenna is not at the ships common reference position, the radar antenna position should be indicated. Differing antenna positions may be required for multiple radar installations. When the picture is centred, the ship common reference position should be at the centre of the bearing scale.

.2 Range measurement is permitted in nautical miles (nm) or metres (m). All indicated values for range measurement should be in the same units and the type of unit should be clearly indicated.

.3 Radar targets should be displayed without an unsafe delay.

.4 [Data Integrity (TBD) (Related to INS/Display of Navigational Related Data)]

5.11 Display Range Scales

.1 Range scales of 0.25, 0.5, 0.75, 1.5, 3, 6, 12 and 24nm should be provided. Additional range scales are permitted outside the mandatory set.

.2 The range scale selected should be permanently indicated.

5.12 Fixed Range Rings

.1 On the 0.25, 0.5 and 0.75nm range scales, at least two and not more than six equidistant spaced range rings should be provided. On other mandatory range scales, six range rings should be provided. On optional range scales outside of the mandatory range scales, any number of rings up to a maximum of [8] may be provided. Additional equidistant-range rings should be provided for an off-centred picture.

.2 The accuracy of fixed range rings should be within 1% of the maximum range of the range scale in use or 30m whichever is the greater distance

5.13 Variable Range Markers (VRM)

.1 At least two VRMs should be provided.
.2 The VRMs should enable the user to measure the range of an object within the effective radar area with a maximum system error of 1% of maximum range of the range scale in use or 30m whichever is the greater distance.
.3 A fast and simple means should be provided to position the VRM.
.4 It should be possible to switch a VRM off.

.5 Each active VRM should have a dedicated numerical readout with a resolution at least compatible with the range scale in use.

5.14 Bearing Scale

.1 A bearing scale around the periphery of the effective radar area should be provided. The bearing scale should either indicate the bearing as seen from the ships reference location or, should be centred with an indication of the ships heading.

.2 The bearing scale should have division marks of 1°, with the 1°, 5° and 10° marks clearly distinguishable from each other [in the centred position]. [The marks may be inside or outside of the effective radar area.]

.3 The bearing scale should be numbered at each 30° division. It is permitted to delete the numbers at the top and bottom of the scale or at the 90° and 270° points depending on the screen orientation. [The numbers should be outside of the effective radar area.]

5.15 Heading Line (HL)

.1 A continuous line from the ship's reference position to the bearing scale should indicate the heading of the ship.

.2 For each radar sensor in a multiple system, electronic means should be provided to align the heading line to within [0.5°]. The heading skew (bearing offset) should be retained and automatically applied when each radar sensor is selected.

.3 Provision should be made to temporarily suppress the heading line. This function may be combined with the suppression of other graphics.

5.16 Electronic Bearing Lines (EBLs)

.1 At least two electronic bearing lines (EBLs) should be provided to measure the bearing of any object within the effective radar area.

.2 The EBLs should be capable of measurement relative to the ships heading or relative to true north. There should be a clear and continuous indication of the bearing reference.

.3 It should be possible to move the EBL origin from the ship's common reference position to any point within the radar display area and to reset the EBL to the ship's common reference position by a fast simple action.

.4 It should be possible to fix the EBL origin or to move the EBL origin at the velocity of own ship.

.5 Means should be provided to ensure that the user is able to take the bearings of any point object within the effective radar area, with a maximum system error of 1° at the periphery of the display.

.6 Means should be provided to ensure that the user is able to position the EBL smoothly in either direction, in steps of not more than 0.25°.

.7 Means of switching OFF an EBL should be provided.

.8 Each active EBL should have a dedicated numerical readout with a resolution of at least [0.5°].

5.17 Parallel Index lines (PI)

.1 A minimum of 4 independent parallel index lines should be provided.

.2 Simple and quick means of setting the bearing of a parallel index line should be provided. The bearing of any selected index line should be available on demand.

.3 Simple and fast means of setting the beam range of an index line should be provided. The beam range of any selected index line should be available on demand.

.4 A means of truncating any index line may be provided.

.5 A means of switching OFF any selected index line should be provided.

.6 A means of temporarily suppressing all parallel index lines should be available. This function may be combined with the suppression of other graphics.

