BS EN 62388:2013

BSI Standards Publication

Maritime navigation and radiocommunication equipment and systems — Shipborne radar — Performance requirements, methods of testing and required test results

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National foreword

This British Standard is the UK implementation of EN 62388:2013. It is identical to IEC 62388:2013, incorporating corrigendum February 2014. It supersedes BS EN 62388:2008, which will be withdrawn on 31 July 2016.

IEC corrigendum February 2014 corrects elements of subclause 16.1.7.2 and Table H.1.

The UK participation in its preparation was entrusted to Technical Committee EPL/80, Maritime navigation and radiocommunication equipment and systems.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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Compliance with a British Standard cannot confer immunity from legal obligations.

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Maritime navigation and radiocommunication equipment and systems - Shipborne radar - Performance requirements, methods of testing and required test results

(IEC 62388:2013)

Matériels et systèmes de navigation et de radiocommunication maritimes - Radars de bord - Exigences de performance, méthodes d'essai et résultats exigés (CEI 62388:2013)

Navigations- und Funkkommunikationsgeräte und -systeme für die Seeschifffahrt - Radar für Schiffe - Leistungsanforderungen, Prüfverfahren und geforderte Prüfergebnisse (IEC 62388:2013)

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CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

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Foreword

The text of document 80/696/FDIS, future edition 2 of IEC 62388, prepared by IEC TC 80 “Maritime navigation and radiocommunication equipment and systems” was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 62388:2013.

The following dates are fixed:

– latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2014-04-30
– latest date by which the national standards conflicting with the document have to be withdrawn	(dow)	2016-07-31

This document supersedes EN 62388:2008.

EN 62388:2013 includes the following significant technical changes with respect to EN 62388:2008:

— In 6.2 (Transmission and interference) reference is now made to a revised Annex B (Unwanted emissions) where the mask has been tightened from 20 dB/decade to 30 dB/decade in line with ITU requirements and a new informative Annex J has been added concerning interference from emissions in adjacent frequency bands;

— Clause 7 (Display presentation) has been simplified (and the previous Annexes J and K deleted) with reference made instead to EN 62288 with associated changes throughout the standard;

— In 9.9.2 (PI lines and positioning) the requirements for parallel index lines have been revised;

— In 10.4.4 (Display orientation) a new mode of display orientation “head-up stabilised” has been added;

— In 11.5 (Automatic Identification System) new requirements and tests have been added for types of AIS targets, AIS repeater stations and filtering of AIS targets;

— In Clause 12 (Chart radar) a new subclause 12.3 has been added for ECDIS backup requirements;

— In Clause 13 (Ergonomic criteria) a new subclause 13.5 has been added giving requirements for default control settings;

— 14.3 (Output interfacing) has been revised together with the associated Annex H to update the requirements particularly with regard to interfaces to the VDR;

— Clause 16 (Alerts and failures) has been revised to update the requirements to align with bridge alert management and new requirements added for an alert management interface with associated changes throughout the standard;

— In Clause 18 (Equipment familiarisation and documentation) a new subclause 18.3 has been added for maintenance information and equipment update.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC [and/or CEN] shall not be held responsible for identifying any or all such patent rights.

Endorsement notice

The text of the International Standard IEC 62388:2013 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

IEC 62616	NOTE	Harmonised as EN 62616.
ISO 9000	NOTE	Harmonised as EN ISO 9000.
ISO 9241-8	NOTE	Harmonised as EN ISO 9241-8.
ISO 9241-12	NOTE	Harmonised as EN ISO 9241-12.

Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

NOTE When an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

Publication	Year	Title	EN/HD	Year
IEC 60945	-	Maritime navigation and radiocommunication equipment and systems - General requirements - Methods of testing and required test results	EN 60945	-
IEC 61162	series	Maritime navigation and radiocommunication equipment and systems - Digital interfaces	EN 61162	series
IEC 61174	-	Maritime navigation and radiocommunication equipment and systems - Electronic chart display and information system (ECDIS) - Operational and performance requirements, methods of testing and required test results	EN 61174	-
IEC 61924-2	2012	Maritime navigation and radiocommunication equipment and systems - Integrated navigation systems - Part 2: Modular structure for INS - Operational and performance requirements, methods of testing and required test results	EN 61924-2	2013
IEC 61996-1	2013	Maritime navigation and radiocommunication equipment and systems - Shipborne voyage data recorder (VDR) - Part 1: Performance requirements, methods of testing and required test results	EN 61996-1	2013
IEC 62288	-	Maritime navigation and radiocommunication equipment and systems - Presentation of navigation-related information on shipborne navigational displays - General requirements, methods of testing and required test results	EN 62288	-
ITU-R Recommendation M.628	-	Technical characteristics for search and rescue radar transponders	-	-
ITU-R Recommendation M.824	-	Technical parameters of radar beacons (racons)	-	-

