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RESOLUTION A.823(19)
adopted on 23 November 1995

PERFORMANCE STANDARDS FOR AUTOMATIC RADAR PLOTTING AIDS (ARPAs)

THE ASSEMBLY,

RECALLING Article 15(j) of the Convention on the International Maritime Organization concerning the functions of the Assembly in relation to regulations and guidelines concerning maritime safety,

RECALLING ALSO the provisions of regulation V/12 of the International Convention for the Safety of Life at Sea (SOLAS), 1974,

RECALLING FURTHER resolution A.422(XI), by which it adopted performance standards for automatic radar plotting aids,

RECOGNIZING that the proper use of automatic radar plotting aids will assist the interpretation of radar data and could reduce the risk of collision and pollution of the marine environment,

RECOGNIZING ALSO the need to ensure that advances in technology are reflected in performance standards, in order to improve the standard of collision avoidance at sea,

BEARING IN MIND that automatic radar plotting aids with inadequate performance standards or operated by insufficiently trained personnel might prejudice safety of navigation,

HAVING CONSIDERED the recommendation made by the Maritime Safety Committee at its sixty-fourth session,

1. ADOPTS the Recommendation on Performance Standards for Automatic Radar Plotting Aids (ARPAs) set out in the Annex to the present resolution;

2. RECOMMENDS Governments to ensure that:

(a) automatic radar plotting aids installed on or after 1 January 1997 conform to performance standards not inferior to those specified in the Annex to the present resolution;

(b) automatic radar plotting aids installed before 1 January 1997 conform, at least, to the performance standards set out in resolution A.422(XI); and

(c) adequate training is established in the proper use of automatic radar plotting aids to enable masters and deck officers to understand the basic principles of the operation of automatic radar plotting aids, including their capabilities, limitations and possible errors;

3. REQUESTS the Maritime Safety Committee to keep these Performance Standards under review and to adopt amendments thereto, as necessary.

ANNEX

RECOMMENDATION ON PERFORMANCE STANDARDS FOR AUTOMATIC RADAR PLOTTING AIDS (ARPAs)

1 INTRODUCTION

1.1 Automatic radar plotting aids (ARPAs) should, in order to improve the standard of collision avoidance at sea:

.1 reduce the workload of observers by enabling them automatically to obtain information about plotted targets, so that they can perform as well with several separate targets as they can by manually plotting a single target; and

.2 provide continuous, accurate and rapid situation evaluation.

1.2 The radar facilities provided by an ARPA display should comply with the performance standards for radar equipment (resolution A.477(XII)) appropriate to its mode of use.

1.3 In addition to the general requirements contained in resolution A.694(17), ARPA should comply with the following minimum performance standards.

2 DEFINITIONS

Definitions of terms used in these performance standards are given in appendix 1.

3 PERFORMANCE STANDARDS

3.1 Detection

Where a separate facility is provided for detection of targets, other than by the radar observer, it should have a performance not inferior to that which could be obtained by the use of the radar display.

3.2 Acquisition

3.2.1 Target acquisition may be manual or automatic for relative speeds up to 100 knots. However, there should always be a facility to provide for manual acquisition and cancellation: ARPA with automatic acquisition should have a facility to suppress acquisition in certain areas. On any range scale where acquisition is suppressed over a certain area, the area of acquisition should be defined and indicated on the display.

3.2.2 Automatic or manual acquisition should have a performance not inferior to that which could be obtained by the user of the radar display.

3.3 Tracking

3.3.1 The ARPA should be able automatically to track, process, simultaneously display and continuously update the information on at least 20 targets, whether automatically or manually acquired.

3.3.2 If automatic acquisition is provided, description of the criteria of selection of targets for tracking should be provided to the user. If the ARPA does not track all targets visible on the display, targets which are being tracked should be clearly indicated with the relevant symbol* on the display. The reliability of tracking should not be less than that obtainable using manual recordings of successive target positions obtained from the radar display.

3.3.3 The ARPA should continue to track an acquired target which is clearly distinguishable on the display for 5 out of 10 consecutive scans, provided the target is not subject to target swop.

3.3.4 The possibility of tracking errors, including target swop, should be minimized by ARPA design. A qualitative description of the effects of error sources on the automatic tracking and corresponding errors should be provided to the user, including the effects of low signal-to-noise and low signal-to-clutter ratios caused by sea returns, rain, snow, low clouds and non-synchronous emissions.

3.3.5 The ARPA should be able to display on request with relevant symbol* at least four equally time-spaced past positions of any targets being tracked over a period appropriate to the range scale in use. The time-scale of the past position plot should be indicated. The operating manual should contain an explanation of what the past position plots represent.

3.4 Display

3.4.1 The display may be a separate or integral part of the ship's radar. However, the ARPA display should include all the data required to be provided by a radar display in accordance with the performance standards for navigational radar equipment.

3.4.2 The design should be such that any malfunction of ARPA parts producing data additional to information to be produced by the radar as required by the performance standards for navigational equipment should not affect the integrity of the basic radar presentation.

3.4.3 The ARPA facilities should be available on at least 3, 6 and 12 nautical mile range scales, and there should be a positive indication of the range scale in use.

3.4.4 ARPA facilities may also be provided on other range scales permitted by resolution A.477(XII) and, if provided, should comply with these standards.

3.4.5 The ARPA should be capable of operating with a relative motion display with "north-up" and "course-up" azimuth stabilization. In addition, the ARPA may also provide for a true motion display. If true motion is provided, the operator should be able to select for the display either true or relative motion. There should be a positive indication of the display mode and orientation in use.

3.4.6 The course and speed information generated by the ARPA for acquired targets should be displayed in a vector or graphic form which clearly indicates the target's predicted motion with relevant symbols*. In this regard:

.1 an ARPA presenting predicted information in vector form only should have the option of both true and relative vectors. There should be an indication of the vector mode selected and, if true vector mode is selected, the display should show whether it is sea or ground stabilized;

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*Refer to IEC 872: Marine Automatic Radar Plotting Aids (ARPAs).

.2 an ARPA which is capable of presenting target course and speed information in graphic form should also, on request, provide the target's true and/or relative vector;

.3 vectors displayed should be time-adjustable;

.4 a positive indication of the time-scale of the vector in use should be given; and

.5 if stationary targets are being used for ground referencing, this fact should be indicated by the relevant symbol*. In this mode, relative vectors including those of the targets used for ground referencing should be displayed when requested.

3.4.7 The ARPA information should not obscure the visibility of radar targets. The display of ARPA data should be under the control of the radar observer. It should be possible to cancel the display of unwanted ARPA data within 3 s.

3.4.8 Means should be provided to adjust independently the brilliance of the ARPA data and radar data, including complete extinction of the ARPA data.

3.4.9 The method of presentation should ensure that the ARPA data are clearly visible in general to more than one observer in the conditions of light normally experienced on the bridge of a ship by day and by night. Screening may be provided to shade the display from sunlight but not to the extent that it will impair the observer's ability to maintain a proper look-out. Facilities to adjust the brightness should be provided.

3.4.10 Provisions should be made to obtain quickly the range and bearing of any object which appears on the ARPA display.

3.4.11 When a target appears on the radar display and, in the case of automatic acquisition, enters within the acquisition area chosen by the observer or, in the case of manual acquisition, has been acquired by the observer, the ARPA should present in a period of not more than 1 min an indication of the target's motion trend, and display within 3 min the target's predicted motion in accordance with 3.4.6, 3.6, 3.8.2 and 3.8.3.

3.4.12 After changing range scales on which the ARPA facilities are available or resetting the display, full plotting information should be displayed within a period of time not exceeding one scan.

3.5 Operational warnings

3.5.1 The ARPA should have the capability to warn the observer with a visual and audible signal of any distinguishable target which closes to a range or transits a zone chosen by the observer. The target causing the warning should be clearly indicated with relevant symbols* on the display.

3.5.2 The ARPA should have the capability to warn the observer with a visual and audible signal of any tracked target which is predicted to close within a minimum range and time chosen by the observer. The target causing the warning should be clearly indicated with relevant symbols* on the display.

3.5.3 The ARPA should clearly indicate if a tracked target is lost, other than out of range, and the target's last tracked position should be clearly indicated on the display.

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*Refer to IEC 872: Marine Automatic Radar Plotting Aids (ARPAs).

3.5.4 It should be possible for the observer to activate or de-activate the audible warning signal.

3.6 Data requirements

3.6.1 The observer should be able to select any tracked target to obtain data. Targets selected should be marked with the relevant symbol* on the radar display. If data is required for more than one target at the same time each symbol should be separately identified, for example with a number adjacent to the symbol*.

3.6.2 The following data for each selected target should be clearly and unambiguously identified and displayed immediately and simultaneously in alpha-numeric form outside the radar area:

.1 present range of the target;

.2 present bearing of the target;

.3 predicted target range at the closest point of approach (CPA);

.4 predicted time to CPA (TCPA);

.5 calculated true course of the target; and

.6 calculated true speed of the target.

3.6.3 The display of the data in 3.6.2.5 and 3.6.2.6 should include an identification of whether the data provided is referenced to sea or ground stabilization.

3.6.4 When data for several targets is displayed, no fewer than two items listed in 3.6.2 should be displayed simultaneously for each target selected. If the items of data are displayed in pairs for each target, the groupings should be 3.6.2.1 with 3.6.2.2, 3.6.2.3 with 3.6.2.4, and 3.6.2.5 with 3.6.2.6.

3.7 Trial manoeuvre

3.7.1 The ARPA should be capable of simulating the effect on all tracked targets of an own ship manoeuvre with or without time delay before manoeuvre without interrupting the updating of target tracking and display of actual target alpha-numeric data. The simulation should be indicated with the relevant symbol* on the display.

3.7.2 The operating manual should contain an explanation of the principles underlying the trial manoeuvre technique adopted including, if provided, the simulation of own ship's manoeuvring characteristics.

3.7.3 It should be possible to cancel a trial manoeuvre at any time.

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*Refer to IEC 872: Marine Automatic Radar Plotting Aids (ARPAs).

3.8 Accuracy

3.8.1 The ARPA should provide accuracies not less than those given in 3.8.2 and 3.8.3 for the four scenarios defined in appendix 2. With the sensor errors specified in appendix 3, the values given relate to the best possible manual plotting performance under environmental conditions of ± 10 degrees of roll.

3.8.2 An ARPA should present within one minute of steady state tracking the relative motion trend of a target with the following accuracy values (95% probability values).

Data / Scenario	Relative course (degrees)	Relative speed (knots)	CPA (nautical miles)
1	11	2.8	1.6
2	7	0.6	
3	14	2.2	1.8
4	15	1.5	2.0

Note 1: In steady state tracking both own and target ship follow straight line course at constant speed.

Note 2: Probability values are the same as confidence levels.

3.8.3 An ARPA should present within three minutes of steady state tracking the motion of a target with the following accuracy values (95% probability values).

Data / Scenario	Relative course (degrees)	Relative speed (knots)	CPA (nautical miles)	TCPA (min)	True course (degrees)	True speed (knots)
1	3.0	0.8	0.5	1.0	7.4	1.2
2	2.3	0.3			2.8	0.8
3	4.4	0.9	0.7	1.0	3.3	1.0
4	4.6	0.8	0.7	1.0	2.6	1.2

3.8.4 When a tracked target, or own ship, has completed a manoeuvre, the system should present in a period of not more than 1 min an indication of the target's motion trend, and display within 3 min the target's predicted motion, in accordance with 3.4.6, 3.6, 3.8.2 and 3.8.3. In this context, a "manoeuvre of own ship" should be deemed to consist of an alteration of course of $\pm 45°$ in 1 min.

3.8.5 The ARPA should be designed in such a manner that under the most favourable conditions of own ship's motion the error contribution from the ARPA should remain insignificant compared to the errors associated with the input sensors, for the scenarios of appendix 2.

3.9 Connections with other equipment

3.9.1 The ARPA should not degrade the performance of any equipment providing sensor inputs, and the connection of the ARPA to any other equipment should not degrade the performance of that equipment. This requirement should be met whether the ARPA is operating or not. Additionally, the ARPA should be designed to comply with this requirement under fault conditions as far as is practicable.

3.9.2 The ARPA should provide an indication when any input from an external sensor is absent. The ARPA should also repeat any alarm or status messages concerning the quality of the input data from its external sensors which may influence its operation.

3.10 Performance tests and warnings

The ARPA should provide suitable warnings of ARPA mulfunction to enable the observer to monitor the proper operation of the system. Additionally, test programmes should be available so that the overall performance of ARPA can be assessed periodically against a known solution. When a test programme is being executed, the relevant test symbols* should be displayed.

3.11 Sea and ground stabilization

3.11.1 The ARPA should be capable of sea and ground stabilization.

3.11.2 Log and speed indicators providing inputs to ARPA equipment should be capable of providing the ship's speed through the water in the fore and aft direction.

3.11.3 The ground stabilized input may be provided from the log, from an electronic position-fixing system, if the speed measurement accuracy is in accordance with the requirements of resolution A.824(19), or from tracked stationary targets.

3.11.4 The type of input and stabilization in use should be displayed.

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*Refer to IEC 872: Marine Automatic Radar Plotting Aids (ARPAs).

APPENDIX 1

DEFINITIONS OF TERMS TO BE USED IN CONNECTION WITH ARPA PERFORMANCE STANDARDS

1. *Target* means any object fixed or moving whose position and motion is determined by measurements of range and bearing on radar.

2. *Relative course* means the direction of motion of a target relative to own ship's position expressed as an angular displacement from north. It is deduced from a number of measurements of target range and bearing on own ship's radar.

3. *Relative speed* means the 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.

4. *Relative motion means* the combination of relative course and relative speed.

5. *True course* means the true direction of motion of a target expressed as an angular displacement from north. It is obtained by a vector combination of target relative motion and own ship's true motion.*

6. *True speed* means the speed of a target obtained by a vector combination of target relative motion and own ship's true motion.*

7. *True motion* means the combination of true course and true speed.

8. *True bearing* means the direction of a target from own ship or from another target expressed as an angular displacement from north.

9. *Relative bearing* means the direction of a target from own ship expressed as an angular displacement from own ship's heading.

10. *True motion display* means a display across which own ship and each target moves with its own true motion.

11. *Relative motion* display means a display on which the position of own ship remains fixed and all targets move relative to own ship.

12. *Azimuth stabilized display* means a display in which the azimuth orientation relative to a nominated true bearing is fixed.

13. *North-up display* means an azimuth stabilized display in which a line connecting the centre with the top of the display is north true bearing.

14. *Course-up display* means an azimuth stabilized display in which a line connecting the centre with the top of the display is own ship's intended course.

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*For the purposes of these definitions there is no need to distinguish between sea and ground stabilization.

15. *Heading* means the direction in which the bows of a ship are pointing expressed as an angular displacement from north.

16. *Target's predicted motion* means a prediction of future target motion based on linear extrapolation from its present motion as determined by past measurements of its range and bearing on the radar.

17. *Relative vector* means the predicted movement of a target relative to own ship.

18. *True vector* means the predicted true motion of a target as a result of own ship's direction and speed input. The true vector may be either displayed with reference to the water or to the ground.

19. *Acquisition* means the process of selecting a target or targets and initiating their tracking.

20. *Tracking* means the computer process of observing the sequential changes in the position of a target in order to establish its motion.

21. *Target swop* means a situation in which the incoming radar data for a tracked target becomes incorrectly associated with another tracked target or a non-tracked radar echo.

22. *Acquisition area* means an area set up by the observer which should automatically acquire a target when it enters such an area.

23. *History* means equally time-spaced past position of a target which is being tracked. The history may be relative or true.

24. *Trails* means tracks displayed by the radar echoes of targets in the form of a synthetic afterglow. The trails may be either relative or true. The true trails may be sea or ground stabilized.

25. *Echo reference* means a facility for indicating that a particular fixed navigational mark which is being tracked is to be used as a ground stabilized reference.

26. *Trial manoeuvre* means a facility to assist the observer in making the correct manoeuvre for navigation and collision avoidance purposes.

27. *Suppressed area* means an area set up by the observer within which targets are not acquired.

28. *ERBL* means the electronic range and bearing line used to measure bearings and/or ranges.

29. *CPA/TCPA* stands for closest point of approach (CPA) and time to closest point of approach (TCPA) limits from own ship as defined by the observer, to give warning of when a tracked target or targets will close to within these limits.

30. *Bow passing prediction* is the situation associated with a target which is crossing or predicted to cross ahead of own ship.

31. *Bad echo* is the name associated with a tracked target which appears to have been temporarily lost or which has a poorly defined radar aspect, so that it does not have tracking ability.

32. *Lost target* is the name associated with a target that is no longer being tracked due to having been lost or obscured.

33. *Sea stabilization* is a mode of display whereby own ship and all targets are referenced to the sea, using gyro heading and single axis log water speed inputs.

34. *Ground stabilization* is a mode of display whereby own ship and all targets are referenced to the ground, using ground track or set and drift inputs.

35. *Predicted points of collision* is a graphical representation of where predicted collision intercept points lie with respect to own ship and other targets.