5.18 Electronic Range and Bearing Line (ERBL)

.1 A range mark (or strobe) may be provided on an EBL to permit the measurement of the range of an object from the origin of the EBL. The function may be used to measure the range and bearing between any two points within the effective radar area.

.2 The range mark may use the variable range marker readout.

5.19 User Cursor

.1 A user cursor should be provided to enable a fast and concise means to designate any position on the display screen.

.2 The cursor position should have a continuous readout to provide the range and bearing measured from the common reference point. The range and bearing of one position relative to another position and the latitude and longitude of the cursor position should also be available.

.3 The cursor should provide the means to select and de-select targets, graphics or objects within the effective radar area. The cursor may be used to select modes, functions, vary parameters and control menus outside of the effective radar area.

.4 [Means should be provided to easily locate the cursor position on the screen.]

5.20 Azimuth Stabilisation

.1 The heading information should be provided by a gyrocompass or by an equivalent sensor with a performance not inferior to the relevant standards adopted by the Organization.

.2 Excluding the limitations of the stabilising sensor and type of transmission system, the accuracy of azimuth alignment of the radar presentation should be within 0.5° with a rate of turn up to 20°/second.

5.21 Display mode

[.1 The radar display mode should be available in at least two formats:

- Relative motion (RM), north up, relative or true trails.
- True motion (TM), north up, true trails only.]

or

[.1 The radar display should be available in at least True Motion North Up mode. The target trails should be available in true [and relative] mode.]

or

[.1 The radar display mode should be available in at least Fixed Origin True Motion mode. The target trails should be available in true and relative mode.]

.2 Other motion and azimuth stabilisation modes, including head up, are permitted. The mode and stabilisation selected should be clearly indicated.

5.22 Off-centring

.1 Manual off centring should be provided to position own ships reference position at any point within 50% of the radius from the centre of the effective radar area.

.2 In Relative Motion and on selection of off centre display; ownship should be capable of being positioned to any point on the screen within 50% of the radius. A facility for automatically positioning ownship for the maximum view ahead may be provided.

.3 In True Motion, own ship origin should automatically reset up to a 50% radius to a position giving the maximum view along ownship's course. Provision for an early reset of ownship origin should be provided.

5.23 Ground and Sea Stabilisation Modes

.1 Ground and Sea stabilisation modes should be provided.

.2 The stabilisation mode and stabilisation source should be clearly indicated.

.3 The source of own ships speed should be from a sensor approved in accordance with the requirements of the Organisation.

.4 A means of inputting manual speed input should be provided, [0-70kn] in steps of no more than 0.5kn. The application of manual speed should be indicated.

5.24 Ships common reference position and own ship scaled outline

.1 Facilities should be provided to compensate for the offset between the antenna location and the ships common reference position.

.2 Where multiple antennas are installed there should be provision for applying different position offsets for each antenna in the radar system. The offsets should be applied automatically when any radar sensor is selected.

.3 Own ships scaled outline should be available on appropriate range scales. The position of the selected radar antenna should be indicated on this graphic.

5.25 Target Trails

.1 Variable length true and relative target trails should be provided, with an indication of trail time and mode.

.2 The trails should be distinguishable from targets.

.3 [Trails should be maintained and available for presentation within [2] scans:

- after the reduction [or increase] of one range scale and
- after the offset and reset of the radar picture.]

5.26 Target Tracking (TT) and Acquisition

.1 General

.1.1 The automatic target tracking calculation should be based on the measurement of radar target position and motion data [including own ship's speed, course and ROT].

.1.2 TT facilities should be available on at least the 3, 6, 12 and 24nm range scales. Tracking range should extend to a minimum of [20 nm].

.1.3 [All available means should be used to provide the optimum tracking performance.]

.2 Acquisition

.2.1 Manual acquisition of radar targets should be provided with provision for tracking at least the number of targets specified in table 1 having a relative speed of up to [140kn].

.2.2 Automatic acquisition should be provided where specified in table 1. In this case, there should be means for the user to define the boundaries of the auto-acquisition area. Automatic target detection should not have a performance inferior to that achievable using manual acquisition.

