RESOLUTION A.422(XI)

Adopted on 15 November 1979
Agenda item 10(b)

PERFORMANCE STANDARDS FOR AUTOMATIC RADAR PLOTTING AIDS (ARPA)

THE ASSEMBLY,

RECALLING Article 16(i) of the Convention on the Inter-Governmental Maritime Consultative Organization concerning the functions of the Assembly,

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,

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

NOTING resolution 13 of the International Conference on Tanker Safety and Pollution Prevention, 1978, concerning carriage of automatic radar plotting aids,

HAVING CONSIDERED the recommendation made by the Maritime Safety Committee at its forty-first session,

1. ADOPTS the recommendation on performance standards for automatic radar plotting aids, set out in the Annex to the present resolution;

2. RECOMMENDS Governments:

(a) To ensure that automatic radar plotting aids required to be carried conform to performance standards not inferior to those specified in the Annex to the present resolution;

(b) To ensure that adequate training will be 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.

ANNEX

PERFORMANCE STANDARDS FOR AUTOMATIC RADAR PLOTTING AIDS (ARPA)

1 INTRODUCTION

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

.1 reduce the work-load of observers by enabling them to automatically obtain information so that they can perform as well with multiple targets as they can by manually plotting a single target;

.2 provide continuous, accurate and rapid situation evaluation.

1.2 In addition to the general requirements for electronic navigational aids (resolution A.281(VIII)), the ARPA should comply with the following minimum performance standards.

2. DEFINITIONS

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

3 PERFORMANCE STANDARDS

3.1 Detection

3.1.1 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. 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 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 to automatically track, process, simultaneously display and continuously update the information on at least:

.1 20 targets, if automatic acquisition is provided, whether automatically or manually acquired;

.2 10 targets, if only manual acquisition is provided.

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

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 at least four equally time-spaced past positions of any targets being tracked over a period of at least eight minutes.

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 adopted by IMCO.

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 adopted by IMCO should not affect the integrity of the basic radar presentation.

3.4.3 The display on which ARPA information is presented should have an effective diameter of at least 340 mm.

3.4.4 The ARPA facilities should be available on at least the following range scales:

.1 12 or 16 miles;

.2 3 or 4 miles.

3.4.5 There should be a positive indication of the range scale in use.

3.4.6 The ARPA should be capable of operating with a relative motion display with "north-up" and either "head-up" or "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 his display either true or relative motion. There should be a positive indication of the display mode and orientation in use.

3.4.7 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. In this regard:

.1 ARPA presenting predicted information in vector form only should have the option of both true and relative vectors;

.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 either be time-adjustable or have a fixed time-scale;

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

3.4.8 The ARPA information should not obscure radar information in such a manner as to degrade the process of detecting 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.

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

3.4.10 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 observers' ability to maintain a proper lookout. Facilities to adjust the brightness should be provided.

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

3.4.12 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 one minute an indication of the target's motion trend and display within three minutes the target's predicted motion in accordance with paragraphs 3.4.7, 3.6, 3.8.2 and 3.8.3.

3.4.13 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 four scans.

3.5 Operational warnings

3.5.1 The ARPA should have the capability to warn the observer with a visual and/or 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 on the display.

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

3.5.4 It should be possible to activate or de-activate the operational warnings.

3.6 Data requirements

3.6.1 At the request of the observer the following information should be immediately available from the ARPA in alphanumeric form in regard to any tracked target:

.1 present range to 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 target;

.6 calculated true speed of target.

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 without interrupting the updating of target information. The simulation should be initiated by the depression either of a spring-loaded switch, or of a function key, with a positive identification on the display.

3.8 Accuracy

3.8.1 The ARPA should provide accuracies not less than those given in paragraphs 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 plus and minus ten 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 per cent 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

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 per cent probability values).

Data / Scenario	Relative course (degrees)	Relative speed (knots)	CPA (nautical miles)	TCPA (mins)	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 one minute an indication of the target's motion trend, and display within three minutes the target's predicted motion, in accordance with paragraphs 3.4.7, 3.6, 3.8.2 and 3.8.3.

3.8.5 The ARPA should be designed in such a manner that under the most favourable conditions of own ship 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 Connexions with other equipment

3.9.1 The ARPA should not degrade the performance of any equipment providing sensor inputs. The connexion of the ARPA to any other equipment should not degrade the performance of that equipment.

3.10 Performance tests and warnings

3.10.1 The ARPA should provide suitable warnings of ARPA malfunction 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.

3.11 Equipment used with ARPA

3.11.1 Log and speed indicators providing inputs to ARPA equipment should be capable of providing the ship's speed through the water.

APPENDIX 1

DEFINITIONS OF TERMS TO BE USED ONLY
IN CONNEXION WITH ARPA PERFORMANCE STANDARDS

Relative course	– The direction of motion of a target related to own ship as deduced from a number of measurements of its range and bearing on the radar, expressed as an angular distance from north.
Relative speed	– The speed of a target related to own ship, as deduced from a number of measurements of its range and bearing on the radar.
True course	– The apparent heading of a target obtained by the vectorial combination of the target's relative motion and own ship's motion*, expressed as an angular distance from north.
True speed	– The speed of a target obtained by the vectorial combination of its relative motion and own ship's motion*.
Bearing	– The direction of one terrestrial point from another, expressed as an angular distance from north.
Relative motion display	– The position of own ship on such a display remains fixed.
True motion display	– The position of own ship on such a display moves in accordance with its own motion.
Azimuth stabilization	– Own ship's compass information is fed to the display so that echoes of targets on the display will not be caused to smear by changes of own ship's heading.
– north-up	– The line connecting the centre with the top of the display is north.
– head-up	– The line connecting the centre with the top of the display is own ship's heading.
– course-up	– An intended course can be set to the line connecting the centre with the top of the display.
Heading	– The direction in which the bows of a vessel are pointing, expressed as an angular distance from north.
Target's predicted motion	– The indication on the display of a linear extrapolation into the future of a target's motion, based on measurements of the target's range and bearing on the radar in the recent past.
Target's motion trend	– An early indication of the target's predicted motion.
Radar plotting	– The whole process of target detection, tracking, calculation of parameters and display of information.

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

Detection	— The recognition of the presence of a target.
Acquisition	— The selection of those targets requiring a tracking procedure and the initiation of their tracking.
Tracking	— The process of observing the sequential changes in the position of a target, to establish its motion.
Display	— The plan position presentation of ARPA data with radar data.
Manual	— Relating to an activity which a radar observer performs, possibly with assistance from a machine.
Automatic	— Relating to an activity which is performed wholly by a machine.

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 paragraph 3.8 are based upon the following sensor errors and are appropriate to equipment complying with IMCO's 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 metres (normal distribution)
Across beam of target σ = 1 metre (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 metres.

Antenna backlash — assumed rectangular distribution giving bearing error ±0.5° maximum.

Quantization
Bearing — rectangular distribution ± 0.01° 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 σ = 0.12°.

Log
Calibration error 0.5 knots
Normal distribution about this, 3 σ = 0.2 knots.