36. *PAD* means the predicted area of danger defined around a predicted close quarter situation area. The size is determined by speed ratios between own ship and the target in question and CPA distance limits as defined by the observer.

37. *Map lines* means the navigational facility whereby the observer can define lines to indicate channels or Traffic Separation Schemes. Sometimes called Nav lines, these lines require ground stabilization to stop them drifting.

Note: Where reference is made to target range, bearing, relative course, relative speed, closest point of approach (CPA) or time to closest point of approach (TCPA), these measurements are made with respect to the radar antenna.

APPENDIX 2

OPERATIONAL SCENARIOS

For each of the following scenarios, predictions are made at the target position defined after previously tracking for the appropriate time of one or three minutes:

Scenario 1

Own ship course	000°
Own ship speed	10 knots
Target range	8 nautical miles
Bearing of target	000°
Relative course of target	180°
Relative speed of target	20 knots

Scenario 2

Own ship course	000°
Own ship speed	10 knots
Target range	1 nautical mile
Bearing of target	000°
Relative course of target	090°
Relative speed of target	10 knots

Scenario 3

Own ship course	000°
Own ship speed	5 knots
Target range	8 nautical miles
Bearing of target	045°
Relative course of target	225°
Relative speed of target	20 knots

Scenario 4

Own ship course	000°
Own ship speed	25 knots
Target range	8 nautical miles
Bearing of target	045°
Relative course of target	225°
Relative speed of target	20 knots

APPENDIX 3

SENSOR ERRORS

The accuracy figures quoted in 3.8 of these standards are based upon the following sensor errors, and are appropriate to equipment complying with the performance standards for shipborne navigational equipment.

Note: σ means "standard deviation".

Radar

Target glint (scintillation) (for 200 m length target)

Along length of target σ = 30 m (normal distribution)

Across beam of target σ = 1 m (normal distribution)

Roll-pitch bearing: The bearing error will peak in each of the four quadrants around own ship for targets on relative bearings of 045°, 135°, 225° and 315°, and will be zero at relative bearings of 0°, 90°, 180° and 270°. This error has a sinusoidal variation at twice the roll frequency.

For a 10° roll the mean error is 0.22° with a 0.22° peak sine wave superimposed.

Beam shape - assumed normal distribution giving bearing error with σ = 0.05°

Pulse shape - assumed normal distribution giving range error with σ = 20 m

Antenna backlash - assumed rectangular distribution giving bearing error ± 0.05° maximum

Quantization

Bearing - rectangular distribution ± 0.1° maximum.

Range - rectangular distribution ± 0.01 nautical miles maximum.

Bearing encoder assumed to be running from a remote synchro giving bearing errors with a normal distribution σ = 0.03°.

Gyro-compass

Calibration error 0.5°.

Normal distribution about this with $\sigma = 0.12°$.

Log

Calibration error 0.5 knots.

Normal distribution about this, $3\sigma = 0.2$ knots.

ANNEX 34

RESOLUTION MSC.192(79)
(adopted on 6 December 2004)

ADOPTION OF THE REVISED PERFORMANCE STANDARDS FOR RADAR EQUIPMENT

THE MARITIME SAFETY COMMITTEE,

RECALLING Article 28(b) of the Convention on the International Maritime Organization concerning the functions of the Committee,

RECALLING ALSO resolution A.886(21) by which the Assembly resolved that the functions of adopting performance standards and technical specifications, as well as amendments thereto, shall be performed by the Maritime Safety Committee on behalf of the Organization,

NOTING resolutions A.222(VII), A.278(VIII), A.477(XII), MSC.64(67), annex 4, A.820(19) and A.823(19) containing performance standards applicable to marine radars being produced and installed at different time periods in the past,

NOTING ALSO that marine radars are used in connection/integration with other navigational equipment required to carry on board ships such as, an automatic target tracking aid, ARPA, AIS, ECDIS and others,

RECOGNIZING the need for unification of maritime radar standards in general, and, in particular, for display and presentation of navigation-related information,

HAVING CONSIDERED the recommendation on the revised performance standards for radar equipment made by the Sub-Committee on Safety of Navigation at its fiftieth session,

1. ADOPTS the Revised Recommendation on Performance Standards for radar equipment set out in the Annex to the present resolution;

2. RECOMMENDS Governments to ensure that radar equipment installed on or after 1 July 2008 conform to performance standards not inferior to those set out in the Annex to the present resolution.

ANNEX

REVISED RECOMMENDATION ON PERFORMANCE STANDARDS FOR RADAR EQUIPMENT

INDEX

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. The integration and display of AIS information should be provided to complement radar. The capability of displaying selected parts of Electronic Navigation Charts and other vector chart information may be provided to aid navigation and for position monitoring.

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 coastal navigation and harbour approaches, by giving a clear indication of land and other fixed hazards;

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

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

- in the detection of small floating and fixed hazards, for collision avoidance and the safety of own ship; and

- in the detection of floating and fixed aids to navigation (see Table 2, note 3).

2 APPLICATION OF THESE STANDARDS

These Performance Standards should apply to all shipborne radar installations, used in any configuration, mandated by the 1974 SOLAS Convention, as amended, independent of the:

- type of ship;

- frequency band in use; and

- type of display,

providing that no special requirements are specified in Table 1 and that additional requirements for specific classes of ships (in accordance with SOLAS chapters 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.

* IEC Publication 60945.

Close interaction between different navigational equipment and systems, makes it essential to consider these standards in association with other relevant IMO standards.

TABLE 1

Differences in the performance requirements for various sizes/categories of ship/craft to which SOLAS applies

Size of ship/craft	<500 gt	500 gt to <10,000 gt and HSC<10,000 gt	All ships/craft ≥10,000 gt
Minimum operational display area diameter	180 mm	250 mm	320 mm
Minimum display area	195 x 195 mm	270 x 270 mm	340 x 340 mm
Auto acquisition of targets	-	-	Yes
Minimum ***acquired*** radar target capacity	20	30	40
Minimum ***activated*** AIS target capacity	20	30	40
Minimum ***sleeping*** AIS target capacity	100	150	200
Trial Manoeuvre	-	-	Yes

3 REFERENCES

References are in appendix 1.

4 DEFINITIONS

Definitions are in appendix 2.

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 effective target detection within the safety-relevant environment surrounding own ship and should permit fast and easy situation evaluation.*

5.1 Frequency

5.1.1 *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.

* Refer to MSC/Circ.878 - MEPC/Circ.346 on Interim Guidelines for the application of Human Element Analysing Process (HEAP) to the IMO rule-making process.

5.1.2 *Radar Sensor Requirements*

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

- X-Band (9.2-9.5 GHz) for high discrimination, good sensitivity and tracking performance; and

- S-Band (2.9-3.1 GHz) to ensure that target detection and tracking capabilities are maintained in varying and adverse conditions of fog, rain and sea clutter.

The frequency band in use should be indicated.

5.1.3 *Interference susceptibility*

The radar should be capable of operating satisfactorily in typical interference conditions.

5.2 Radar Range and Bearing Accuracy

The radar system range and bearing accuracy requirements should be:

Range - within 30 m or 1% of the range scale in use, whichever is greater;
Bearing - within 1°.

5.3 Detection Performance and Anti-clutter Functions

All available means for the detection of targets should be used.

5.3.1 *Detection*

5.3.1.1 *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 normal propagation conditions, in the absence of sea clutter, precipitation and evaporation duct, with an antenna height of 15 m above sea level.

Based on:

- an indication of the target in at least 8 out of 10 scans or equivalent; and

- a probability of a radar detection false alarm of 10^{-4},

the requirement contained in Table 2 should be met as specified for X-Band and S-Band equipment.

The detection performance should be achieved using the smallest antenna that is supplied with the radar system.

Recognizing the high relative speeds possible between own ship and target, the equipment should be specified and approved as being suitable for classes of ship having normal (<30 kn) or high (>30 kn) own ship speeds (100 kn and 140 kn relative speeds respectively).

TABLE 2

Minimum detection ranges in clutter-free conditions

Target Description	Target Feature	Detection Range in NM[6]	
Target description[5]	Height above sea level in metres	X-Band NM	S-Band NM
Shorelines	Rising to 60	20	20
Shorelines	Rising to 6	8	8
Shorelines	Rising to 3	6	6
SOLAS ships (>5,000 gross tonnage)	10	11	11
SOLAS ships (>500 gross tonnage)	5.0	8	8
Small vessel with radar reflector meeting IMO Performance Standards[1]	4.0	5.0	3.7
Navigation buoy with corner reflector[2]	3.5	4.9	3.6
Typical Navigation buoy[3]	3.5	4.6	3.0
Small vessel of length 10 m with no radar reflector[4]	2.0	3.4	3.0

5.3.1.2 ***Detection at Close Range***

The short-range detection of the targets under the conditions specified in Table 2 should be compatible with the requirement in paragraph 5.4.

5.3.1.3 ***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 5.3.1.1 and Table 2.

5.3.1.3.1 The radar equipment should be designed to provide the optimum and most consistent detection performance, restricted only by the physical limits of propagation.

5.3.1.3.2 The radar system should provide the means to enhance the visibility of targets in adverse clutter conditions at close range.

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1 IMO revised performance standards for radar reflectors (resolution MSC.164(78)) – Radar Cross Section (RCS) 7.5 m^2 for X-Band, 0.5 m^2 for S-Band.

2 The corner reflector (used for measurement), is taken as 10 m^2 for X-Band and 1.0 m^2 for S-Band.

3 The typical navigation buoy is taken as 5.0 m^2 for X-Band and 0.5 m^2 for S-Band; for typical channel markers, with an RCS of 1.0 m^2 (X-band) and 0.1 m^2 (S-band) and height of 1 metre, a detection range of 2.0 and 1.0 NM respectively.

4 RCS for 10 m small vessel taken as 2.5 m^2 for X-Band and 1.4 m^2 for S-Band (taken as a complex target).

5 Reflectors are taken as point targets, vessels as complex targets and shorelines as distributed targets (typical values for a rocky shoreline, but are dependent on profile).

6 Detection ranges experienced in practice will be affected by various factors, including atmospheric conditions (e.g. evaporation duct), target speed and aspect, target material and target structure. These and other factors may either enhance or degrade the detection ranges stated. At ranges between the first detection and own ship, the radar return may be reduced or enhanced by signal multi-path, which depend on factors such as antenna/target centroid height, target structure, sea state and radar frequency band.

5.3.1.3.3 Degradation of detection performance (related to the figures in Table 2) at various ranges and target speeds under the following conditions, should be clearly stated in the user manual:

- light rain (4 mm per hour) and heavy rain (16 mm per hour);
- sea state 2 and sea state 5; and
- and a combination of these.

5.3.1.3.4 The determination of performance in clutter and specifically, range of first detection, as defined in the clutter environment in 5.3.1.3.3, should be tested and assessed against a benchmark target, as specified in the Test Standard.

5.3.1.3.5 Degradation in performance due to a long transmission line, antenna height or any other factors should be clearly stated in the user manual.

5.3.2 *Gain and Anti-Clutter Functions*

5.3.2.1 Means should be provided, as far as is possible, for the adequate reduction of unwanted echoes, including sea clutter, rain and other forms of precipitation, clouds, sandstorms and interference from other radars.

5.3.2.2 A gain control function should be provided to set the system gain or signal threshold level.

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

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

5.3.2.5 There should be a clear and permanent indication of the status and level for gain and all anti-clutter control functions.

5.3.3 *Signal Processing*

5.3.3.1 Means should be available to enhance target presentation on the display.

5.3.3.2 The effective picture update period should be adequate, with minimum latency to ensure that the target detection requirements are met.

5.3.3.3 The picture should be updated in a smooth and continuous manner.

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

5.3.4 *Operation with SARTs and Radar Beacons*

5.3.4.1 The X-Band radar system should be capable of detecting radar beacons in the relevant frequency band.

5.3.4.2 The X-Band radar system should be capable of detecting SARTs and radar target enhancers.

5.3.4.3 It should be possible to switch off those signal processing functions, including polarization modes, which might prevent an X-Band radar beacon or SARTs from being detected and displayed. The status should be indicated.

5.4 Minimum Range

5.4.1 With own ship at zero speed, an antenna height of 15 m above the sea level and in calm conditions, the navigational buoy in Table 2 should be detected at a minimum horizontal range of 40 m from the antenna position and up to a range of 1 NM, without changing the setting of control functions other than the range scale selector.

5.4.2 Compensation for any range error should be automatically applied for each selected antenna, where multiple antennas are installed.

5.5 Discrimination

Range and bearing discrimination should be measured in calm conditions, on a range scale of 1.5 NM or less and at between 50% and 100% of the range scale selected:

5.5.1 *Range*

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

5.5.2 *Bearing*

The radar system should be capable of displaying two point targets at the same range, separated by 2.5° in bearing, as two distinct objects.

5.6 Roll and Pitch

The target detection performance of the equipment should not be substantially impaired when own ship is rolling or pitching up to +/-10°.

5.7 Radar Performance Optimization and Tuning

5.7.1 Means should be available to ensure that the radar system is operating at the best performance. Where applicable to the radar technology, manual tuning should be provided and additionally, automatic tuning may be provided.

5.7.2 An indication should be provided, in the absence of targets, to ensure that the system is operating at the optimum performance.

5.7.3 Means should be available (automatically or by manual operation) and while the equipment is operational, to determine a significant drop in system performance relative to a calibrated standard established at the time of installation.

5.8 Radar Availability

The radar equipment should be fully operational (RUN status) within 4 minutes after switch ON from cold. A STANDBY condition should be provided, in which there is no operational radar transmission. The radar should be fully operational within 5 sec from the standby condition.

5.9 Radar Measurements – Consistent Common Reference Point (CCRP)

5.9.1 Measurements from own ship (e.g. range rings, target range and bearing, cursor, tracking data) should be made with respect to the consistent common reference point (e.g. conning position). Facilities should be provided to compensate for the offset between antenna position and the consistent common reference point on installation. 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.

5.9.2 Own ship's scaled outline should be available on appropriate range scales. The consistent common reference point and the position of the selected radar antenna should be indicated on this graphic.

5.9.3 When the picture is centred, the position of the Consistent Common Reference Point should be at the centre of the bearing scale. The off-centre limits should apply to the position of the selected antenna.

5.9.4 Range measurements should be in nautical miles (NM). In addition, facilities for metric measurements may be provided on lower range scales. All indicated values for range measurement should be unambiguous.

5.9.5 Radar targets should be displayed on a linear range scale and without a range index delay.

5.10 Display Range Scales

5.10.1 Range scales of 0.25, 0.5, 0.75, 1.5, 3, 6, 12 and 24 NM should be provided. Additional range scales are permitted outside the mandatory set. Low metric range scales may be offered in addition to the mandatory set.

5.10.2 The range scale selected should be permanently indicated.

5.11 Fixed Range Rings

5.11.1 An appropriate number of equally spaced range rings should be provided for the range scale selected. When displayed, the range ring scale should be indicated.

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

5.12 Variable Range Markers (VRM)

5.12.1 At least two variable range markers (VRMs) should be provided. Each active VRM should have a numerical readout and have a resolution compatible with the range scale in use.

5.12.2 The VRMs should enable the user to measure the range of an object within the operational display area with a maximum system error of 1% of the range scale in use or 30 m, whichever is the greater distance.

5.13 Bearing Scale

5.13.1 A bearing scale around the periphery of the operational display area should be provided. The bearing scale should indicate the bearing as seen from the consistent common reference point.

5.13.2 The bearing scale should be outside of the operational display area. It should be numbered at least every 30° division and have division marks of at least 5°. The 5° and 10° division marks should be clearly distinguishable from each other. 1° division marks may be presented where they are clearly distinguishable from each other.

5.14 Heading Line (HL)

5.14.1 A graphic line from the consistent common reference point to the bearing scale should indicate the heading of the ship.

5.14.2 Electronic means should be provided to align the heading line to within 0.1°. If there is more than one radar antenna (see 5.35) the heading skew (bearing offset) should be retained and automatically applied when each radar antenna is selected.

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

5.15 Electronic Bearing Lines (EBLs)

5.15.1 At least two electronic bearing lines (EBLs) should be provided to measure the bearing of any point object within the operational display area, with a maximum system error of 1° at the periphery of the display.

5.15.2 The EBLs should be capable of measurement relative to the ships heading and relative to true north. There should be a clear indication of the bearing reference (i.e. true or relative).

5.15.3 It should be possible to move the EBL origin from the consistent common reference point to any point within the operational display area and to reset the EBL to the consistent common reference point by a fast and simple action.

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

5.15.5 Means should be provided to ensure that the user is able to position the EBL smoothly in either direction, with an incremental adjustment adequate to maintain the system measurement accuracy requirements.

5.15.6 Each active EBL should have a numerical readout with a resolution adequate to maintain the system measurement accuracy requirements.

5.16 Parallel Index lines (PI)

5.16.1 A minimum of four independent parallel index lines, with a means to truncate and switch off individual lines, should be provided.

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

5.17 Offset Measurement of Range and Bearing

There should be a means to measure the range and bearing of one position on the display relative to any other position within the operational display area.