.3 Tracking

.3.1 When a target is acquired, the system should present the trend of the targets motion within one minute and the prediction of the targets motion within 3 minutes.

.3.2 TT should be capable of tracking and updating the information of all targets automatically.

.3.3 The system should continue to track Radar targets that are clearly distinguishable on the display for 5 out of 10 consecutive scans.

.3.4 The TT design should be such that target vector and data smoothing is effective. Target manoeuvres should be detected as early as possible.

.3.5 The possibility of tracking errors, including target swap, should be minimised by design.

.3.6 Separate facilities for cancelling the tracking of any and all target(s) should be provided.

.3.7 Automatic tracking accuracy should be at least as good as manual plotting. [Examples of accuracy values of TCPA/CPA and optionally other data, to be devised.]

.3.8 Stationary tracked targets used for ground referencing should be marked with the relevant symbol.

.4 Vectors

.4.1 The course and speed of a tracked target should be displayed graphically by a vector that clearly indicates the predicted motion.

.4.2 The selection of true and relative vectors should be available. A clear indication of the mode selected should be provided.

.4.3 Vector time should be adjustable. A permanent indication of the time scale of the vectors should be provided.

.5 Target Data

.5.1 Means should be provided to select any target to obtain its individual data. A selected target should have a designated symbol on the display.

.5.2 For each selected target, data should be available in alphanumeric form on any target, which has been tracked for at least one minute:

- i) Source(s) of data
- ii) Actual range of target
- iii) Actual bearing of target
- iv) Predicted target range at the closest point of approach (CPA)

- v) Predicted time to CPA (TCPA)
- vi) True course of target
- vii) True speed of target.

.5.3 Provision for the selection of multiple targets is permitted. The alphanumeric data indicated may be in a reduced and paired format. The groupings should be ii) with iii), iv) with v) and vi) with vii). Each selected target and its related data should be clearly identified.

.6 Trial manoeuvre

The system should, where required by table 1, be capable of simulating the predicted effects of own ships manoeuvre in a potential threat situation. Own ship course and speed should be variable. Time to manoeuvre [should][may] be provided. During simulation, target tracking should continue and the actual target data should be indicated.

.7 TT operational Alarms

.7.1 The TT should provide an audible and visual alarm for any target that is predicted to close within a minimum range Closest point of approach (CPA) and time to closest point of approach (TCPA). The target should be clearly indicated by the dangerous target symbol.

.7.2 A guard zone facility should be provided. When a target enters the zone or closes to a range pre-determined by the user, the target should be clearly identified with the relevant symbol and an audio and visual intrusion alarm should be provided.

.7.3 The TT should alert the user if a tracked target is lost, other than out of a pre-determined range or pre-set parameter. The targets last known or predicted position should be clearly indicated by the relevant symbol on the display.

5.27 Automatic Identification System (AIS)

.1 General

.1.1 As far as possible, the user interface for AIS functions should be common and consistent with radar tracking. These functions include range scale availability, guard/acquisition zones, CPA and TCPA limits, vector modes/lengths and the target numeric data.

.1.2 The minimum input from the AIS information to the radar system should be the target's position, course over ground (COG), speed over ground (SOG) and if available, heading, turn or rate of turn (ROT) indicator. The MMSI and call sign should also be available as source identifiers If AIS target position information is unreliable, the relevant AIS symbol should be inhibited.

.2 Target capacity and activation

.2.1 The radar system should be capable of processing and displaying a minimum number of AIS targets (see table 1), additional to those associated with the TT.

.2.2 There should be a clear indication when the target capability has been exceeded. Target overflow should not degrade the radar system performance.

.2.3 Automatic (zone or parameter) and manual selection of AIS targets should be provided.

.2.4 Automatic AIS target activation may be initiated within a defined zone or by other user-specified parameter(s) (e.g. range/CPA) to filter the display of AIS targets. The filter criteria should be permanently and clearly indicated in numeric or graphic form.

.2.5 All targets that are selected by the filter criteria should be activated targets; those AIS targets excluded from the criteria should be displayed as sleeping targets.

.2.6 It should be possible to manually activate or de-activate AIS targets (reverting to a sleeping target).