Publication	Year	Title	EN/HD	Year
ITU-R Recommendation M.1176	-	Technical parameters of radar target enhancers	-	-
IHO S-52	-	Specifications for chart content and display aspects of ECDIS	-	-
IHO S-52, Appendix 2, Annex A	-	IHO ECDIS Presentation Library	-	-
IMO Resolution A.424(IX)	-	Performance standards for gyro-compasses	-	-
IMO Resolution A.694(17)	-	General requirements for shipborne radio equipment forming part of the global maritime distress and safety system (GMDSS) and for electronic navigational aids	-	-
IMO Resolution A.821(19)	-	Performance standards for gyro-compasses for high-speed craft	-	-
IMO Resolution MSC.96(72)	-	Amendments to performance standards for devices to indicate speed and distance (resolution A.824(19))	-	-
IMO Resolution MSC.116(73)	-	Performance standards for marine transmitting heading devices (THDs)	-	-
IMO Resolution MSC.191(79)	-	Performance standards for the presentation of navigation-related information on shipborne navigational displays	-	-
IMO Resolution MSC.192(79)	-	Adoption of the revised performance standards for radar equipment	-	-
IMO Resolution MSC.232(82)	-	Revised performance standards for electronic chart display and information systems (ECDIS)	-	-
IMO Resolution MSC.302(87)	-	Adoption of performance standards for Bridge Alert Management	-	-
IMO MSC.1/Circ.1389	-	Guidance on procedures for updating shipborne navigation and communication equipment	-	-
VESA-2007-5	2007	Industry Standards and Guidelines for Computer Display Monitor Timing (DMT) Standard	-	-
DDWG DVI	1999	Digital Visual Interface (DVI) Revision 1.0, Digital Display Working Group (DDWG)	-	-

CONTENTS

MARITIME NAVIGATION AND RADIOCOMMUNICATION EQUIPMENT AND SYSTEMS –

Shipborne radar – Performance requirements, methods of testing and required test results

1 Scope

This International Standard specifies the minimum operational and performance requirements, methods of testing and required test results conforming to performance standards not inferior to those adopted by the IMO in Resolution MSC.192(79).

(MSC.192/2) The radar installation, in addition to meeting the general requirements as set out in resolution A.694(17) and the related standard IEC 60945*, should comply with the performance standards of* MSC.192(79). When a requirement of this standard is different from IEC 60945, the requirement in this standard takes precedence.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60945, *Maritime navigation and radiocommunication equipment and systems – General requirements – Methods of testing and required test results*

IEC 61162 (all parts), *Maritime navigation and radiocommunication equipment and systems – Digital interfaces*

IEC 61174, *Maritime navigation and radiocommunication equipment and systems – Electronic chart display and information systems (ECDIS) – Operational and performance requirements, methods of testing and required test results*

IEC 61924-2:2012, *Maritime navigation and radiocommunication equipment and systems – Part 2 Modular Structure for INS - Operational and performance requirements, methods of testing and required test results*

IEC 61996-1:2012, *Maritime navigation and radiocommunication equipment and systems – Shipborne voyage data recorder (VDR) – Part 1: Voyage data recorder (VDR) - Performance requirements – Methods of testing and required test results*

IEC 62288, *Maritime navigation and radiocommunication equipment and systems – Presentation of navigation-related information on shipborne navigational displays – General requirements, methods of testing and required results*

ITU-R Recommendation M.628, *Technical characteristics for search and rescue radar transponders*

ITU-R Recomendation M.824, *Technical parameters of radar beacons (racons)*

ITU-R Recommendation M.1176, *Technical parameters of radar target enhancers*

IHO S-52, *Specifications for chart content and display aspects of ECDIS*

IHO S-52 Annex A, *IHO ECDIS Presentation Library*

IMO Resolution A.424(XI), *Performance standards for Gyro-compasses*

IMO Resolution A.694(17), *General requirements for shipborne radio equipment forming part of the global maritime distress and safety system (GMDSS) and for electronic navigational aids*

IMO Resolution A.821(19), *Performance standards for Gyro-compasses for High-Speed Craft*

IMO Resolution MSC.96(72), *Amendments to IMO Resolution A.824(19), Performance standards for devices to indicate speed and distance*