5.18 User Cursor

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

5.18.2 The cursor position should have a continuous readout to provide the range and bearing, measured from the consistent common reference point, and/or the latitude and longitude of the cursor position presented either alternatively or simultaneously.

5.18.3 The cursor should provide the means to select and de-select targets, graphics or objects within the operational display area. In addition, the cursor may be used to select modes, functions, vary parameters and control menus outside of the operational display area.

5.18.4 Means should be provided to easily locate the cursor position on the display.

5.18.5 The accuracy of the range and bearing measurements provided by the cursor should meet the relevant requirements for VRM and EBL.

5.19 Azimuth Stabilization

5.19.1 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.

5.19.2 Excluding the limitations of the stabilizing 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 likely to be experienced with the class of ship.

5.19.3 The heading information should be displayed with a numerical resolution to permit accurate alignment with the ship gyro system.

5.19.4 The heading information should be referenced to the consistent common reference point (CCRP).

5.20 Display Mode of the Radar Picture

5.20.1 A True Motion display mode should be provided. The automatic reset of own ship may be initiated by its position on the display, or time related, or both. Where the reset is selected to occur at least on every scan or equivalent, this should be equivalent to True Motion with a fixed origin (in practice equivalent to the previous relative motion mode).

5.20.2 North Up and Course Up orientation modes should be provided. Head Up may be provided when the display mode is equivalent to True Motion with a fixed origin (in practice equivalent to the previous relative motion Head Up mode).

5.20.3 An indication of the motion and orientation mode should be provided.

5.21 Off-Centring

5.21.1 Manual off-centring should be provided to locate the selected antenna position at any point within at least 50% of the radius from the centre of the operational display area.

5.21.2 On selection of off-centred display, the selected antenna position should be capable of being located to any point on the display up to at least 50%, and not more than 75%, of the radius from the centre of the operational display area. A facility for automatically positioning own ship for the maximum view ahead may be provided.

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

5.22 Ground and Sea Stabilization Modes

5.22.1 Ground and Sea stabilization modes should be provided.

5.22.2 The stabilization mode and stabilization source should be clearly indicated.

5.22.3 The source of own ships' speed should be indicated and provided by a sensor approved in accordance with the requirements of the Organization for the relevant stabilization mode.

5.23 Target Trails and Past Positions

5.23.1 Variable length (time) target trails should be provided, with an indication of trail time and mode. It should be possible to select true or relative trails from a reset condition for all true motion display modes.

5.23.2 The trails should be distinguishable from targets.

5.23.3 Either scaled trails or past positions or both, should be maintained and should be available for presentation within 2 scans or equivalent, following:

- the reduction or increase of one range scale;
- the offset and reset of the radar picture position; and
- a change between true and relative trails.

5.24 Presentation of Target Information

5.24.1 Targets should be presented in accordance with the performance standards for the Presentation of Navigation-related Information on Shipborne Navigational Displays adopted by the Organization and with their relevant symbols according to SN/Circ.243.

5.24.2 The target information may be provided by the radar target tracking function and by the reported target information from the Automatic Identification System (AIS).

5.24.3 The operation of the radar tracking function and the processing of reported AIS information is defined in these standards.

5.24.4 The number of targets presented, related to display size, is defined in Table 1. An indication should be given when the target capacity of radar tracking or AIS reported target processing/display capability is about to be exceeded.

5.24.5 As far as practical, the user interface and data format for operating, displaying and indicating AIS and radar tracking information should be consistent.

5.25 Target Tracking (TT) and Acquisition

5.25.1 *General*

Radar targets are provided by the radar sensor (transceiver). The signals may be filtered (reduced) with the aid of the associated clutter controls. Radar targets may be manually or automatically acquired and tracked using an automatic Target Tracking (TT) facility.

5.25.1.1 The automatic target tracking calculations should be based on the measurement of radar target relative position and own ship motion.

5.25.1.2 Any other sources of information, when available, may be used to support the optimum tracking performance.

5.25.1.3 TT facilities should be available on at least the 3, 6, and 12 NM range scales. Tracking range should extend to a minimum of 12 NM.

5.25.1.4 The radar system should be capable of tracking targets having the maximum relative speed relevant to its classification for normal or high own ship speeds (see 5.3).

5.25.2 ***Tracked Target Capacity***

5.25.2.1 In addition to the requirements for processing of targets reported by AIS, it should be possible to track and provide full presentation functionality for a minimum number of tracked radar targets according to Table 1.

5.25.2.2 There should be an indication when the target tracking capacity is about to be exceeded. Target overflow should not degrade the radar system performance.

5.25.3 ***Acquisition***

5.25.3.1 Manual acquisition of radar targets should be provided with provision for acquiring at least the number of targets specified in Table 1.

5.25.3.2 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.

5.25.4 ***Tracking***

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

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

5.25.4.3 The system should continue to track radar targets that are clearly distinguishable on the display for 5 out of 10 consecutive scans or equivalent.

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

5.25.4.5 The possibility of tracking errors, including target swap, should be minimized by design.

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

5.25.4.7 Automatic tracking accuracy should be achieved when the tracked target has achieved a steady state, assuming the sensor errors allowed by the relevant performance standards of the Organization.

5.25.4.7.1 For ships capable of up to 30 kn true speed, the tracking facility should present, within 1 min steady state tracking, the relative motion trend and after 3 minutes, the predicted motion of a target, within the following accuracy values (95% probability):

TABLE 3

Tracked Target Accuracy (95% probability figures)

Time of steady state (minutes)	Relative Course (degrees)	Relative Speed (kn)	CPA (NM)	TCPA (minutes)	True Course (degrees)	True Speed (kn)
1 min: Trend	11	1.5 or 10% (whichever is greater)	1.0	-	-	-
3 min: Motion	3	0.8 or 1% (whichever is greater)	0.3	0.5	5	0.5 or 1% (whichever is greater)

Accuracy may be significantly reduced during or shortly after acquisition, own ship manoeuvre, a manoeuvre of the target, or any tracking disturbance and is also dependent on own ship's motion and sensor accuracy.

Measured target range and bearing should be within 50 m (or +/-1% of target range) and 2°.

The testing standard should have detailed target simulation tests as a means to confirm the accuracy of targets with relative speeds of up to 100 kn. Individual accuracy values shown in the table above may be adapted to account for the relative aspects of target motion with respect to that of own ship in the testing scenarios used.

5.25.4.7.2 For ships capable of speeds in excess of 30 kn (typically High-Speed Craft (HSC)) and with speeds of up to 70 kn, there should be additional steady state measurements made to ensure that the motion accuracy, after 3 minutes of steady state tracking, is maintained with target relative speeds of up to 140 kn.

5.25.4.8 A ground referencing function, based on a stationary tracked target, should be provided. Targets used for this function should be marked with the relevant symbol defined in SN/Circ.243.

5.26 Automatic Identification System (AIS) Reported Targets

5.26.1 *General*

Reported targets provided by the AIS may be filtered according to user-defined parameters. Targets may be sleeping, or may be activated. Activated targets are treated in a similar way to radar tracked targets.

5.26.2 *AIS Target Capacity*

In addition to the requirements for radar tracking, it should be possible to display and provide full presentation functionality for a minimum number of sleeping and activated AIS targets according to Table 1. There should be an indication when the capacity of processing/display of AIS targets is about to be exceeded.

5.26.3 *Filtering of AIS Sleeping Targets*

To reduce display clutter, a means to filter the presentation of sleeping AIS targets should be provided, together with an indication of the filter status. (e.g. by target range, CPA/TCPA or AIS target class A/B, etc.). It should not be possible to remove individual AIS targets from the display.

5.26.4 *Activation of AIS Targets*

A means to activate a sleeping AIS target and to deactivate an activated AIS target should be provided. If zones for the automatic activation of AIS targets are provided, they should be the same as for automatic radar target acquisition. In addition, sleeping AIS targets may be automatically activated when meeting user defined parameters (e.g. target range, CPA/TCPA or AIS target class A/B).

5.26.5 *AIS Presentation Status*

TABLE 4

The AIS presentation status should be indicated as follows:

Function	Cases to be Presented		Presentation
AIS ON/OFF	AIS processing switched ON/ graphical presentation switched OFF	AIS processing switched ON/ graphical presentation switched ON	Alphanumeric or graphical
Filtering of sleeping AIS targets	Filter status	Filter status	Alphanumeric or graphical
Activation of Targets		Activation criteria	Graphical
CPA/TCPA Alarm	Function ON/OFF Sleeping targets included	Function ON/OFF Sleeping targets included	Alphanumeric and graphical
Lost Target Alarm	Function ON/OFF Lost target filter criteria	Function ON/OFF Lost target filter criteria	Alphanumeric and graphical
Target Association	Function ON/OFF Association criteria Default target priority	Function ON/OFF Association criteria Default target priority	Alphanumeric

5.27 AIS Graphical Presentation

Targets should be presented with their relevant symbols according to the performance standards for the Presentation of Navigation-related Information on Shipborne Navigational Displays adopted by the Organization and SN/Circ.243.

5.27.1 AIS targets that are displayed should be presented as sleeping targets by default.

5.27.2 The course and speed of a tracked radar target or reported AIS target should be indicated by a predicted motion vector. The vector time should be adjustable and valid for presentation of any target regardless of its source.

5.27.3 A permanent indication of vector mode, time and stabilization should be provided.

5.27.4 The consistent common reference point should be used for the alignment of tracked radar and AIS symbols with other information on the same display.

5.27.5 On large scale/low range displays, a means to present the true scale outline of an activated AIS target should be provided. It should be possible to display the past track of activated targets.

5.28 AIS and Radar Target Data

5.28.1 It should be possible to select any tracked radar or AIS target for the alphanumeric display of its data. A target selected for the display of its alphanumeric information should be identified by the relevant symbol. If more than one target is selected for data display, the relevant symbols and the corresponding data should be clearly identified. There should be a clear indication to show that the target data is derived from radar or from AIS.

5.28.2 For each selected tracked radar target, the following data should be presented in alphanumeric form: source(s) of data, actual range of target, actual bearing of target, predicted target range at the closest point of approach (CPA), predicted time to CPA (TCPA), true course of target, true speed of target.

5.28.3 For each selected AIS target the following data should be presented in alphanumeric form: Source of data, ship's identification, navigational status, position where available and its quality, range, bearing, COG, SOG, CPA and TCPA. Target heading and reported rate of turn should also be made available. Additional target information should be provided on request.

5.28.4 If the received AIS information is incomplete, the absent information should be clearly indicated as 'missing' within the target data field.

5.28.5 The data should be displayed and continually updated, until another target is selected for data display or until the window is closed.

5.28.6 Means should be provided to present own ship AIS data on request.

5.29 Operational Alarms

A clear indication of the cause for all alarm criteria should be given.

5.29.1 If the calculated CPA and TCPA values of a tracked target or activated AIS target are less than the set limits:

- A CPA/TCPA alarm should be given.
- The target should be clearly indicated.

5.29.2 The preset CPA/TCPA limits applied to targets from radar and AIS should be identical. As a default state, the CPA/TCPA alarm functionality should be applied to all activated AIS targets. On user request the CPA/TCPA alarm functionality may also be applied to sleeping targets.

5.29.3 If a user defined acquisition/activation zone facility is provided, a target not previously acquired/activated entering the zone, or is detected within the zone, should be clearly identified with the relevant symbol and an alarm should be given. It should be possible for the user to set ranges and outlines for the zone.

5.29.4 The system should alert the user if a tracked radar target is lost, rather than excluded by a pre-determined range or pre-set parameter. The target's last position should be clearly indicated on the display.

5.29.5 It should be possible to enable or disable the lost target alarm function for AIS targets. A clear indication should be given if the lost target alarm is disabled.

If the following conditions are met for a lost AIS target:

- The AIS lost target alarm function is enabled.
- The target is of interest, according to lost target filter criteria.
- A message is not received for a set time, depending on the nominal reporting rate of the AIS target.

Then:

- The last known position should be clearly indicated as a lost target and an alarm be given.
- The indication of the lost target should disappear if the signal is received again, or after the alarm has been acknowledged.
- A means of recovering limited historical data from previous reports should be provided.

5.30 AIS and Radar Target Association

An automatic target association function based on harmonized criteria avoids the presentation of two target symbols for the same physical target.

5.30.1 If the target data from AIS and radar tracking are both available and if the association criteria (e.g. position, motion) are fulfilled such that the AIS and radar information are considered as one physical target, then as a default condition, the activated AIS target symbol and the alphanumeric AIS target data should be automatically selected and displayed.

5.30.2 The user should have the option to change the default condition to the display of tracked radar targets and should be permitted to select either radar tracking or AIS alphanumeric data.

5.30.3 For an associated target, if the AIS and radar information become sufficiently different, the AIS and radar information should be considered as two distinct targets and one activated AIS target and one tracked radar target should be displayed. No alarm should be raised.

5.31 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 and should include own ship's dynamic characteristics. A trial manoeuvre simulation should be clearly identified. The requirements are:

- The simulation of own ship course and speed should be variable.
- A simulated time to manoeuvre with a countdown should be provided.
- During simulation, target tracking should continue and the actual target data should be indicated.
- Trial manoeuvre should be applied to all tracked targets and at least all activated AIS targets.

5.32 The Display of Maps, Navigation Lines and Routes

5.32.1 It should be possible for the user to manually create and change, save, load and display simple maps/navigation lines/routes referenced to own ship or a geographical position. It should be possible to remove the display of this data by a simple operator action.

5.32.2 The maps/navigation lines/routes may consist of lines, symbols and reference points.

5.32.3 The appearance of lines, colours and symbols are as defined in SN/Circ.243.

5.32.4 The maps/navigation lines/route graphics should not significantly degrade the radar information.

5.32.5 The maps/navigation lines/routes should be retained when the equipment is switched OFF.

5.32.6 The maps/navigation lines/route data should be transferable whenever a relevant equipment module is replaced.

5.33 The Display of Charts

5.33.1 The radar system may provide the means to display ENC and other vector chart information within the operational display area to provide continuous and real-time position monitoring. It should be possible to remove the display of chart data by a single operator action.

5.33.2 The ENC information should be the primary source of information and should comply with IHO relevant standards. Status of other information should be identified with a permanent indication. Source and update information should be made available.

5.33.3 As a minimum, the elements of the ECDIS Standard Display should be made available for individual selection by category or layer, but not as individual objects.

5.33.4 The chart information should use the same reference and co-ordinate criteria as the radar/AIS, including datum, scale, orientation, CCRP and stabilization mode.

5.33.5 The display of radar information should have priority. Chart information should be displayed such that radar information is not substantially masked, obscured or degraded. Chart information should be clearly perceptible as such.

5.33.6 A malfunction of the source of chart data should not affect the operation of the radar/AIS system.

5.33.7 Symbols and colours should comply with the performance standards for the Presentation of Navigation-related Information on Shipborne Navigational Displays adopted by the Organization (SN/Circ.243).

5.34 Alarms and Indications

Alarms and indications should comply with the performance standards for the Presentation of Navigation-related Information on Shipborne Navigational Displays adopted by the Organization.

5.34.1 A means should be provided to alert the user of "picture freeze".

5.34.2 Failure of any signal or sensor in use, 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 (see fallback modes, section 9).

5.35 Integrating Multiple Radars

5.35.1 The system should safeguard against single point system failure. Fail-safe condition should be applied in the event of an integration failure.

5.35.2 The source and any processing or combination of radar signals should be indicated.

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

6 ERGONOMIC CRITERIA

6.1 Operational Controls

6.1.1 The design should ensure that the radar system is simple to operate. Operational controls should have a harmonized user interface and be easy to identify and simple to use.

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

6.1.3 The control functions may be dedicated hardware, screen accessed or a combination of these; however the primary control functions should be dedicated hardware controls or soft keys, with an associated status indication in a consistent and intuitive position.

6.1.4 The following are defined as primary radar control functions and should be easily and immediately accessible:

Radar Standby/RUN, Range scale selection, Gain, tuning function (if applicable), Anti-clutter rain, Anti-clutter sea, AIS function on/off, Alarm acknowledge, Cursor, a means to set EBL/VRM, display brightness and acquisition of radar targets.

6.1.5 The primary functions may also be operated from a remote operating position in addition to the main controls.

6.2 Display Presentation

6.2.1 The display presentation should comply with the performance standards for the Presentation of Navigation-related Information on Shipborne Navigational Displays adopted by the Organization.

6.2.2 The colours, symbols and graphics presented should comply with SN/Circ.243.

6.2.3 The display sizes should conform to those defined in Table 1.

6.3 Instructions and Documentation

6.3.1 *Documentation Language*

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

6.3.2 *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 display and tracking process and accuracy, including any delays;
- using heading and SOG/COG information for collision avoidance;
- limitations and conditions of target association;
- criteria of selection for automatic activation and cancellation of targets;
- methods applied to display AIS targets and any limitations;
- principles underlying the trial manoeuvre technology, including simulation of own ship's manoeuvring characteristics, if provided;
- alarms and indications;
- installation requirements as listed under section 7.5;
- radar range and bearing accuracies; and
- any special operation (e.g. tuning) for the detection of SARTs; and
- the role of the CCRP for radar measurements and its specific value.