.3 AIS graphical presentation

.3.1 All AIS targets should be displayed with the appropriate symbol and the orientation of the symbol should indicate the target's heading.

.3.2 If the heading is not received, the orientation of the AIS symbol should be aligned to the COG.

.3.3 The turn or rate of turn (ROT) indicator should indicate the manoeuvre of an AIS target.

.3.4 AIS target symbols and numeric data should be available within three seconds of a change in range scale.

.3.5 It should not be possible to remove individual AIS targets from the display.

.3.6 The radar system may provide the means to process and display selected AIS messages transmitted from VTS stations.

.3.7 [The radar system should have the means to process and display AIS information from Aids to Navigation (A to Ns).]

.3.8 By a fast and simple action, it should be possible to turn the display of AIS information ON and OFF. AIS display and functional status should be clearly and continuously indicated. When the display presentation is OFF, target association and AIS target processing should continue including the violation of CPA/TCPA limits. When the AIS is switched completely OFF, target association and monitoring of CPA/TCPA limits should cease.

.4 AIS and radar target association

.4.1 Automatic Identification System (AIS) data, where available, should be used to enhance the TT performance. In this case, association of AIS and the TT should be provided.

.4.2 AIS and radar targets should be displayed regardless of the presence of each other.

.4.3 [If target data from AIS and from radar plotting are both available and if the target association criteria are fulfilled, then as a default condition, the activated AIS target symbol and the alphanumeric AIS target data should be automatically selected and displayed. The user should be permitted to select either TT or AIS alphanumeric data and may change the default condition.]

.4.4 [Means should be provided to enable or disable the automatic target association. The design should minimise the presentation of more than one symbol and set of data for any target.]

.4.5 [The AIS and TT information should be combined and processed to provide the best information to the user.]

.4.6 AIS target position should be updated upon receipt of each AIS report: Dead reckoning between AIS reports is permitted for a limited period.

.5 AIS target data

.5.1 When an AIS target is selected, the target numeric data should be similar in content to that derived from tracked targets. In addition, the MMSI, call sign and ROT, if available, should be displayed. Further AIS data may be made available.

.5.2 If the received AIS information associated with any target is incomplete, the missing information should be clearly indicated in the alphanumeric data. The design should ensure that missing or invalid AIS data should not impair the accuracy of associated tracked targets.

.6 AIS operational alarms

.6.1 AIS targets that are calculated to be within the CPA and TCPA limits should be automatically activated and an alarm should be given.

.6.2 For AIS targets that intrude into a target guard zone, for dangerous targets and for lost targets, the alarm functionality should be similar to that defined for TT.

.6.3 The system should alert the user if the signal from an activated AIS target is not received within a set time dependent on the nominal reporting rate of the AIS target (AIS lost target) and there should be means of recovering limited historical data from previous reports.

5.28 The display of maps

.1 It should be possible for the user to create simple relative or true maps.

.2 The maps may consist of lines, symbols and reference points.

.3 The appearance of lines, colours and symbols are as defined in MSC xx [See IEC 62288].

.4 The map graphics should not appreciably degrade the radar information.

.5 It should be possible to change, save, load and display the maps should comply with MSC xx [See IEC 62288[.

.6 The maps should be retained when the equipment is switched OFF.

.7 The map data should be transferable whenever a relevant equipment module is replaced.

.8 The capability and functionality of the mapping function should be fully documented in the user's manual.

5.29 The display of charts

.1 The radar system may provide the means to display vector chart information within the effective display area. The display of radar information should have priority. Chart information should be displayed such that radar information is not masked, obscured or degraded. SENC information should be clearly perceptible as such.

.2 The chart information should use the same reference and co-ordinate criteria as the radar system.

.3 The SENC database information for a radar display should, at least include; coastlines, own ships safety contour, dangers to navigation and fixed/floating aids to navigation.

.4 Means should be provided to enable the user to select parts of the available SENC information. Information should only be selected on a class or layer basis, not as individual objects.

.5 Symbols and graphics should comply with MSC xx [See IEC62288Table 5]

.6 There should be an indication of the SENC status in terms of source, authorisation and update information.