IMO Resolution MSC.116(73), *Performance standards for marine transmitting heading devices (THDs)*

IMO Resolution MSC.191(79), *Performance standards for the presentation of navigation-related information on shipborne navigational displays*

IMO Resolution MSC.192(79), *Revised performance standards for radar equipment*

IMO Resolution MSC.232(82), *Revised performance standards for electronic chart display and information systems (ECDIS)*

IMO Resolution MSC.302(87)*, Performance standards for bridge alert management*

IMO MSC.1/Circ.1389, *Guidance on procedures for updating shipborne navigation and communication equipment*

VESA-2007-5:2007, *Industry standards and guidelines for computer display monitor timing (DMT)*

DDWG DVI:1999, *Digital Visual Interface (DVI) Revision 1.0, Digital Display Working Group (DDWG)*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
activated AIS target
target representing the automatic or manual activation of a sleeping target for the display of additional graphically presented information

Note 1 to entry: *The target is displayed by an "activated target" symbol including a vector; the heading; and the ROT or direction of turn indication (if available) to indicate initiated course changes.*

[SOURCE: IMO Resolution MSC.192(79):2004, Appendix 2, modified – added Note 1 to entry]

3.2
acquisition of a radar target
process of acquiring a target and initiating its tracking

[SOURCE: IMO Resolution MSC.192(79):2004, Appendix 2]

3.3
activation of an AIS target
activation of a sleeping AIS target for the display of additional graphical and alphanumerical information

[SOURCE: IMO Resolution MSC.192(79):2004, Appendix 2]

3.4
acquired radar target
automatic or manual acquisition initiates radar tracking

Note 1 to entry: *Vectors and past positions* (if provided) *are displayed when data has achieved a steady state condition* (after 1 min).

[SOURCE: IMO Resolution MSC.192(79):2004, Appendix 2, modified – added Note 1 to entry]

3.5
automatic identification system
AIS
Automatic Identification System which complies with the requirements of IMO resolution MSC.74(69) Annex 3 and IEC 61993-2

3.6
AIS target
target generated from an AIS message

[SOURCE: IMO Resolution MSC.192(79):2004, Appendix 2, modified – deleted referral to other targets]

3.7
associated target
target simultaneously representing a tracked target and *a reported AIS target having similar parameters (for example position, course, speed) which comply with an association algorithm*

[SOURCE: IMO Resolution MSC.192(79):2004, Appendix 2, modified – deleted examples]

3.8
acquisition/activation zone
zone set up by the operator in which the system should automatically acquire radar targets and activate reported AIS targets when entering the zone

[SOURCE: IMO Resolution MSC.192(79):2004, Appendix 2]

3.9
azimuth-stabilised
heading reference input, for example own ship's gyro, is used to orientate the heading line on the radar display so that it points from the CCRP to own ship's referenced heading on the bearing scale

3.10
bow crossing range/bow crossing time
BCR/BCT
measurements presented as from the bow of the ship as opposed to the CCRP

3.11
cardinal points (compass)
0, 090, 180, 270 compass points

3.12
consistent common reference point
CCRP
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

[SOURCE: IMO Resolution MSC.192(79):2004, Appendix 2]

3.13
closest point of approach/time to the closest point of approach
CPA/TCPA
distance to the closest point of approach (CPA) and time to the closest point of approach (TCPA)

Note 1 to entry: *Limits are set by the operator* and are *related to own ship*.

[SOURCE: IMO Resolution MSC.192(79):2004, Appendix 2, modified – added Note 1 to entry]

3.14
course
direction in which the ship is moving or intended to move, expressed in degrees from North, usually from 000° at north, then in a clockwise direction through 360°

3.15
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

[SOURCE: IMO Resolution MSC.192(79):2004, Appendix 2]

3.16
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

[SOURCE: IMO Resolution MSC.192(79):2004, Appendix 2]

3.17
course-up
C-up
azimuth-stabilised display in which the bearing scale can be orientated so that own ship’s course on the bearing scale is vertically above the CCRP

Note 1 to entry: The heading line will continue to point from the CCRP to own ship’s referenced heading on the bearing scale.

Note 2 to entry: If own ship’s heading differs from the course, then the heading line will not point vertically upwards from the CCRP until the bearing scale is reset (manually or automatically) to reflect the course alteration.