6.3.3 *Manufacturer's Documentation*

6.3.3.1 The manufacturer's documentation should contain a description of the radar system and factors that may affect detection performance, including any latency in signal processing.

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

6.3.3.3 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

7.1.1 As far as is practical, the radar system should be of a design to facilitate simple fault diagnosis and maximum availability.

7.1.2 The radar system should include a means to record the total operational hours for any components with a limited life.

7.1.3 The documentation should describe any routine servicing requirements and should include details of any restricted life components.

7.2 Display

The display device physical requirements should meet those specified in the performance standards for the Presentation of Navigation-related Information on Shipborne Navigational Displays adopted by the Organization (SN/Circ.243) and those specified in Table 1.

7.3 Transmitter Mute

The equipment should provide a mute facility to inhibit the transmission of radar energy over a preset sector. The mute sector should be set up on installation. An indication of sector mute status should be available.

7.4 Antenna

7.4.1 The antenna should be designed to start operating and to continue to operate in relative wind speeds likely to be encountered on the class of ship on which it is installed.

7.4.2 The combined radar system should be capable of providing an appropriate information update rate for the class of ship on which it is installed.

7.4.3 The antenna side lobes should be consistent with satisfying the system performance as defined in this standard.

7.4.4 There should be a means to prevent antenna rotation and radiation during servicing, or while personnel are in the vicinity of up-mast units.

7.5 Radar System Installation

Requirements and guidelines for the radar system installation should be included in the manufacturers' documentation. The following subjects should be covered:

7.5.1 *The Antenna*

Blind sectors should be kept to a minimum, and should not be placed in an arc of the horizon from the right ahead direction to 22.5^{o} abaft the beam and especially should avoid the right ahead direction (relative bearing 000^{o}). The installation of the antenna should be in such a manner that the performance of the radar system is not substantially degraded. The antenna should be mounted clear of any structure that may cause signal reflections, including other antenna and deck structure or cargo. In addition, the height of the antenna should take account of target detection performance relating to range of first detection and target visibility in sea clutter.

7.5.2 *The Display*

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

7.6 Operation and Training

7.6.1 The design should ensure that the radar system is simple to operate by trained users.

7.6.2 A target simulation facility should be provided for training purposes.

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 Organization.

The radar should be interfaced to relevant sensors required by these performance standards in accordance with recognized international standards.*

8.2 Input Data Integrity and Latency

8.2.1 The radar system should not use data indicated as invalid. If input data is known to be of poor quality this should be clearly indicated.

8.2.2 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.

8.2.3 The latency of processing input data should be minimized.

8.3 Output Data

8.3.1 Information provided by any radar output interface to other systems should be in accordance with international standards*.

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

8.3.3 At least one normally closed contact (isolated) should be provided for indicating failure of the radar.

8.3.4 The radar should have a bi-directional interface to facilitate communication so that alarms from the radar can be transferred to external systems and so that audible alarms from the radar can be muted from external systems, the interface should comply with relevant international standards.

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* Refer to IEC publication 61162.

9 BACKUP AND FALLBACK ARRANGEMENTS

In the event of partial failures and to maintain minimum basic operation, the fallback arrangements listed below should be provided. There should be a permanent indication of the failed input information.

9.1 Failure of Heading Information (Azimuth Stabilization)

9.1.1 The equipment should operate satisfactorily in an unstabilized head-up mode.

9.1.2 The equipment should switch automatically to the unstabilized head up mode within 1 minute after the azimuth stabilization has become ineffective.

9.1.3 If automatic anti-clutter processing could prevent the detection of targets in the absence of appropriate stabilization, the processing should switch off automatically within 1 minute after the azimuth stabilization has become ineffective.

9.1.4 An indication should be given that only relative bearing measurements can be used.

9.2 Failure of Speed through the Water Information

A means of manual speed input should be provided and its use clearly indicated.

9.3 Failure of Course and Speed Over Ground Information

The equipment may be operated with course and speed through the water information.

9.4 Failure of Position Input Information

The overlay of chart data and geographically referenced maps should be disabled if only a single Reference Target is defined and used, or the position is manually entered.

9.5 Failure of Radar Video Input Information

In the absence of radar signals, the equipment should display target information based on AIS data. A frozen radar picture should not be displayed.

9.6 Failure of AIS Input Information

In the absence of AIS signals, the equipment should display the radar video and target database.

9.7 Failure of an Integrated or Networked System

The equipment should be capable of operating equivalent to a stand alone system.

Appendix 1 - References

IMO SOLAS chapters IV, 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(17)	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.817(19), as amended	Performance Standards for ECDIS.
IMO resolution A.821(19)	Performance standards for gyro-compasses for high-speed craft.
IMO resolution A.824(19)	Performance standards for devices to indicate speed and distance.
IMO resolution MSC.86(70)	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	Guidelines on ergonomic criteria for bridge equipment and layout.
IHO S-52 appendix 2	Colour and symbol specification for ECDIS.
IEC 62388	Radar Test Standard (replacing 60872 and 60936 series of test standards).
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 61174	Maritime navigation and radio communication equipment and systems – Electronic chart display and information system (ECDIS) – Operational and performance requirements, methods of testing and required test results.
IEC 62288	Presentation and display of navigation information.
ISO 9000 (all parts)	Quality management/assurance standards.

Appendix 2 – Definitions

Activated AIS target	A target representing the automatic or manual activation of a sleeping target for the display of additional graphically presented information. The target is displayed by an "activated target" symbol including: ● a vector (COG / SOG); ● the heading; and ● ROT or direction of turn indication (if available) to indicate initiated course changes.
Acquisition of a radar target	Process of acquiring a target and initiating its tracking.
Activation of an AIS target	Activation of a sleeping AIS target for the display of additional graphical and alphanumerical information.
Acquired radar target	Automatic or manual acquisition initiates radar tracking. Vectors and past positions are displayed when data has achieved a steady state condition.
AIS	Automatic Identification System.
AIS target	A target generated from an AIS message**.** See activated target, lost target, selected target and sleeping target.
Associated target	If an acquired radar target and an AIS reported target have similar parameters (e.g. position, course, speed) complying with an association algorithm, they are considered to be the same target and become an associated target.
Acquisition/activation zone	A zone set up by the operator in which the system should automatically acquire radar targets and activate reported AIS targets when entering the zone.
CCRP	Consistent Common Reference Point: A location on own 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.
CPA/TCPA	Closest Point of Approach / Time to the Closest Point of Approach: Distance to the closest point of approach (CPA) and time to the closest point of approach (TCPA). Limits are set by the operator related to own ship.
Course Over Ground (COG)	Direction of the ship's movement relative to the earth, measured on board the ship, expressed in angular units from true north.

Course Through Water (CTW)	Direction of the ship's movement through the water, defined by the angle between the meridian through its position and the direction of the ship's movement through the water, expressed in angular units from true north.
Dangerous target	A target whose predicted CPA and TCPA are violating the values as preset by the operator. The respective target is marked by a "dangerous target" symbol.
Display modes	**Relative motion:** means a display on which the position of own ship remains fixed, and all targets move relative to own ship. **True motion:** a display across which own ship moves with its own true motion.
Display orientation	**North up display:** an azimuth stabilized presentation which uses the gyro input (or equivalent) and north is uppermost on the presentation. **Course up display:** an azimuth stabilized presentation which uses the gyro input or equivalent and the ship's course is uppermost on the presentation at the time of selection. **Head up display:** an unstabilized presentation in which own ship's heading is uppermost on the presentation.
ECDIS	Electronic Chart Display and Information System.
ECDIS Display Base	The level of information which cannot be removed from the ECDIS display, consisting of information which is required at all times in all geographic areas and all circumstances. It is not intended to be sufficient for safe navigation.
ECDIS Standard Display	The level of information that should be shown when a chart is first displayed on ECDIS. The level of the information it provides for route planning or route monitoring may be modified by the mariner according to the mariner's needs.
ENC	Electronic Navigational Chart. The database standardized as to content, structure and format according to relevant IHO standards and issued by, or on the authority of, a Government.
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 two objects.

Evaporation duct	A low lying duct (a change in air density) that traps the radar energy so that it propagates close to the sea surface. Ducting may enhance or reduce radar target detection ranges.
Heading	Direction in which the bow of a ship is pointing expressed as an angular displacement from north.
HSC	High-speed craft (HSC) are vessels which comply with the definition in SOLAS for high speed craft.
Latency	The delay between actual and presented data.
Lost AIS target	A target representing the last valid position of an AIS target before the reception of its data was lost. The target is displayed by a "lost AIS target" symbol.
Lost tracked target	Target information is no longer available due to poor, lost or obscured signals. The target is displayed by a "lost tracked radar target" symbol.
Maps/Nav lines	Operator defined or created lines to indicate channels, Traffic Separation Schemes or borders of any area important for navigation.
Operational display area	Area of the display used to graphically present chart and radar information, excluding the user dialogue area. On the chart display this is the area of the chart presentation. On the radar display this is the area encompassing the radar image.
Past positions	Equally time-spaced past position marks of a tracked or reported 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 the determination of distance and direction of reflecting objects and of transmitting devices.
Radar beacon	A navigation aid which responds to the radar transmission by generating a radar signal to identify its position and identity.
Radar detection false alarm	The probability of a radar false alarm represents the probability that noise will cross the detection threshold and be called a target when only noise is present.
Radar target	Any object fixed or moving whose position and motion is determined by successive radar measurements of range and bearing.

Radar target enhancer	An electronic radar reflector, the output of which is an amplified version of the received radar pulse without any form of processing except limiting.
Reference target	Symbol indicating that the associated tracked stationary target (e.g. a navigational mark) is used as a speed reference for the ground stabilization.
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. (Bearing).
Relative motion	Combination of relative course and relative speed.
Relative speed	Speed of a target relative to own ship's speed data.
Rate of turn	Change of heading per time unit.
SART	Search And Rescue Transponder.
SDME	Speed and Distance Measuring Equipment.
Selected target	A manually selected target for the display of detailed alphanumeric information in a separate data display area. The target is displayed by a "selected target" symbol.
Sleeping AIS target	A target indicating the presence and orientation of a vessel equipped with AIS in a certain location. The target is displayed by a "sleeping target" symbol. No additional information is presented until activated.
Stabilization modes	**Ground stabilization:** Display mode in which speed and course information are referred to the ground, using ground track input data, or EPFS as reference. **Sea stabilization:** Display mode in which speed and course information are referred to the sea, using gyro or equivalent and water speed log input as reference.
Standard display	The level of information that should be shown when a chart is first displayed on ECDIS. The level of the information it provides for route planning or route monitoring may be modified by the mariner according to the mariner's needs.
Standard radar reflector	Reference reflector mounted 3.5 m above sea level with 10 m^2 effective reflecting area at X-Band.

Steady state tracking	Tracking a target, proceeding at steady motion: - after completion of the acquisition process, or - without a manoeuvre of target or own ship, or - without target swap or any disturbance.
Speed Over Ground (SOG)	Speed of the ship relative to the earth, measured on board of the ship.
Speed Through Water	Speed of the ship relative to the water surface.
SOLAS	International Convention for the Safety of Life at Sea.
Suppressed area	An area set up by the operator within which targets are not acquired.
Target swap	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 course and speed based on linear extrapolation from its present motion as determined by past measurements of its range and bearing on the radar.
Target Tracking (TT)	Computer process of observing the sequential changes in the position of a radar target in order to establish its motion. Such a target is a Tracked Target.
Trails	Tracks displayed by the radar echoes of targets in the form of an afterglow. Trails may be true or relative.
Trial manoeuvre	Graphical simulation facility used to assist the operator to perform a proposed manoeuvre for navigation and collision avoidance purposes, by displaying the predicted future status of at least all acquired or activated 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 or to sea, 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, or to sea.

Vector modes	**True vector:** Vector representing the predicted true motion of a target, showing course and speed with reference to the ground. **Relative vector:** Predicted movement of a target relative to own ship's motion.
User configured presentation	A display presentation configured by the user for a specific task at hand. The presentation may include radar and/or chart information, in combination with other navigation or ship related data.
User dialogue area	Is an area of the display consisting of data fields and/or menus that is allocated to the interactive presentation and entry or selection of operational parameters, data and commands mainly in alphanumeric form.

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ARPA :
Aide Automatique au Pointage Radar

1. Performances minimales de l'ARPA

Résolution A823(19) du 23/11/1995 sur les performances minimales de l'ARPA.

En lisant ce texte réglementaire de l'O.M.I., répondez aux questions suivantes en précisant le paragraphe contenant les informations. Pages 1 à 5

Question & réponse	paragraphe
Comparé à un chef de quart seul, quel sont les deux avantages de l'ARPA pour l'anti-collision ? Réduire la charge de travail du chef de quart par un pointage et un suivi automatisé des pistes, fournir une évaluation précise et continue de l'anti-collision.	1.1
L'ARPA doit être capable de suivre des échos jusqu'à quelle vitesse relative ? Acquisition manuelle ou automatique d'échos jusqu'à 100 nd relatifs.	3.2.1
Dans quelle partie de l'écran l'ARPA acquiert-il automatiquement les échos ? Seulement dans la ou les zones paramétrées par le chef de quart.	3.2.1
L'ARPA doit être capable de suivre combien d'échos simultanément ? A moins 20 échos.	3.3.1
Sur quel(s) critère(s) un écho cesse-t-il d'être suivi par l'ARPA ? Lorsqu'il disparaît sur 6 tours d'antenne ou plus sur 10 tours consécutifs.	3.3.3
Quelles sont les sources d'erreur rendant impossible le suivi des échos par l'ARPA ? Échange de pistes entre deux échos proches, faible signal sur bruit, notamment le bruit des échos parasites : vagues, pluie, neige, nuages à basse altitude et interférences.	3.3.4
Comment est représenté la trajectoire passée récente d'une piste suivie par l'ARPA ? Par quatre points espacés par une échelle de temps visible et modifiable par le chef de quart.	3.3.5
Les fonctions ARPA sont-elles disponibles sur toutes les échelles possibles avec le radar ? Les fonctions ARPA doivent être disponibles au moins sur les échelles de 3, 6 et 12 milles.	3.4.3
L'ARPA fonctionne-t-il en mode North Up, Course Up ou Head Up ? L'ARPA doit être capable de fonctionner en mode North Up et Course Up.	3.4.5
Les informations ARPA sont-elles pertinentes si l'image radar est en TRUE MOTION ? L'ARPA doit être capable de fonctionner en mode TRUE MOTION comme en RELATIVE MOTION.	3.4.5
Le vecteur ajouté par l'ARPA sur une piste est-il vrai ou relatif ? L'ARPA affiche le vecteur VRAI ou RELATIF des pistes selon le choix du chef de quart.	3.4.6.1
Le vecteur vrai ajouté par l'ARPA sur une piste montre-t-il son vecteur-surface ou fond ? Le vecteur VRAI affiché par l'ARPA est un vecteur fond ou surface selon la stabilisation FOND ou SURFACE visible et choisie par le chef de quart.	3.4.6.1
Quelle est l'échelle de temps utilisée par l'ARPA pour dessiner le vecteur de chaque piste ? L'ARPA doit dessiner le vecteur de chaque piste avec une échelle de temps visible et choisie par le chef de quart.	3.4.6.3

Question & réponse	paragraphe
Un « écho de référence » peut-il avoir un vecteur vrai ou relatif ? Le vecteur VRAI d'une piste choisie comme écho de référence est un vecteur nul. Si l'ARPA affiche les vecteurs relatifs, celui de l'écho de référence (fixe par rapport à la terre) sera l'opposé du vecteur FOND de notre navire.	3.4.6.5
Peut-on diminuer la luminosité du radar sans perdre la visibilité des informations ARPA ? La luminosité de l'image radar et celle des informations de l'ARPA doivent être réglables indépendamment l'une de l'autre. Le chef de quart doit pouvoir stopper l'affichage de l'ARPA.	3.4.8
Quel est le délai maximal entre l'acquisition d'un écho et l'affichage de son vecteur ? Une minute. La « tendance » d'une piste est sa route relative, sa vitesse relative et son CPA.	3.4.11
À 24 tours/min, combien y a-t-il de tours d'antenne entre acquisition d'un écho et affichage de son CPA ? Le CPA doit être affiché au plus tard en 1 minute, soit 24 tours d'antenne (précision 1,2 à 2 M).	3.4.11 + 3.8.2
Quel est le temps de latence pour mettre à jour les informations ARPA après un changement d'échelle ? Un tour d'antenne, soit 2,5 secondes à 24 tours par minute.	3.4.12
Le chef de quart peut-il paramétrer des alarmes sur l'ARPA ? Si oui, sur quel critère ? Oui : en cas d'entrée d'un écho dans une zone de garde, ou pour une piste ayant un CPA ***et*** un TCPA inférieurs aux seuils choisis par le chef de quart. Idem pour BCR ***et*** BCT.	3.5.1 + 3.5.2
Existe-t-il une alarme lorsque l'ARPA perd l'écho d'une piste ? Lorsque l'ARPA ne distingue plus l'écho d'une piste (durant 6 tours d'antenne sur 10 consécutifs) il déclenche une alarme sonore et visuelle sauf s'il s'agit d'un écho hors de portée *(> 12 M)*.	3.5.3