.7 Means to align the radar and chart information is permitted. The application of such alignment should be clearly indicated. A simple alignment reset facility should be available.

.8 A malfunction of the source of SENC data should not affect the operation of the radar system.

5.30 Alarms and Indications

.1 An alarm should alert the user if invalid data is presented. If there is any detectable reason for the invalid information, a clear indication should be given.

.2 Means should be provided to display and acknowledge alarm messages concerning the quality of data from external sensors that are used by the radar system.

.3 If more than one source of data is available, the selected source should be clearly indicated.

.4 Means should be provided to signal to an external alarm system the following conditions:

- Unacknowledged collision alarm
- Unacknowledged lost target alarm
- etc TBD

.5 To alert the user of "picture freeze", there should be a positive and continuous indication on the display that the screen content is being refreshed.

.6 Failure of any primary signal, including; gyro, log, azimuth, video, sync and heading marker, should be alarmed. System functionality should be limited to a fall back mode or in some cases, the display presentation should be inhibited.

.7 It should be possible for the user to enable or disable the audible alarm signal. The alarm status should be indicated.

5.31 Inter-Switching and / or integrating Multiple Radars

.1 The system should safeguard against single point system failure. If an interswitch function is provided, a fail-safe condition should be applied in the event of a failure.

.2 The source of radar signals should be clearly indicated.

.3 The system status for each display position should be available.

6 Ergonomic criteria

6.1 Operational controls

.1 The design should ensure that the radar system is simple to operate. Operational controls should be easy to identify and simple to use.

.2 The radar system should be capable of being switched ON or OFF at the main system radar display position.

.3 The controls may be discrete (hardware), screen accessed (software) or a combination of these.

.4 Primary controls should be easily and immediately accessed.

.5 The radar system design should provide controls or control functions that comply with Table 3.

TABLE 3 - Controls and control functions

	Directly accessible and immediately effected	Continuously variable or in small, quasi-analogue steps	Settings readable under all light conditions	The use of automatic adjustment-mode to be indicated to the user
On-/off-switch	X			
Monitor brilliance	X	X	X	X
Panel illumination	X		X	
Tuning	X	X	X	
Gain	X	X	X	X
Range scale selection	X		X	
Mode of trails/vectors	X		X	
Anticlutter rain	X	X	X	X
Anti-clutter sea	X	X	X	X
EBL	X	X	X	
VRM	X	X	X	
User Cursor	X	X	X	

6.2 Display Presentation

.1 It should be possible to control the [intensity] [brilliance] of [all] [global] [independent] [separate] display information.

.2 The radar display presentation should be viewable under all display light conditions. The display colours and intensity should take account of user night vision requirements. The Display colours should track down to low ambient light levels and be visible in the minimum video levels compatible with dark conditions.

.3 If a light shield is provided, it should be simple to attach and remove the shield. The design of the shield should not impair the user's ability to maintain a proper lookout. It should be possible for the display to be viewed by more than one observer.

.4 The user should have the means to remove and to temporarily suppress all graphical information from the display [, retaining only radar video and trails.]

.5 The brilliance of the fixed rings, VRMs and EBLs shall be variable to extinction. The function may be combined with other graphics.

.6 The brilliance of the heading line should not be variable to extinction.

.7 [No part of the effective radar area should be used for presentation of information that is not part of the navigation presentation (e.g. pop up displays, drop down menus and information windows]. Temporary, limited and relevant alphanumeric

data may be displayed adjacent to a selected symbol, graphic or target within the effective radar area.

.8 The colours, symbols and graphics presented should comply with MSC xx [See IEC 62288].

.9 The display screen performance and presentation should be [adequate for the type of information displayed] and in accordance with MSC xx [See IEC 62288].

.10 The screen sizes should conform those defined in table 1.

6.3 Instructions and Documentation

.1 Documentation Language

The operating instructions and manufacturer's documentation [should be written in a clear and comprehensible manner to the user and should]be available at least in the English language.

