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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.