Pages 6 à 14

Question & réponse	paragraphe
Lorsque chef de quart sélectionne une piste ARPA, quelles informations doit-il pouvoir lire ? L'azimut et la distance actuels, le CPA et le TCPA prédits, la route et la vitesse VRAIES de la cible.	3.6.2
Le vecteur vrai indique-t-il la route & vitesse fond ou surface ? En stabilisation SURFACE, le vecteur VRAI d'une piste est son vecteur SURFACE, en stabilisation FOND, le vecteur VRAI d'une piste est son vecteur FOND.	3.6.3 + 3.11.1 + 3.11.4
Durant une simulation de manœuvre avec un écho, l'ARPA continue le suivi de combien de pistes ? En mode TRIAL, l'ARPA simule la trajectoire de toutes les pistes tout en continuant le suivi des échos.	3.7.1
Quels sont les paramètres choisis par le chef de quart pour simuler une manœuvre sur l'ARPA ? Un délai avant la manœuvre, un changement de route et / ou de vitesse de notre navire.	3.7.1 + 3.7.2
Quel est le délai entre l'acquisition d'un écho et l'affichage des informations sur cette piste ? 1 minute pour la route RELATIVE, la vitesse RELATIVE et le CPA, avec une précision grossière ; 3 minutes pour toutes les informations, avec une précision optimale.	3.8.2 + 3.8.3
La route-surface d'une piste suivie par l'APRA depuis 3 minutes a quelle précision ? Route SURFACE précise de 2,6° à 7,4° près selon le scénario retenu, avec 95 % de pertinence.	3.8.3
La vitesse relative d'une piste suivie par l'APRA depuis 3 minutes a quelle précision ? Vitesse RELATIVE précise de 0,3 à 0,9 nd près selon le scénario retenu, avec 95 % de pertinence.	3.8.3
La route relative d'une piste suivie par l'APRA depuis 3 minutes a quelle précision ? Route RELATIVE précise de 2,3° à 4,6° près selon le scénario retenu, avec 95 % de pertinence.	3.8.3
La vitesse-surface d'une piste suivie par l'APRA depuis 3 minutes a quelle précision ? Vitesse SURFACE précise de 0,8 à 1,2 nd près selon le scénario retenu, avec 95 % de pertinence.	3.8.3

Question & réponse	paragraphe
Quel est le délai entre la manœuvre d'un navire et la mise à jour précise des informations ARPA ? Le délai APRÈS la FIN de la manœuvre d'un autre navire ou du nôtre, pour mettre à jour l'affichage est de : 1 minute pour la route RELATIVE, la vitesse RELATIVE et le CPA, avec une précision grossière ; 3 minutes pour toutes les informations, avec une précision optimale.	3.8.4
Quel taux de giration maximal de notre navire doit tolérer l'ARPA sans perdre précision ni délai ? La précision (grossière en 1 minute ou optimale en 3 minutes) à respecter après une manœuvre de NOTRE NAVIRE est considérée pour une giration au taux de 45°/min.	3.8.4
Quel roulis maximal de notre navire doit tolérer l'ARPA sans perdre précision ni délai ? 10° de roulis.	3.8.1
L'ARPA cesse-t-il de fonctionner en cas de défaut d'un appareil connecté (compas, loch, GPS, etc) ? L'ARPA continue de fonctionner mais signale les données extérieures manquantes par une alarme.	3.9.1 + 3.9.2
L'ARPA est-il en mesure de détecter son propre dysfonctionnement ? Oui, par une auto-surveillance de son fonctionnement mais aussi par un autotest à démarrage manuel.	3.10
Quelles sont les informations nécessaires à une stabilisation par rapport à la surface ? Le cap gyroscopique et la vitesse-surface longitudinale (mesurée par un loch ou entrée manuellement).	3.11.2 + 33 p. 11
Quelles sont les informations nécessaires à une stabilisation par rapport au fond ? Route & vitesse-FOND du récepteur GNSS, ou du loch DOPPLER 2 axes en BOTTOM TRACK, ou entrée manuelle du courant en direction et vitesse, ou désignation d'un écho de référence (fixe sur le fond).	3.11.3 + 34 p. 11
Bow Crossing Range et Bow Crossing Time sont-ils calculés pour un navire devant nous ou l'inverse ? Pour le passage d'un autre navire sur la ligne de foi de notre navire.	30 p. 10
Qu'est-ce qu'un faux écho (bad echo) pour l'ARPA ? Écho perdu ou de rapport signal sur bruit trop faible pour permettre un suivi par l'ARPA.	31 p. 10
Les CPA et TCPA sont calculés par rapport à quelle position du navire ? L'antenne du radar.	Note p. 11
Les performances mini. de l'ARPA sont choisies pour quelles vitesse-surface et distance maxi. des pistes ? Vitesse SURFACE de notre navire de 5 à 25 nd ; distance des autres navires de 1 à 8 milles.	p. 12

Résolution MSC192(79) du 06/12/2004 révisant les performances des radars

Performances minimum et fonctions requises selon la taille et le type de navire page 4

Taille de navire	< 500 t	500 t ≤ tonnage < 10 000 t + Navires à Grande Vitesse <10 000 t	≥ 10 000 t
Diamètre de l'image radar	≥ 180 mm	≥ 250 mm	≥ 320 mm
Taille de l'écran	195 x 195 mm	270 x 270 mm	340 x 340 mm
Acquisition automatique	-	-	OUI
Nombre minimum de pistes	20	30	40
Simulation de manœuvre	-	-	OUI

Détection à courte distance, par mer calme page 8

- antenne radar à 15 m au-dessus de la mer ; - bouée de signalisation (S.E.R. bande X 5 m² / S 0,5 m²).

l'écho doit être visible de 40 m à 1 M sans changer les réglages du radar (autres que l'échelle).

Discrimination en distance : séparation des échos de deux navires dans le même azimut et distants de 40 m.

- situés à une distance de 0,75 à 1,5 M ; - observés sur une échelle de 1,5 M.

Discrimination en azimut: séparation des échos de deux navires à la même distance et séparés de 2,5°.

Roulis et tangage de notre navire ***:*** pas de dégradation des performances jusqu'à ±10°.

Distance de détection en l'absence de retour de mer ni de pluie page 6

description de l'objet	caractéristiques	distance de détection	
	hauteur / mer	bande X	bande S
littoral	60 m	20 M	20 M
littoral	6 m	8 M	8 M
littoral	3 m	6 M	6 M
navire SOLAS > 5 000 t	10 m	11 M	11 M
navire SOLAS > 500 t	5 m	8 M	8 M
petit navire avec réflecteur radar OMI (S.E.R. bande X 7,5 m² / S 0,5 m²)	4m	5 M	3,7 M
bouée avec réflecteur en coin (S.E.R. bande X 10 m² / S 1,0 m²)	3,5 m	4,9 M	3,6 M
bouée de signalisation (S.E.R. bande X 5 m² / S 0,5 m²)	3,5 m	4,6 M	3 M
embarcation longueur 10 m sans réflecteur (S.E.R. bande X 2,5 m² / S 1,4 m²)	2 m	3,4 M	3 M

Pour un navire à vitesse normale (< 30 nd) ou élevée (< 70 nd), soit des vitesses relatives d'écho de 100 à 140 nd.

Le radar doit proposer une ***amélioration de la visibilité des échos*** à courte distance
en cas de retour de mer ou de pluie.

Délai maximum de fonctionnement : 4 minutes après démarrage ; 5 secondes après mode STANDBY. page 9
STANDBY signifie arrêt des émissions radar : les autres fonctions demeurent actives.

Point de référence (Consistent Common Reference Point : CCRP)
Les distances, azimuts, position du curseur et paramètre des pistes doivent être exprimés par rapport à la passerelle après correction des décalages de position des antennes radar à bord du navire.

Échelles de distance : le radar doit proposer au minimum 0,25 / 0,5 / 0,75 / 1,5 / 3 / 6 / 12 / 24 M.

Cercle de distance (Variable Range Markers VRM) : erreur inférieure à 1 % de l'échelle ou à 30 m. page 10
Au moins deux cercles modifiables par le chef de quart.

Ligne de foi (Head Line HL) : visible sur le radar, calée sur le cap à 0,1° près.
L'erreur due au décalage de l'antenne et de la passerelle doit être corrigée en permanence.

Ligne d'azimut (Electronic Bearing Lines EBL) : erreur inférieure à 1 °.
Au moins deux lignes modifiables ; mesure exprimée en azimut ou en gisement au choix du chef de quart.
L'origine d'une ligne doit pouvoir être déplacée par le chef de quart ; elle doit suivre le mouvement du navire ou pouvoir être immobilisée sur la surface (ou le fond selon la stabilisation choisie).

Index parallèles (Parallel Index lines PI) : au moins 4 disponibles, page 11
réglables en distance depuis le navire et en azimut.

Le curseur doit être exprimé en latitude / longitude et en azimut / distance avec la précision des VRM et EBL.
Il sert à sélectionner ou dé-sélectionner une piste, ainsi qu'aux réglages du radar et de l'ARPA.

L'***alignement du radar sur le cap*** du navire doit respecter une erreur maximum de 0,5°,
même lors d'une giration, dont le taux maximum est fixé pour chaque classe de navire.

Précision des paramètres des pistes ARPA avec une pertinence de 95 % page 15

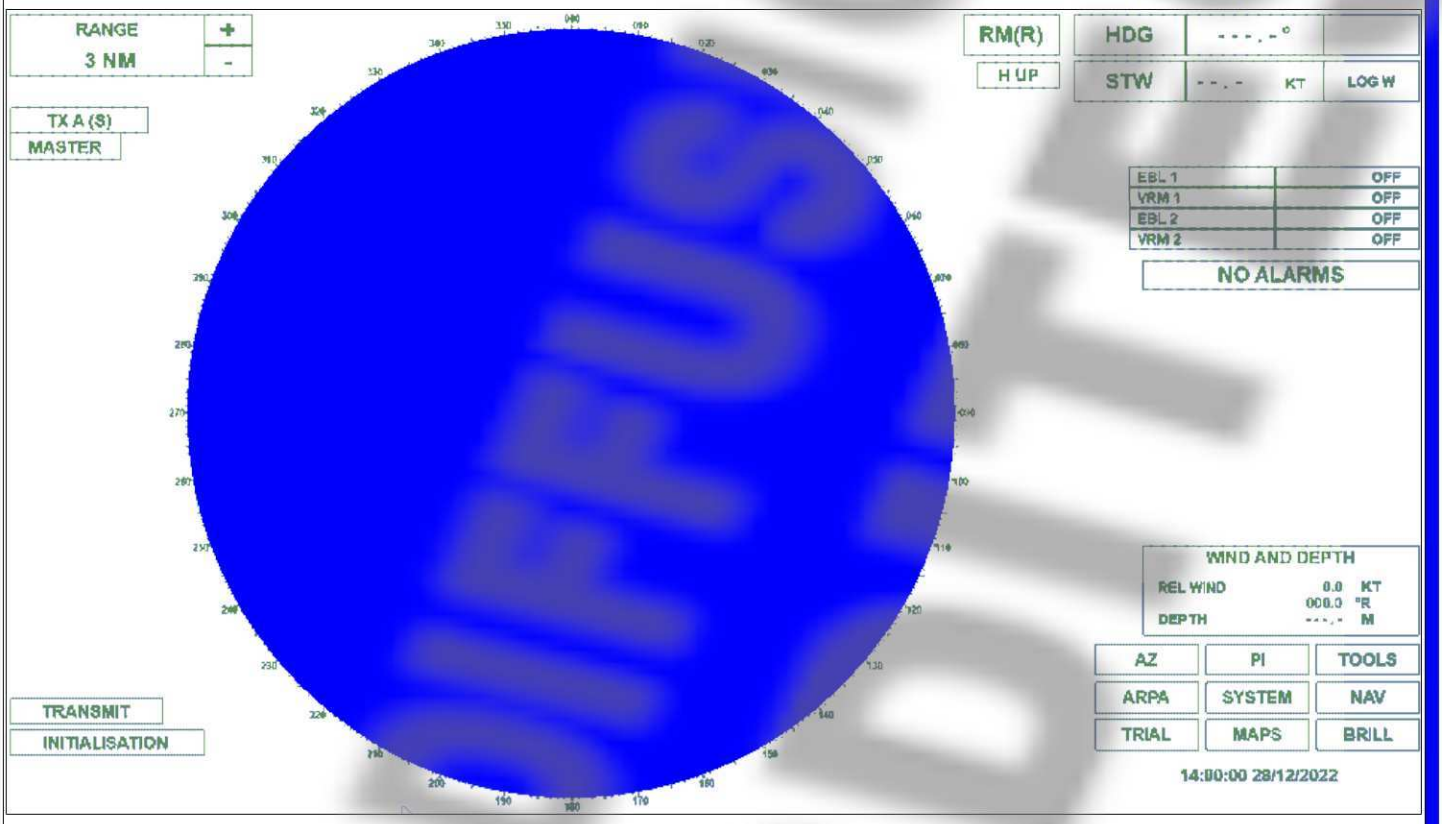
cap & vitesse stables	route relative	vitesse relative	**CPA**	**TCPA**	route vraie	vitesse vraie
1 min	11°	1,5 nd ou 10 %	1 M	-	-	-
3 min	3°	0,8 nd ou 1 %	**0,3 M**	**0,5 min**	5°	0,5 nd ou 1 %

Gestion des pistes AIS et corrélation avec l'ARPA / simulation de manœuvre / pages 15 à 25
affichage de fonds de cartes, de lignes de route ou de navigation / alarmes de dysfonctionnement / ergonomie /
couleurs, termes, abréviations et symboles selon la circulaire 243 du 14/06/2019 / notice d'utilisation /
conception, installation et interface / fonctionnement avec défaut de cap, de vitesse, de position, d'AIS, de signal radar.

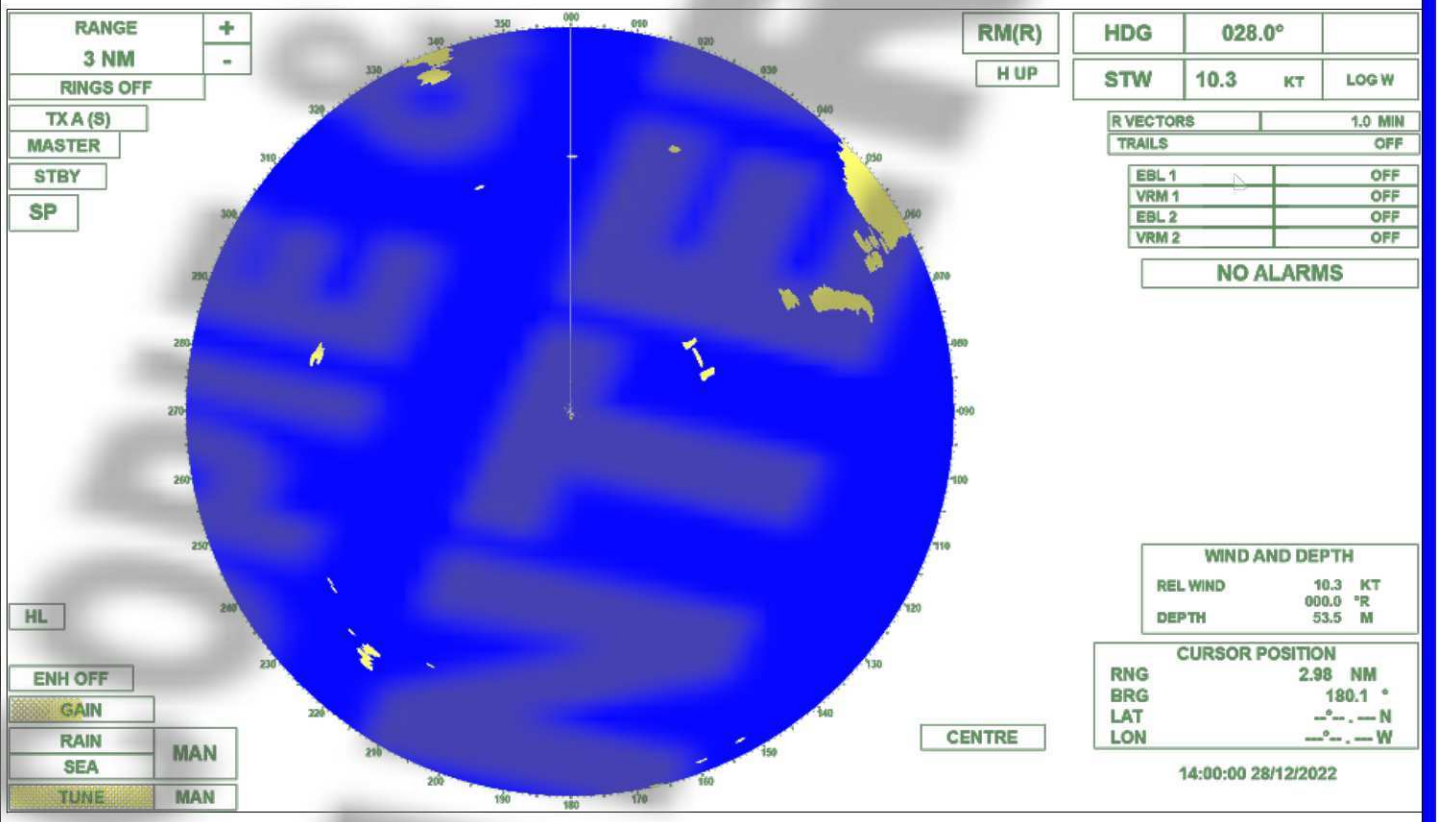
2. Pratique sur simulateur

1. Réglages du radar

Au démarrage de chaque exercice du simulateur, on sélectionnera le modèle BRIDGE-MASTER ; les autres radars fonctionnent bien mais leur interface est moins adaptée à leur simulation à travers un écran et une souris. L'écran affiche alors la console du radar éteinte : aucun écho n'apparaît.