.2 Operating Instructions

The operating instructions should contain a qualified explanation and/or description of information required by the user to operate the radar system correctly, including:

- [appropriate settings for different weather conditions];
- monitoring the radar system's performance;
- operating in a failure or fall-back situation;
- limitations of the tracking process, including any delays;
- using heading and SOG/COG information for collision avoidance;
- the limitations and conditions of target merging and de-merging;
- the criteria of selection for automatic activation and cancellation of targets;
- the methods applied to display AIS targets, target association and any limitations;
- the principles underlying the trial manoeuvre technology, including the simulation of own ship's manoeuvring characteristics, if provided.

.3 Manufacturer's documentation

.3.1 The manufacturer's documentation should contain a description of the radar system.

.3.2 Documentation should describe the basis of AIS and radar target association and the filter criteria.

.3.3 The equipment documentation should include full details of installation information, including additional recommendations on unit location and factors that may degrade performance or reliability.

7 Design and installation

7.1 Design for Servicing

As far as is practical, the radar system should be of a design to facilitate easy repair and maximum availability.
The radar system should include a means to record the total operational hours, the documentation should describe any routine servicing, requirements and include details of any restricted life components.

7.2 External Effects on the Equipment

After installation and final adjustment, any electromagnetic influences should not degrade the performance of the equipment as defined in these standards. [See IEC 60945]

7.3 Display

The display device physical requirements should meet those specified in IMO xx [IEC 62288] and those specified in table 1.

7.4 Power Supply

The power supply should withstand typical ship supply tolerances and interrupts.

7.5 Antenna

The manufacturer should provide guidelines on installation of the radar system to ensure that the equipment's performance will not be substantially impaired if their guidelines are followed.

.1 The antenna should be designed to start operating and to continue to operate in relative wind speeds of at least [100kn][120kn].

.2 The combined radar system should be capable of providing a picture update rate that meets that detection requirements of Table 1.

.3 The antenna side lobes should be kept to a minimum so as not to degrade the system performance as defined in this standard.

7.6 Radar System Installation

.1 The Antenna

The installation of the antenna should be in such a manner that the performance of the radar system is optimised to the highest possible level. Blind sectors should be kept to a minimum. The antenna should be mounted clear of any structure that may cause signal reflections, including other antenna and deck cargo.

.2 The Display

The orientation of the display should be in such a way that the user is looking ahead, the lookout view is not obscured and there is minimum ambient light on the display screen.

.3 Servicing

The equipment should be installed to ensure easy access for servicing.
There should be a safe means to prevent the antenna rotation antenna for servicing the up-mast radar transceiver units.

7.7 [Operation

The design shall ensure that the radar system is simple to operate by personnel holding the appropriate certification.]

8 Interfacing

8.1 Input Data

The radar system should be capable of receiving the required input information from:

- a gyro-compass or transmitting heading device (THD)
- a speed and distance measuring equipment (SDME)
- an electronic position fixing system (EPFS)
- an Automatic Identification system (AIS) or
- other sensors or networks providing equivalent information acceptable to the organisation.

The radar should be connected to the relevant sensors, which are required by this performance standard [in accordance with the international standards.]

8.2 Input Data Integrity

.1 The radar system should not use data indicated as invalid or of poor quality.

.2 As far as is practical, the integrity of data should be checked, prior to its use, by comparison with other connected sensors or by testing to valid and plausible data limits.

8.3 Output Data

.1 Information provided by any radar output interface should be in accordance with international standards [2].

.2 The radar system should provide an output of the display screen data for the voyage data recorder (VDR).

.3 An isolated output should be provided for a central alarm system.

[2] Refer to IEC publication 61162

9 Backup and Fall-Back Arrangements

In the event of partial failures and to maintain minimum basic operation, the following fallback arrangements should be provided when the following functions are not available:

.1 Heading information (azimuth stabilisation)

.1 The equipment should operate satisfactorily in an unstabilised head-up mode.

.2 The equipment should switch automatically to the unstabilised head up mode within 1 minute after the azimuth stabilisation has become ineffective.

.3 If automatic anti-clutter controls could prevent the detection of targets due to the missing stabilisation, they should switch off automatically within 1 minute after the azimuth stabilisation has become ineffective.

.2 Course and Speed Over Ground Information

[If available, the equipment may be operated with course and speed through the water information. [In this case, a clear indication should be given on the display.]]