3.18
dangerous target
target whose predicted CPA and TCPA are violating the values as preset by the operator

Note 1 to entry: *The respective target is marked by a “dangerous target” symbol.*

[SOURCE: IMO Resolution MSC.192(79):2004, Appendix 2, modified – added Note 1 to entry]

3.19
default
predefined condition set either by the user or the equipment manufacturer

3.20
ECDIS
electronic chart display and information system, which complies with IMO resolution MSC.232(82) and IEC 61174

3.21
ECDIS display base
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

Note 1 to entry: *It is not intended to be sufficient for safe navigation.*

[SOURCE: IMO Resolution MSC.192(79):2004, Appendix 2, modified – added Note 1 to entry]

3.22
ECDIS standard display
level of information that should be shown when a chart is first displayed on ECDIS

Note 1 to entry: *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.*

[SOURCE: IMO Resolution MSC.192(79):2004, Appendix 2, modified – added Note 1 to entry]

3.23
electronic navigational chart
ENC
database standardised as to content, structure and format according to relevant IHO standards and issued by, or on the authority of, a Government

[SOURCE: IMO Resolution MSC.192(79):2004, Appendix 2]

3.24
electronic position fixing system
EPFS
position fixing system using electronic means

3.25
electronic range and bearing line
ERBL
electronic bearing line carrying a marker, which is combined with the variable *range marker, used to measure range and bearing from own ship or between two objects*

[SOURCE: IMO Resolution MSC.192(79):2004, Appendix 2, modified – added "variable"]

3.26
EUT
equipment under test
equipment (devices, appliances and systems) subjected to tests

3.27
evaporation duct
low lying duct (a change in air density) that traps the radar energy so that it propagates close to the sea surface

Note 1 to entry: *Ducting may enhance or reduce radar target detection ranges.*

[SOURCE: IMO Resolution MSC.192(79):2004, Appendix 2, modified – added Note 1 to entry]

3.28
exclusion zone
area which may exclude the automatic acquisition for target tracking and/or may suppress the automatic activation of sleeping AIS targets

3.29
ground stabilisation
display mode in which speed and course information are referred to the ground, using ground track input data, or EPFS as reference

[SOURCE: IMO Resolution MSC.192(79):2004, Appendix 2, see "Stabilization modes"]

3.30
heading
horizontal direction that the bow of a ship is pointing expressed as an angular displacement from north

[SOURCE: IMO Resolution MSC.192(79):2004, Appendix 2]

3.31
heading line
graphic line on a radar presentation drawn from the consistent common reference point to the bearing scale to indicate the heading of the ship

3.32
head-up
H UP
presentation mode in which own ship's heading is oriented "up" toward the top of the bearing scale

Note 1 to entry: In head-up, the top of the bearing scale shows ships relative heading, 000 degrees.

Note 2 to entry: Radar echoes are shown at their measured distances and moving in a direction relative to own ship's heading with relative Target trails.

3.33
head-up stabilised
STAB H UP
azimuth stabilised head-up presentation mode in which own ship's heading is azimuth stabilised "up" toward the top of the bearing scale

Note 1 to entry: The top of the bearing scale shows the ship's true heading degrees from North.

Note 2 to entry: Radar echoes and tracked targets are shown at their measured distances and moving in a direction relative to own ship's heading.

3.34
high speed craft
HSC
vessels which comply with the definition in SOLAS for high speed craft

[SOURCE: IMO Resolution MSC.192(79):2004, Appendix 2]

3.35
icon
graphic that provides or signifies a control function capability

3.36
integrated navigation system
INS
navigation system which complies with the requirements of IMO resolution MSC.252(82) and IEC 61924-2

3.37
latency
delay between actual data received by the equipment *and the presentation* or use of that *data*

[SOURCE: IMO Resolution MSC.192(79):2004, Appendix 2, modified – specified the equipment and use]

3.38
lost AIS target
target symbol representing the last valid position of an AIS target before the reception of its data was lost, or its last dead-reckoned (DR) position

Note 1 to entry: *The target is displayed by a "lost AIS target" symbol.*

[SOURCE: IMO Resolution MSC.192(79):2004, Appendix 2, modified – specified position and added Note 1 to entry]

3.39
lost tracked target
target information is no longer available due to poor, lost or obscured signals

Note 1 to entry: *The target is displayed by a "lost tracked radar target" symbol* at its last known or dead-reckoned position.

[SOURCE: IMO Resolution MSC.192(79):2004, Appendix 2, modified – added Note 1 to entry]

3.40
maps
navigation lines
operator defined or created lines to indicate channels, traffic separation schemes or borders of any area important for navigation

[SOURCE: IMO Resolution MSC.192(79):2004, Appendix 2]

3.41
menu
area of display that is allocated to the interactive display and operation of a structured menu for the selection and entry of operational parameters, data and commands

Note 1 to entry: The menu display, when selected, is typically replacing parts of, or the whole, data display.