- démarrage du radar : cliquer sur « **TRANSMIT** »
  la console affiche des échos avec ses réglages par défaut : bande S, Head Up, Gain bas, ACR & ACR nuls…



- choix du radar : « **TX(A) S** » ⇒ « **TX(A) X** » ⇒ « **TX(A) S** »...
  bande X pour anti-collision et point par distances radar ;
  bande S pour détection des petits échos et / ou navigation par mauvais temps ;
  le lobe d'antenne en bande X est plus étroit (≈ 1°) qu'en bande S (≈ 5°) : adapter le choix selon la discrimination en azimut recherchée.
- réglage de l'accord en fréquence : TUNNING « MAN » ⇒ « **AFC** »
  Auto Frequency Control = synchronisation automatique de la chaîne de réception sur $F_{émission}$.
- amplification automatique des petits échos : ENH « OFF » ⇒ « **ON** »
  enhancement = amélioration : étalement des petits échos pour les « renforcer » ; en cas d'échos proches les uns des autres, choisir ENH OFF pour améliorer la résolution en distance et azimut ;
- stabilisation de l'image en azimut : « HU » ⇒ « CU » ⇒ « **NU** »
  Head Up bloque la ligne de foi en haut de l'écran : l'image tourne en sens opposé du navire ;
  Course Up bloque le cap du navire (au moment de cette sélection) en haut et stabilise l'image ;
  North Up bloque le Nord en haut de l'écran et stabilise l'image ;
  le cap du navire (heading) est fourni au radar le compas gyroscopique.
- réglage du gain : « **GAIN** » puis déplacement latéral de la souris ; validation en recliquant
  augmenter au maximum puis réduire jusqu'à disparition de la « neige » sur l'écran ;
  il peut subsister un amas de faux échos autour du navire (sea clutter)
  ou d'une zone chargée de nuages / pluie (rain clutter).
- réglage des anti clutters : « **MAN** » ⇒ « AUTO » ⇒ « **MAN** »
  éviter AUTO qui évalue le contraste tout l'écran mais sur aucune zone ou écho en particulier ;
  « **ACS** » puis déplacement latéral de la souris ; validation en recliquant
  tester plus moins d'effet pour éclaircir les abords du navire sans perdre d'écho à surveiller ;
  « **ACR** » puis déplacement latéral de la souris ; validation en recliquant
  tester plus moins d'effet pour éclaircir l'arrière d'un nuage sans perdre d'écho à surveiller.
- réglage de la longueur d'impulsion : « **SP** » ⇒ « **MP** » ⇒ « **LP** »…
  SP pour discriminer en distance des échos voisins, ou pour une image plus détaillée de la côte ;
  LP pour détecter les petits navires ou une côte basse, notamment sur grande échelle ;
  chaque échelle offre une seule, ou deux, ou trois longueurs d'impulsion.

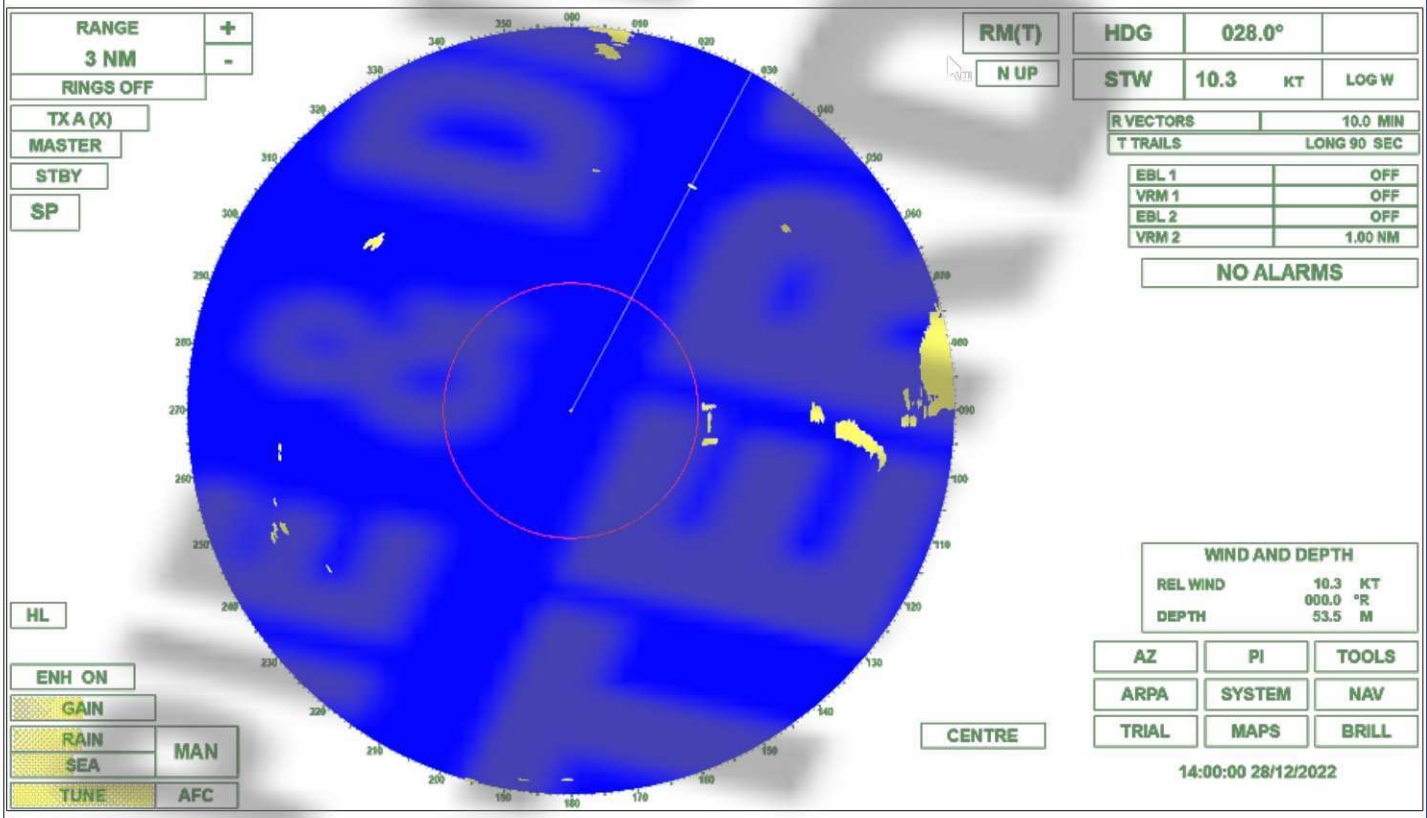
Bande X/S, GAIN, ACS, ACR et longueur d'impulsion doivent être adaptés à chaque changement d'état de la mer, de météo, de densité du trafic, voire d'échelle !… et au besoin : surveillance d'un petit navire à proximité, mesure de distance sur le trait de côte, recherche d'un écho sous un nuage, etc. ***Le chef de quart est responsable de l'image radar exploitée par l'ARPA.***

- mouvement de l'image : « **RM(R)** » ⇒ « **RM(T)** » ⇒ « TM »… ou clic droit
  Relative Motion est la présentation idéale pour l'anti-collision ;
  True Motion est dangereux car notre navire se déplace sur l'écran puis se recale en arrière, et parce que l'évaluation des risques de collision est beaucoup moins intuitive ;
  RM(R) représente les positions antérieures de chaque écho sur sa trajectoire relative ;
  RM(T) représente les positions antérieures de chaque écho sur leur trajectoire vraie ;
  cette trajectoire passée est appelée trace (TRAILS) et disparaît à chaque changement d'échelle.
- stabilisation de l'image : « **LOG W** » ⇒ « MANUAL, ECHO REF, NAV, LOG-G, SET & DRIFT »

sea $\begin{cases} \vec{V}_V = \vec{V}_S \\ \vec{V}_V \approx \vec{V}_S \end{cases}$
LOG Water : vitesse loch sur un ou deux axes, pour estimer la trajectoire vraie des échos ;
MANUAL : entrée manuelle de la vitesse-surface en remplacement de la vitesse-loch ;

ground $\begin{cases} \vec{V}_V = \vec{V}_F \\ \vec{V}_V = \vec{V}_F \\ \vec{V}_V \approx \vec{V}_F \end{cases}$
ECHO REF : écho suivi par l'ARPA puis désigné par le chef de quart comme immobile sur le fond, en remplacement du cap gyroscopique et de la vitesse-loch ;
LOG- Ground : route et vitesse-fond fournies par le récepteur GNSS, en remplacement du cap gyroscopique et de la vitesse-loch ;
SET (direction) & DRIFT (vitesse) : courant saisi manuellement, en remplacement du cap gyroscopique et de la vitesse-loch.

- affichage des vecteurs ARPA : « **R VECTORS** » ⇒ « T VECTORS »
  Relative Vectors est la présentation idéale pour l'anti-collision ;
  True Vectors est dangereux car l'évaluation des risques de collision est moins intuitive ;
  la trace (TRAILS) en mouvement vrai RM(T) permet de voir la trajectoire vraie des échos tandis que le vecteur relatif des pistes affiche leur trajectoire relative pour l'anti-collision ;
  RM(R) affiche une trajectoire relative pour chaque écho, même ceux qui ne sont pas suivis par l'ARPA : le choix RM(R) ou RM(T) est à la diligence du chef de quart.
- longueur des vecteurs : « **10.0 MIN** » puis déplacement latéral de la souris ; validation en recliquant
  durée à adapter selon l'échelle utilisée par défaut : 10 min est un bon compromis sur 6 à 12 M pour évaluer le rapprochement rapide ou lent des pistes ;
  la limite de TCPA minimum imposée par le commandant est souvent utilisée.
- longueur de la trace : « OFF » ⇒ « SHORT » ⇒ « **LONG** » ⇒ « PERM »… ou clic droit
  choix à adapter pour ne pas surcharge l'écran : même la trace de la côte est représentée !
  Attention ! La trace est effacée par un changement d'échelle.
- affichage d'un cercle rouge : « **VRM2** »
- rayon du cercle = CPA mini : « OFF » puis déplacement latéral de la souris ; validation en recliquant
  régler le rayon à **1 M** par défaut, ou selon les ordres du commandant pour le CPA mini.
- décentrage de l'image : « **CENTRE** » puis sélection de « MAX VIEW »
  en cas d'image excentrée, si le navire vient à changer de cap, vérifier que le décentrage demeure adapté à l'évaluation de la situation : au besoin, revenir au centre ou décentrer selon le nouveau cap : à utiliser selon la préférence du chef de quart.



Lorsque la souris est sur l'image radar, elle prend une forme de croix ; la position de ce curseur est mesuré et affichée en temps réel en :

- azimut et distance par rapport au navire ;
- latitude et longitude (si le récepteur GNSS est démarré).

2. Acquisition et suivi des pistes par l'ARPA

Un ***écho*** désigne un point jaune sur l'écran du radar, correspondant à une puissance électromagnétique reçue dans l'antenne en raison de :

- la réflexion de notre émission radar sur un obstacle (navire, bouée, tourelle, ilot rocheux, côte, vague, gouttes de pluie) ;
- l'émissions d'un autre radar utilisant une fréquence égale ou proche, dont l'alternance d'émission et de réception est momentanément synchronisée avec notre radar, dont l'antenne est tournée vers notre radar et réciproquement : on parle d'interférences ;
- de bruit électromagnétique ambiant amplifié par un gain élevé, dépassant ainsi le seuil de puissance fixé par le fabricant pour la détection.

Une ***piste*** (ou cible : en anglais « target ») est un écho radar suivi par l'ARPA : elle est identifiée par un numéro et, après quelques tours d'antenne, « habillée » d'un vecteur montrant sa trajectoire vraie ou relative.
L'ARPA peut afficher les paramètres suivant pour la piste sélectionnée :

- azimut et distance depuis la passerelle de notre navire ;
- route et vitesse vraie (surface ou fond selon la stabilisation « sea » ou « ground » choisie) ;
- CPA et TCPA ;
- BCR et BCT : distance et temps du passage de la cible sur l'avant de notre étrave.

L'***acquisition manuelle d'un écho*** : le chef de quart place son curseur sur l'écho souhaité et clique à gauche.

- l'ARPA dessine une fenêtre de recherche de sa position par contraste d'un pic de puissance (tâche jaune) au-dessus du bruit de fond (puissance inférieure au seul de détection : fond bleu de l'écran radar) et ajoute un numéro d'identification ;
- après quelques tours d'antenne, l'ARPA affiche la trajectoire relative (ou vraie selon le réglage) avec un vecteur partant de l'écho ;
- si cet écho est toujours sélectionné, l'ARPA précise les valeurs numériques de ses paramètres.

Le ***suivi d'une piste*** (target tracking) continue jusqu'à sa suppression manuelle (clic droit) ou sa disparition :

- lorsque le « rapport signal sur bruit » de l'écho se dégrade durant plusieurs tours d'antenne, l'ARPA affiche la piste en rouge avec un message « LOST TARGET » et une alarme sonore ; l'ARPA continue à déplacer sa fenêtre de recherche durant quelques tours d'antenne au cas où l'écho serait de nouveau détectable ;
- si l'écho ne peut être suivi à longue distance, son suivi cesse et son numéro de piste peut être réalloué.

Des ***alarmes sont paramétrables*** sur l'ARPA pour aider le chef de quart dans la gestion des risques de collision :

- CPA et TCPA limite : si les paramètres d'une piste sont inférieures à ces ***deux critères***, l'ARPA affiche la piste et son vecteur en rouge clignotant avec un message « CPA LIMIT » et une alarme sonore. Par défaut, les valeurs choisies correspondent aux consignes de CPA et TCPA fixées par le commandant ;
- BCR et BCT limite : si les paramètres d'une piste sont inférieures à ces ***deux critères***, l'ARPA affiche la piste et son vecteur en rouge clignotant avec un message « BOW CROSSING LIMIT » et une alarme sonore. Cette alarme est moins utilisée : pour éviter qu'elle s'active, ses deux valeurs sont fixées à zéro.

Exercice en baie de Marseille

lorsque l'exercice est chargé mais pas encore démarré :

- régler le pupitre de machine sur AV2 ; attention à ne **jamais** appuyer sur les boutons « EMERGENCY STOP » ;
- vérifier que le pilote automatique est paramétré en « TRACK CONTROL » ;
- démarrer puis régler le radar BRIDGE MASTER en bande X ; **pas d'acquisition manuelle d'écho** ;
- faire un tour d'horizon visuel puis comparer les navires et la côte avec les échos observés sur le radar ;

Lorsque l'exercice est démarré :

- observer la trace des échos pour en déduire leur trajectoire relative (et le risque de collision) puis leur trajectoire vraie.

Stabilisation par rapport à la surface « SEA » $\overrightarrow{V_V} = \overrightarrow{V_S}$; ***CSE & STW***

Lorsque l'exercice est chargé mais pas encore démarré :

- régler le pupitre de machine sur AV2 ;
- démarrer puis régler le radar BRIDGE MASTER en bande X ; **pas d'acquisition manuelle d'écho** ;
- faire un tour d'horizon visuel puis identifier leur écho sur le radar ;
  - le voilier sur l'avant ;
  - le petit cargo sur l'avant tribord.

Lorsque l'exercice démarre, à 14h00 (heure du scénario) :

- mesurer le temps écoulé entre l'acquisition manuelle de ces deux échos et :
  - l'ajout du vecteur sur la piste ;
  - l'affichage des paramètres numériques dans la fenêtre ARPA : ***noter CSE et STW initiaux*** ;
  - la stabilisation des valeurs de route et vitesse : ***noter CSE et STW finaux.***
- le voilier commence une giration à 14h06 et le petit cargo à 14h08 :
  - mesurer le temps nécessaire pour voir se stabiliser les valeurs des nouvelles route & vitesse.