.3 Position Input

The overlay of SENC data and maps should be disabled if only a single TT reference target is defined and used, or the position is manually entered.

.4 Radar Video Input

[In the absence of radar signals,] the equipment should display information based on AIS data.

.5 AIS Input

[In the absence of AIS signals,] the equipment should display the radar video and target data, based on the radar video.

Appendix 1 – Definitions

[Relevant definitions will be taken from the new Navigation Display Presentation Standard] or

[**AIS target**	See activated target, lost target, selected target and sleeping target
Activated target	Target, indicated by a special symbol, whose motion is displayed graphically (RADAR or AIS).
Activation area	Area set up by the operator in which the radar should automatically activate a target when it is entering such an area.
Activation of a Radar Target	Process of selecting a target and initiating its tracking.
Activation of an AIS target	Activation of a sleeping target for the display of additional graphical and alphanumerical information about the targets motion.
AtoN (real)	Aid to Navigation, in this context transmitting an AIS signal (e.g. a buoy).
AtoN (virtual)	Aid to Navigation, in this context generated by an AIS signal and not physically existing.
Azimuth stabilized display	Display in which the azimuth orientation relative to a nominated true bearing is fixed.
Bow passing prediction	Pre-calculated time and distance to the point where a target is predicted to cross own ship's heading line.
Course-up display	Azimuth-stabilized display in which a line connecting the centre with the top of the display is own ship's intended course.
CPA/TCPA	Distance to the closest point of approach (CPA) and time to the closest point of approach (TCPA) of a target as determined by the Target Tracking (**TT**) facility of the Radar composite system.
Dangerous Target	Target whose predicted CPA and TCPA are violating their values as preset by the operator. The respective target is marked by a "dangerous target" symbol.
Effective display area	Area within the bearing scale for graphical display of [radar] targets and other objects.
EPFS	Electronic Position Fixing System
ERBL	Electronic bearing line carrying a marker, which is combined with the range marker, used to measure range and bearing from own ship or between objects.
Fixed Origin Selectable Trails	Display on which own ship's reference location is fixed either at centre or off-centred and the radar picture is reset quasi-continuously. Targets are moving across the display at their relative speed and course. Own ship and targets are showing trails in accordance with their true or relative speed and course, as selected by the operator.

Ground stabilization	Display mode for targets, in which all speed and course information are based on true motion over ground, using ground track input data for own ship's motion.
Heading	Direction in which the bow of a ship is pointing expressed as an angular displacement from north.
HSC	High-speed craft (HSC) are craft with the following characteristics: .1 a minimum speed as per SOLAS, chapter X, Rule 1 .2 a maximum speed of 70 knots; .3 a maximum rate of turn 20°/s; and .4 a normal range of operation between latitudes 70°N and 70°S.
Lost target	Target that can no longer be tracked due to poor, lost or obscured signals.
Lost target symbol	Symbol representing the last valid position of a target that can no longer be tracked.
Maps / Nav Lines	Operator-defined lines to indicate channels, Traffic Separation Schemes or borders of any area important for navigation. These lines require ground stabilisation to prevent their drifting.
Past positions	Equally time-spaced past position marks of a tracked target and own ship. The past positions' track may be either relative or true.
Radar	(**Ra**dio **d**irection **a**nd **r**anging) A radio system that allows to determine distance and direction of reflecting objects and of transmitting devices such as racons, RTEs and SARTs.
Radar composite system	Equipment to transmit radio signals, to receive, process and display both echo signals and signals from other sources such as AIS. The equipment is capable to display other information such as SENC data.
Radar target	Any object fixed or moving whose position and motion is determined by successive radar measurements of range and bearing.
Reference target	Symbol indicating that the associated tracked stationary target (e.g. a navigational mark) is used as a speed reference for the ground stabilisation.
Reference location	Location at the ship, to which all horizontal measurements such as target range, bearing, relative course, relative speed, closest point of approach (CPA) or time to closest point of approach (TCPA) are referenced, typically the conning position of the bridge.
Relative bearing	Direction of a target's position from own ship's reference location expressed as an angular displacement from own ship's heading
Relative course	Direction of motion of a target relative to own ship's direction.
Relative motion	Combination of relative course and relative speed.