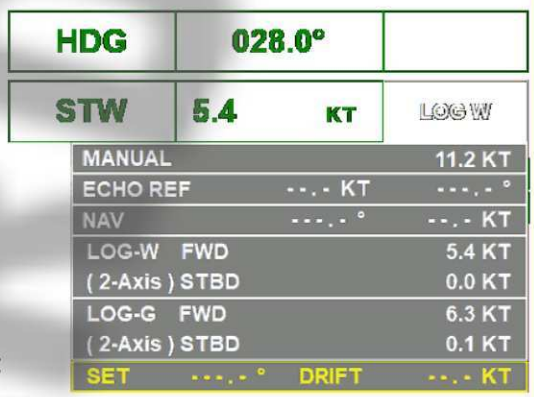
Mesure du courant

Le radar a démarré en exploitant le cap du compas gyroscopique et la vitesse-surface du loch (électromagnétique, ou DOPPLER en mode WATER TRACK) : la route et la vitesse « vraies » calculées par le radar sont correspondent au vecteur-surface.

- CSE COURSE = route surface (traduction pour l'usage du radar) sans distinction de dérive ni de cap ;
- STW SPEED THROUGH the WATER = vitesse-surface.

En suivant avec l'ARPA l'écho d'un objet fixe par rapport au fond, on obtient son vecteur surface et le courant.

$$\overrightarrow{V_{courant}} = -\overrightarrow{V_{Surface\ tourelle}} \qquad \begin{cases} R_{courant} = R_{Surface\ tourelle} \pm 180° \\ V_{courant} = V_{Surface\ tourelle} \end{cases}$$



<u>Identifier les échos des tourelles de Sourdaras et de Canoubier</u> puis en acquérir un avec l'ARPA ; en déduire le courant subi par notre navire (en faisant l'hypothèse qu'il est identique entre les tourelles et notre position).

Vitesse-surface de notre navire en manuelle : MANUAL

Au préalable, noter les routes et vitesses-surface des pistes suivantes :

piste	en LOG W CSE / STW & CPA / TCPA	en MANUAL à 12 nd CSE / STW & CPA / TCPA
Sourdaras / Canoubier piste n°		
voilier piste n°		
petit cargo piste n°		

<u>Remplacer la vitesse-loch-surface</u> LOG W par une valeur erronée ***MANUAL 12,0 nd***. Noter les nouvelles valeurs de route et vitesse-surface après une minute et trois minutes.

Ce mode MANUAL est utilisé en cas d'avarie du loch surface, suspectée ou avérée, afin de calculer des vecteurs-surface pertinents avec l'ARPA. Attention ! Si la vitesse loch / manuelle est erronée, les résultats de l'ARPA sont faussés… mais les CPA et TCPA demeurent corrects.

Stabilisation par rapport au fond « GROUND » $\overrightarrow{V_V} = \overrightarrow{V_F}$; ***COG & SOG***

Lorsque l'exercice est chargé mais pas encore démarré :

- régler le pupitre de machine sur AV2 ;
- démarrer puis régler le radar BRIDGE MASTER en bande X ;

Au démarrage de l'exercice, acquérir les échos des tourelles, du voilier, du petit cargo et des autres navires : noter dans la seconde colonne du tableau leur route et vitesse-surface

piste	**en LOG W** **CSE / STW & CPA / TCPA**	**en SET & DRIFT** **COG / SOG & CPA / TCPA**
Sourdaras / Canoubier piste n°		
voilier piste n°		
petit cargo piste n°		

En cliquant sur LOG W, paramétrer le courant mesuré auparavant :

- ***SET*** route du courant = direction où se dirige le courant ;
- ***DRIFT*** vitesse du courant.

Les paramètres des cibles changent alors CSE & STW en COG & SOG (course & speed over ground).
Noter ces valeurs dans la dernière colonne du tableau ci-dessus : si le courant paramétré est correct, la vitesse-fond des échos des tourelles doit être (presque) nul.

La dérive due au vent n'est pas mesurée ni corrigée par l'ARPA. Lorsque le compas gyroscopique est exploité pour calculer les vecteurs vrais des pistes, l'écart entre cap gyroscopique et route-surface peut entraîner une erreur de quelques degrés…

En cliquant sur LOG W, sélectionner ***LOG G*** (loch DOPPLER deux axes en mode BOTTOM TRACK) et remplir la seconde colonne du tableau ci-dessous avec les routes et vitesses-fond.

piste	**en LOG G** **COG / SOG**	**en NAV** **COG / SOG**	**en ECHO REF** **COG / SOG**
Sourdaras / Canoubier piste n°			
voilier piste n°			
petit cargo piste n°			

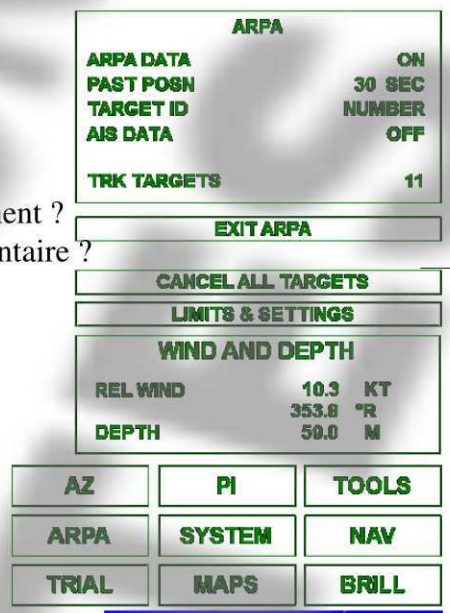
Sélectionner ensuite ***NAV*** (route et vitesse-fond de notre navire fournis à l'ARPA par un système de navigation par satellites GNSS) et remplir la troisième colonne du tableau ci-dessus avec leur route et vitesse fond.

Sélectionner enfin ***ECHO REF***, déplacer le curseur sur l'écho d'une tourelle Sourdaras / Canoubier et cliquer : l'ARPA calcule la route et la vitesse-fond de notre navire et des pistes par rapport à l'écho de la piste choisie. Celle-ci est désormais repérée par la lettre R.
Remplir la dernière colonne du tableau ci-dessus avec les routes et vitesses-fond. Comparer les résultats.

Exercice en baie de Marseille

lorsque l'exercice est chargé mais pas encore démarré :

- régler le pupitre de machine sur AV2 ;
- démarrer puis régler le radar BRIDGE MASTER en bande X ;
- acquérir le maximum d'échos possible :
  - combien de pistes ce modèle de radar peut-il suivre simultanément ?
  - quel message apparaît lors de l'acquisition d'un écho supplémentaire ?



Dans le menu ARPA, lire le nombre de pistes en cours de suivi :
TRK TARGETS.

Supprimer toutes les pistes suivies par l'ARPA :
CANCEL ALL TARGETS
Les informations des cibles sont perdues mais l'ARPA reste en fonction et conserve ses réglages (LOG W, échelle de temps des vecteurs, etc).

Acquisition automatique des échos

Au démarrage de l'exercice, aucun écho n'est désigné manuellement à l'ARPA.
Dans le menu AZ = ACQUISITION ZONE,

- activer la zone de garde 1 et éditer ses limites :
  - en azimut de HEADING – 50° à + 50° (environ) ;
  - en distance de 2 à 3 M (environ) ;
- observer l'alarme pour les échos présents ou entrants dans la zone ;
- activer la zone 2 sans la modifier :
  - comment sont traités les échos de la côte dans la zone de garde ?
  - après cinq minutes d'exercice, combien de pistes suit l'ARPA ?
- quitter le menu AZ pour aller au menu ARPA et supprimer toutes les pistes :
  - qu'advient-il des zones de garde ?
    Elles sont effacées de l'écran mais leurs limites sont mémorisées.

Trace des échos TRAILS (R/T) et historique des pistes PAST POSITIONS (R)

Acquérir manuellement les échos « à surveiller » :

- ceux qui ont une vitesse-surface : T TRAILS réglé sur LONG permet d'estimer leur vecteur vitesse après une durée variable selon l'échelle choisie (90 secondes sur 1,5 et 3 M, 3 minutes au-delà, etc) ;
- ceux qui ne correspondent pas à la côte ni au balisage.

Dans le menu ARPA, afficher l'historique des positions enregistrées par l'ARPA : PAST POSITIONS
et régler le délai entre chacun des quatre points blancs ajoutés par l'ARPA sur 30 secondes.
L'historique est dessiné :

- dans le « sillage » de la trajectoire relative de chaque piste (pas d'historique en mouvement vrai) ;
- même après un changement d'échelle (contrairement à la trace qui recommence à zéro).

Suppression des données ARPA sur l'écran radar

Lorsque le radar est surchargé par les « habillages de pistes » (vecteur, historique, numéro de piste), voire les zones de garde et autres outils activés, le chef de quart peut supprimer l'affichage des données ARPA :

- méthode 1 : dans le menu ARPA, régler ARPA DATA sur OFF ; sur ON pour ré-activer ;
- méthode 2 : clic droit sur le bouton ARPA en bas à droite de l'écran du radar ; idem pour ré-activer ;
- les alarmes de l'ARPA demeurent actives même si aucune piste n'est dessinée sur les échos concernés.

- AIS DATA toujours sur OFF -

Le chef de quart évalue les risques de collision avec son propre radar : il acquiert les échos selon ses critères. L'aide supplémentaire apportée par l'AIS est corrélée avec les données ARPA sur l'ECDIS.

Affichage des paramètres de plusieurs pistes

Par défaut, l'ARPA affiche la dernière piste acquise ou sélectionnée en cliquant avec le curseur sur sa position. Il est possible d'afficher plusieurs pistes simultanément en les classant :

- par CPA croissants ;
- par distances (à notre navire) croissantes ;
- par sélection manuelle des pistes à l'aide du curseur sur l'écran radar.

TARGET	(6)	
RANGE	3.7	NM
T BRG	306.7	°
CPA	0.0	NM
TCPA	18.5	MIN
CSE	157.9	°
STW	2.8	KT
BCR	-0.3	NM
BCT	20.0	MIN

TARGET	(CPA)	
ID	TCPA MIN	CPA NM
3	-- . -	-- . -
13	32.4	0.1
4	21.1	0.1
1	6.0	0.2
14	20.9	0.2
7	8.5	0.3

SINGLE TARGET
MULTI TARGET BY CPA
MULTI TARGET BY RANGE
MULTI TARGET (USER)

La liste exhaustive des pistes suivies par l'ARPA et de tous leurs paramètres peut aussi être visualisée sur l'ECDIS.

Paramétrage des alarmes de l'ARPA

Dans le menu ARPA, le sous-menu LIMITS AND SETTINGS permet de paramétrer les critères de déclenchement d'alarme concernant les pistes suivies :

- CPA < 1 M ***et*** TCPA < 10 minutes (par exemple) ;
- BCR < 0 M ***et*** BCT < 0 minutes (pour qu'il ne sonne jamais).

LIMITS & SETTINGS	
AUTODROP	OFF
VECTOR TIMEOUT	OFF
NMEA TARGETS	ALL
CPA LIMIT	1.0 NM
TCPA LIMIT	10.0 MIN
BCR LIMIT	0.0 NM
BCT LIMIT	0.0 MIN

EXIT LIMITS & SETTINGS

Les trois alarmes suivantes ne sont jamais utilisées car peu utiles et probablement mal simulées...

En mode ***AUTODROP***, une cible est supprimée sans aucune alarme si elle répond à tous les critères suivants :

- la cible n'est pas dans une zone de garde ;
- elle n'est pas désignée comme écho de référence ;
- aucune alarme CPA / TCPA ou Bow Crossing n'est active sur cette cible ;
- son TCPA est supérieur à 3 minutes ;
- la cible est sur l'arrière de notre navire ;
- sa distance est supérieure à 10 km de notre navire.

Laisser ce réglage sur OFF pour être averti des échos perdus. Par ailleurs, même si AUTODROP est inactif, une piste sera automatiquement supprimée sans alarme si :

- sa distance est supérieure à 40 km de notre navire ;
- ou elle n'est pas détectée durant 60 balayages successifs ;
- ou le radar est mis en veille : STAND BY.

En mode ***VECTOR TIMEOUT,*** l'ARPA force le réglage des vecteurs relatifs / vrais après 30 secondes d'une combinaison avec l'image en mouvement relatif / vrai qui risquerait de cacher les dangers de collision.
Laisser ce réglage sur OFF et garder exclusivement les vecteurs en mouvement relatif. Par ailleurs, ces combinaisons dangereuses sont signalées par un affichage en rouge de T VECTOR.

En mode ***NMEA TARGETS***, la liste des pistes suivies par l'ARPA est limitée à six (MULTI TARGET) ou exhaustive (ALL). Réglage laissé au choix du chef de quart.

RÔLE DU CHEF DE QUART :

Le risque d'anti-collision doit être évalué sur ***l'image radar qu'il a lui-même réglée***,
à l'aide des vecteurs dessinés et des alarmes déclenchées selon ***les paramétrages ARPA qu'il a choisis***.

Décentrage de notre position

En complément de la fonction CENTRE / MAX VIEW en bas à droite de l'écran, le chef de quart peut décentrer la position de son navire sur l'écran du radar à l'aide du curseur : cliquer sur notre position puis glisser et déposer à l'endroit souhaité.

Attention ! En cas de changement de route, adapter la position du navire sur l'écran à la nouvelle route afin de voir toujours loin sur l'avant.

Pour la sécurité de la navigation, le navire ne peut pas être décentré entre 75 % et 100 % du rayon de l'écran.

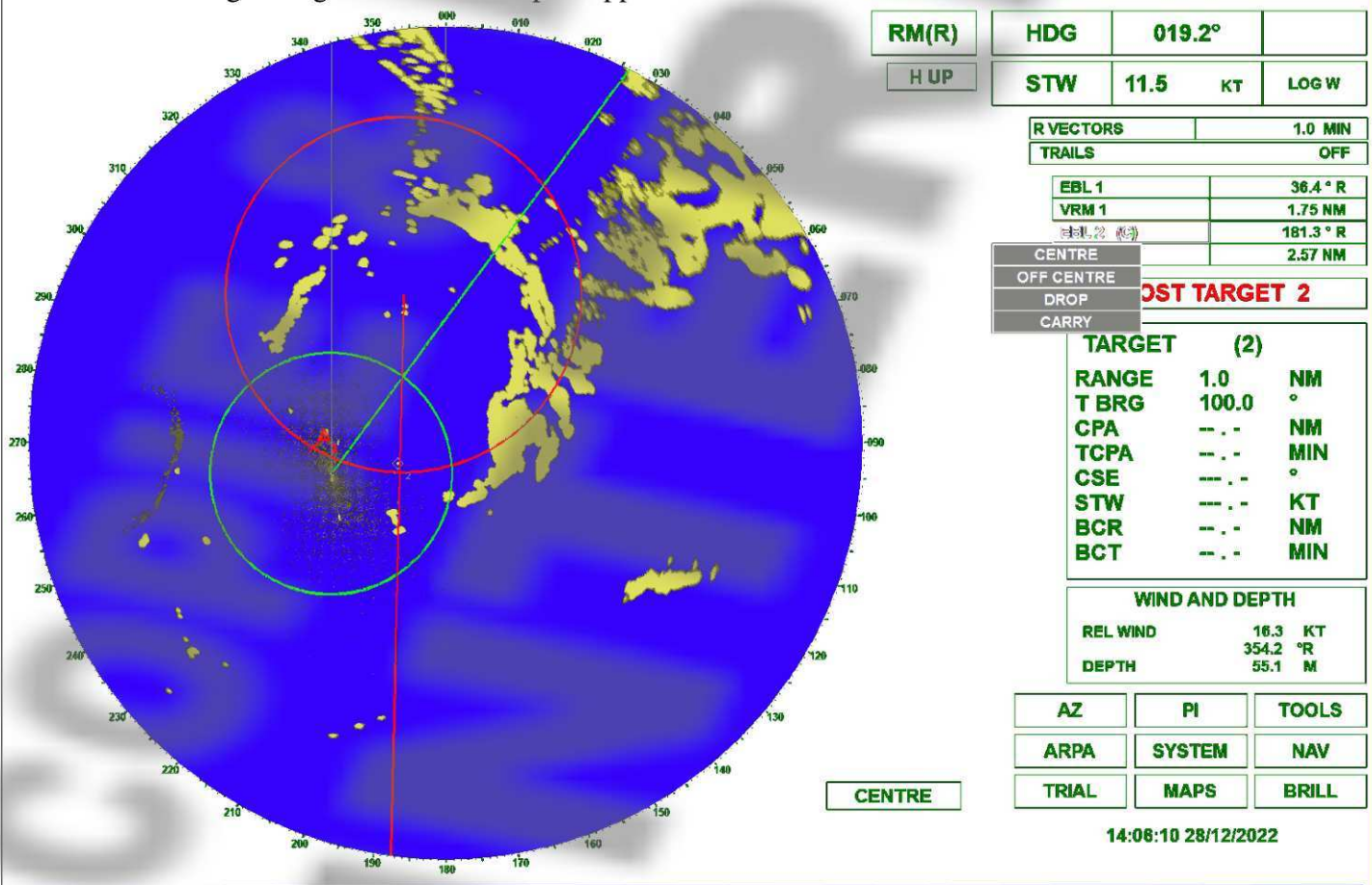
Mesures d'azimut et de distance d'un écho

Plusieurs moyens sont disponibles :

- si l'écho est suivi par l'ARPA et que sa piste est sélectionnée, ces paramètres sont affichés à droite ;
- en déplaçant le curseur sur l'écho, le chef de quart peut lire ces paramètres ainsi que la latitude et la longitude du curseur ;
- en activant EBL1 et VRM1 (ou le tandem EBL2 et VRM2, aussi noté ERBL2) : l'intersection de la ligne d'azimut et du cercle de distance est marquée par un petit disque que l'on peut modifier avec le curseur. En cliquant dessus et en le glissant jusqu'à l'écho, on lit l'azimut de l'EBL et la distance du VRM.