Relative speed	Speed of a target relative to own ship's position. It is deduced from a number of measurements of target range and bearing on own ship's radar.
Relative vector	Predicted movement of a target relative to own ship's motion.
SDME	Speed and Distance Measurement Equipment
Selected target	AIS target, which is selected for the display of detailed information in a separate data display area. A selected target is indicated by a symbol.
Sleeping target	AIS target, of which only the presence and orientation is graphically displayed by a special symbol.
Standard radar reflector (dot target)	Reflector mounted 3.5 m above sea level with 10 m^2 effective reflector area when reflecting X- band signals.
Steady state tracking	Tracking a target, proceeding at steady motion - after activation or - without a manoeuvre of target or own ship or - without target swop or any disturbance.
Suppressed area	Area set up by the operator within which targets are not activated.
Target swop	Situation in which the incoming radar data for a tracked target becomes incorrectly associated with another tracked target or a non-tracked radar echo.
Target's predicted motion	Prediction of a target's future true course and speed based on linear extrapolation from its present motion as determined by past measurements of its range and bearing on the radar.
Tracking	Computer process of observing the sequential changes in the position of a target in order to establish its motion.
Trails	Tracks displayed by the radar echoes of targets in the form of a synthetic afterglow.
Trial manoeuvre	Graphical simulation facility used to assist the operator to perform the correct manoeuvre for navigation and collision avoidance purposes by displaying the predicted future tracks of all targets as a result of own ship's simulated manoeuvres.
True bearing	Direction of a target from own ship's reference location or from another target's position expressed as an angular displacement from true north.
True course	Direction of motion relative to ground of a target expressed as an angular displacement from north.
True motion	Combination of true course and true speed.
True speed	Speed of a target relative to ground.
True vector	Vector representing the predicted true motion of a target, showing course and speed with reference to the ground.]

[to be completed]

Appendix 2 - References

[The following list is included here as an aide memoir and will be subject to change in the final draft:

[IMO SOLAS Chapters V and X	Carriage rules
[IMO Resolution A.278(VII)	Supplement to the recommendation on PS for navigational radar equipment].
IMO Resolution A.424 (XI)	Performance standards for gyro-compasses
[IMO Resolution A.477 (XII)	Performance standards for radar equipment]
IMO Resolution A.694	General requirements for ship borne radio equipment forming part of the global maritime distress and safety system and for electronically navigational aids
[IMO Resolution A.820 (19)	Performance standards for navigational radar equipment for high- speed craft]
IMO Resolution A.821 (19)	Performance standards for gyro-compasses for high-speed craft
[IMO Resolution A.823(19)	Performance standards for automatic radar plotting aids (ARPA)]
IMO Resolution A.824	Performance standards for devices to indicate speed and distance
[IMO Resolution A.xxx	Performance standards for INS]
[IMO Resolution MSC.64(67)	Recommendations on new and amended performance standards (Annex 2 revised by MSC.114(73))]
IMO Resolution MSC.112(73)	Revised performance standards for ship borne global positioning (GPS) receiver equipment
IMO Resolution MSC.114(73)	Revised performance standards for ship borne DGPS and DGLONASS maritime radio beacon receiver equipment
IMO Resolution MSC.116(73)	Performance standards for marine transmitting heading devices (THD)
IMO MSC Circ. 982 (20.12.2000)	Guidelines on ergonomic criteria for bridge equipment and layout
IMO SN/Circ. 217	Interim guidelines for the presentation and display of AIS target information
IHO S-52 appendix 2:1997	Colour and symbol specification for ECDIS
IEC 60872 /1, /2, / 3	Maritime radar plotting aids (ARPA, ATA and EPA)
IEC 60936-1,-2,-3, -5	Maritime navigation and radio communication equipment and systems - radar
IEC 60945	Maritime navigation and radio communication equipment and systems – General requirements – Methods of testing and required test results
IEC 61162	Maritime navigation and radio communication equipment and systems – Digital interfaces
IEC 62288	Presentation and display of navigation information
ISO 9000 (all parts)	Quality management/assurance standards

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