L'origine de l'ERBL2 peut être déplacée sur l'écran radar :

- approcher le curseur des cases EBL2 et VRM2 et cliquer à droite pour afficher le menu déroulant ;
- CENTRE rapporte l'origine de l'ERBL2 sur notre navire s'il avait été décalé ;
- après un clic sur OFF CENTRE, le curseur est placé sur notre navire : déplacer le curseur sur l'écho ou à la nouvelle origine souhaitée et cliquer à gauche pour valider ;
- le petit disque de l'intersection entre ligne d'azimut et cercle de distance peut être alors déplacée pour mesurer une position par rapport à cette nouvelle origine ;
- DROP laisse dériver l'origine de l'ERBL2 à la surface selon la route et la vitesse du navire choisies pour la stabilisation du radar : l'ERBL2 se déplace sur l'écran ;
- CARRY fige l'origine de l'ERBL2 par rapport au navire : ils avancent avec les mêmes route et vitesse.



Simulation de manœuvre : TRIAL

Pour aider à l'anti-collision, l'ARPA permet de simuler la trajectoire relative des pistes selon la manœuvre envisagée. Au préalable, le chef de quart doit préparer les outils graphiques :

- VRM à la distance du CPA minimum à respecter :
- vecteurs en mouvement relatif ;
- échelle de temps des vecteurs sur deux à trois fois la durée du TCPA minimum ;
- échelle de distance et décentrage adaptés pour visualiser les pistes à éviter.

Lorsque le menu TRIAL est actif :

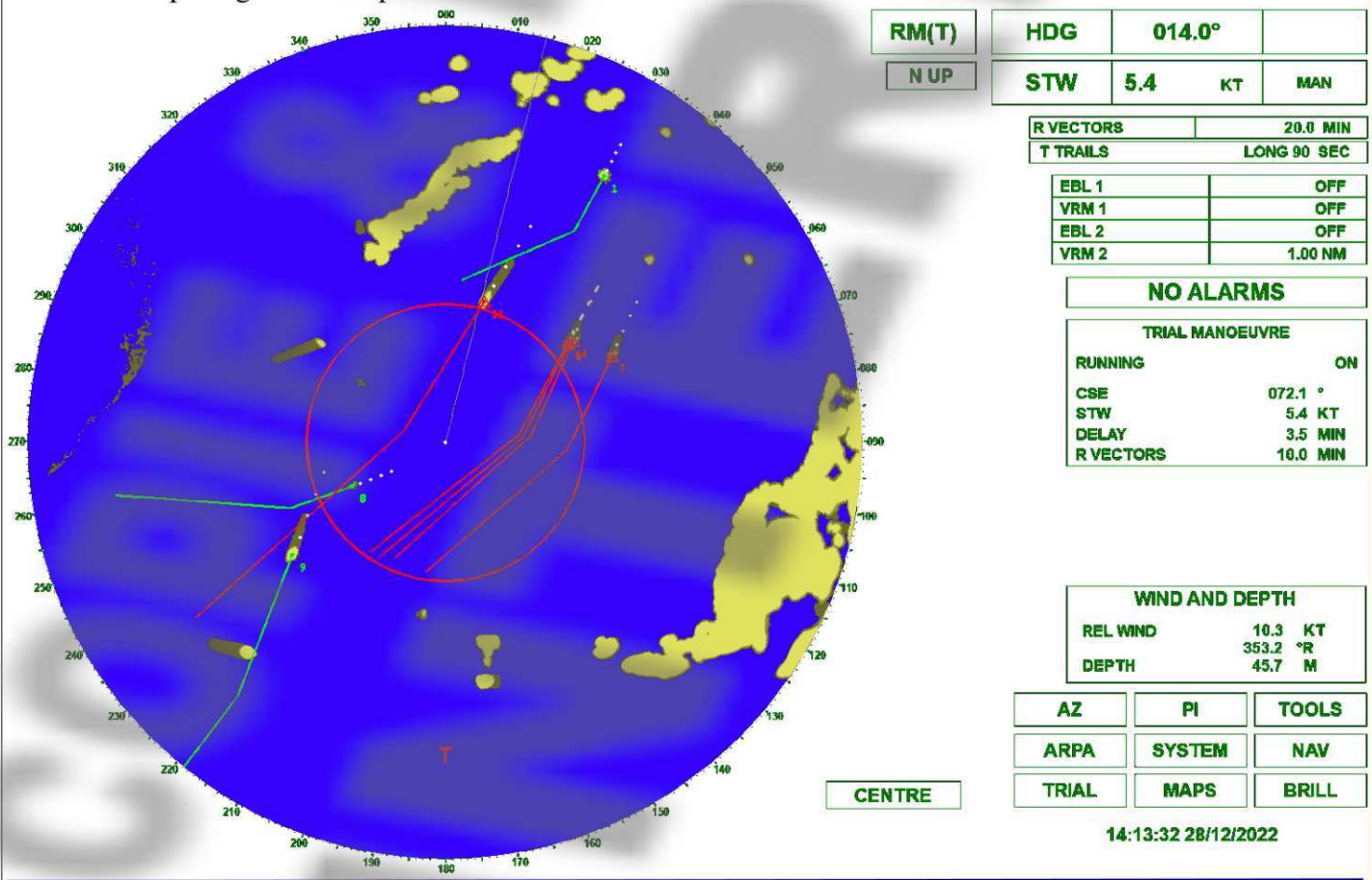
- RUNNING……..ON est affiché dans la fenêtre du menu TRIAL ;
- la lettre majuscule **T** clignote en bac de l'écran radar ;
- les vecteurs relatifs des pistes représentent leur trajectoire relative :
  - entre l'instant présent et la fin du DELAY selon la route et la vitesse ***actuelles*** du navire, puis
  - entre la fin du DELAY et l'échelle de temps des R VECTOR selon la route et la vitesse ***simulées*** ;
- la couleur des vecteurs relatifs dépend des paramètres choisis pour les alarmes de CPA, TCPA et BOW CROSSING et des trajectoires relatives des pistes selon la route et la vitesse ***actuelles*** du navire afin d'alerter sur le danger présent même si une manœuvre simulée semble satisfaisante ;
- le DELAY est un compte à rebours : lorsqu'il arrive à zéro, le mode TRIAL s'arrête et le **T** disparaît.

Une manœuvre simulée est jugée satisfaisante lorsqu'aucune trajectoire relative des pistes ne pénètre dans le cercle du VRM = CPA minimum : l'appréciation appartient exclusivement au chef de quart.

Attention ! Le radar BRIDGE MASTER ne prend pas en compte ***le cercle de giration*** du navire. Lorsqu'une manœuvre simulée a été validée, le chef de quart doit alors :

- estimer la durée Δt de la manœuvre selon l'abattée, l'angle de barre prévu, la vitesse actuelle et la vitesse finale (si elle est modifiée par la simulation) ;
- démarrer la manœuvre lorsque le compte à rebours du DELAY atteint $\frac{1}{2}\cdot\Delta t$.

La manœuvre finira ainsi $\frac{1}{2}\cdot\Delta t$ après la fin du compte à rebours (DELAY = 0) et respectera la distance minimum de passage illustrée par le VRM.



Les index parallèles : PARALLEL INDEX (PI)

L'ARPA permet de dessiner quatre lignes droites de couleur blanche sur l'écran du radar en ajustant :

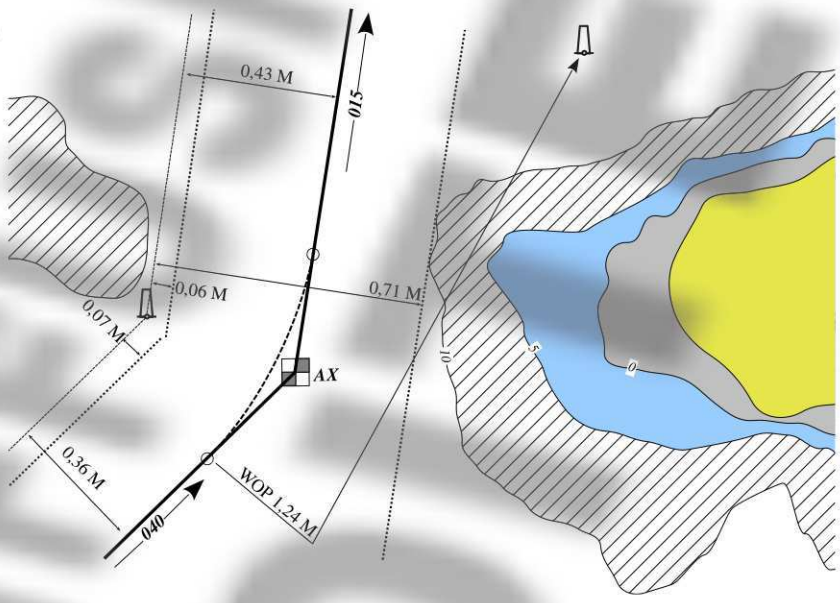
- leur distance (perpendiculaire) avec le navire ;
- leur azimut, affiché simultanément avec l'azimut opposé ±180°.

Ces paramètres peuvent être modifiés : en changeant leur valeur numérique à droite de l'écran, ou sur l'écran :

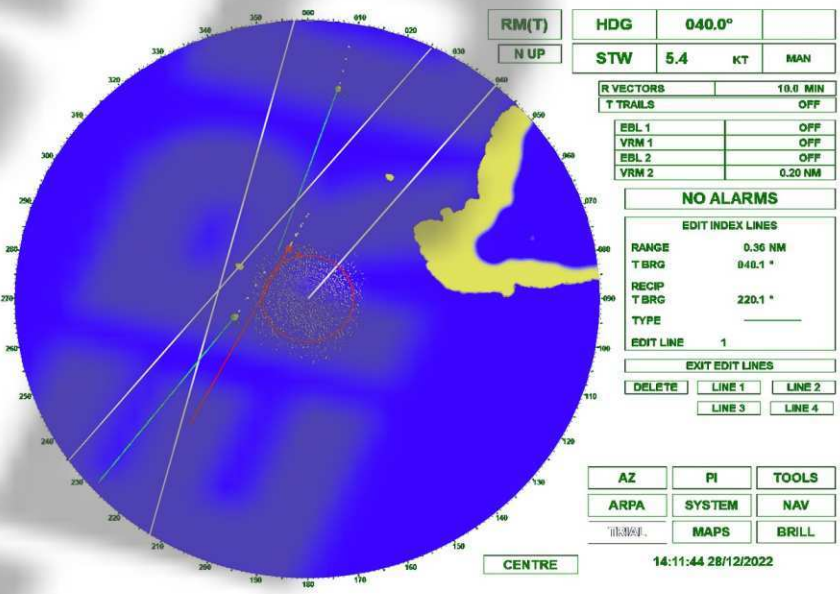
- cliquer sur le petit cercle blanc du PI et déplacer sa position pour modifier la distance ;
- cliquer sur le PI ailleurs que sur son petit cercle blanc pour modifier l'azimut.

Navigation sur PI : pour une route-fond R_F = 040° tracée sur la carte et laissant à bâbord un amer radar (tourelle isolée sur l'eau, pointe rocheuse facile à identifier, etc) à 0,36 M, on peut afficher un PI orienté au 040° (ou 220°) à une distance de 0,36 M sur notre bâbord (soit au Nord-Ouest) :

- si l'écho de l'amer est superposé avec le PI nous sommes sur la route-fond ;
- si l'écho de l'amer est entre nous et le PI nous sommes à gauche de la route ;
- si l'écho de l'amer est au-delà du PI nous sommes à droite de la route.



Point tournant avec PI : si l'on affiche un autre PI associé à un amer radar pour notre prochaine route-fond, on peut observer son écho se rapprocher de ce dernier PI à mesure que notre navire approche du point tournant. Lorsque le même amer peut servir au PI sur l'ancienne et sur la nouvelle route-fond, cette observation est encore plus aisée.

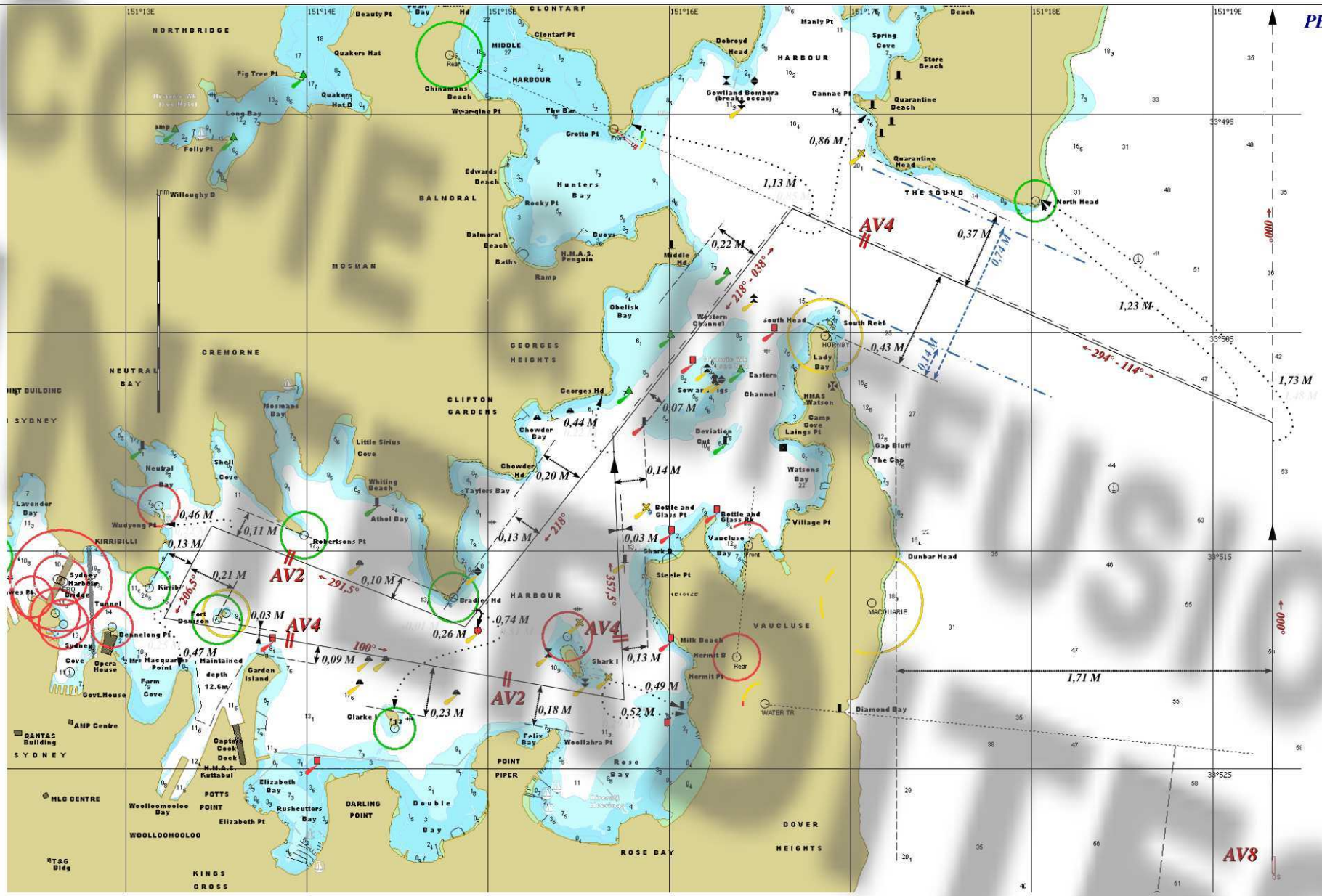


Marge de sécurité avec PI : lors d'une navigation en eaux resserrées, les eaux saines (zone navigable sans risque d'échouement) sont balisées par des relèvements de garde sur des amers visuels ou par des lignes droites parallèles à la route-fond. Ces dernières ne sont pas visibles dans le paysage mais peuvent être matérialisées sur le radar à l'aide de PI dont les distances sont mesurées sur la carte.

<u>Exercice d'arrivée à Sydney</u>

lorsque l'exercice est chargé mais pas encore démarré :

- régler le pupitre de machine sur AV8, le pilote automatique sur HEADING, girations en manuel ;
- démarrer puis régler le radar BRIDGE MASTER en bande X ;
- acquérir le maximum d'échos de navire au fil de l'exercice ;
- respecter avec les autres navires : CPA > 0,5 M et TCPA > 10 min sauf en chenalage ;
- afficher un PI pour la route actuelle et un autre pour la route suivante (point tournant) ;
- réduire la vitesse après la première giration : machine AV4, puis AV2 pour le chenalage ;
- dans le goulet « the Sound », afficher deux PI supplémentaires pour marquer les eaux saines.



distances des débuts de giration pour 30° d'angle de barre