3.42
navigation situation
broad and general description of the type of navigation that is planned or being conducted, for example open ocean, coastal, approach, confined waters, restricted, docking/manoeuvring

3.43
non-volatile and transferable memory
memory which retains its data when it is not provided with power and removed from one equipment or module, and fitted to another equipment or module

3.44
north-up
N-up
azimuth-stabilised presentation in which north on the bearing scale remains fixed vertically above the CCRP

Note 1 to entry: The heading line points from the CCRP to own ship's referenced heading on the bearing scale, and the bearing of any target on the display is measured from north. Such a bearing is commonly referred to as a true bearing when the heading reference input comes from a gyro aligned with true north.

3.45
operational display area
area of the display used to graphically present chart and radar information, excluding the user dialogue area

Note 1 to entry: *On the chart display this is the area of the chart presentation.*

Note 2 to entry: *On the radar display this is the area encompassing the radar image.*

[SOURCE: IMO Resolution MSC.192(79):2004, Appendix 2, modified – added Note 1 and 2 to entry]

3.46
operational mode
primary function of the presentation selected by the user, for the task at hand or navigation situation, for example radar, chart, conning

3.47
past positions
equally time-spaced past position marks of a tracked or reported target and own ship

Note 1 to entry: *The past positions' track may be either relative or true,* and may apply to tracked radar targets or AIS targets.

[SOURCE: IMO Resolution MSC.192(79):2004, Appendix 2, modified – added Note 1 to entry]

3.48
presentation mode
result of the combination of user selected parameters that affect the display of information, for example azimuth orientation, motion, stabilisation, chart projection

3.49
protected menu
one which is not easily accessed by the user and access may be, for example by a password or a switch

3.50
radar
rad*io* **d***irection* **a***nd* **r***anging*
radio frequency *system that allows the determination of distance and direction of reflecting objects and of transmitting devices*

[SOURCE: IMO Resolution MSC.192(79):2004, Appendix 2]

3.51
radar beacon
navigation aid which responds to the radar transmission by generating a radar signal to identify its position and identity

[SOURCE: IMO Resolution MSC.192(79):2004, Appendix 2]

3.52
radar cross-section
RCS
determines the power density returned to the radar for a particular power density incident on a target

3.53
radar detection false alarm
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

[SOURCE: IMO Resolution MSC.192(79):2004, Appendix 2]

3.54
radar display
module of a radar system, consisting of the presentation hardware

3.55
radar echo
signal reflected by a target to a radar antenna that appears in the radar video signal and radar image

3.56
radar image
plan view of the radar video in range and bearing

3.57
radar presentation
display of a radar image together with related alpha-numeric and graphical information

3.58
radar system
entire content and functionality of a system necessary to meet the requirements of this test standard

3.59
radar target
object, fixed or moving, which is detected or detectable by a radar system and has a *motion determined by successive radar measurements of range and bearing*

Note 1 to entry: A radar target is derived from video signals provided by the radar sensor (transceiver) and which appears in the radar image.

[SOURCE: IMO Resolution MSC.192(79):2004, Appendix 2, modified – specified detectability and added Note 1 to entry]

3.60
radar video
signal produced by a radar receiver as a result of radar echoes returned

3.61
radar target enhancer
electronic radar reflector, the output of which is an amplified version of the received radar pulse without any form of processing except limiting

[SOURCE: IMO Resolution MSC.192(79):2004, Appendix 2]

3.62
range index delay
delay provided at the start of a radar presentation causing the near range radar signal contents to effectively be suppressed and distorting the linear plan presentation

3.63
rate of turn
ROT
change of heading per time unit

[SOURCE: IMO Resolution MSC.192(79):2004, Appendix 2]

3.64
reference target
symbol indicating that the associated tracked stationary target (for example a navigational mark) is used as a speed reference for the ground stabilisation

[SOURCE: IMO Resolution MSC.192(79):2004, Appendix 2]

3.65
relative bearing
direction of a target's position from own ship's CCRP *expressed as an angular displacement from own ship's heading*

[SOURCE: IMO Resolution MSC.192(79):2004, Appendix 2, modified – added CCRP]

3.66
relative course
direction of motion of a target relative to own ship's direction (bearing)

[SOURCE: IMO Resolution MSC.192(79):2004, Appendix 2]

3.67
relative motion
RM
combination of relative course and relative speed

Note 1 to entry: On the display the position of own ship remains fixed, and all targets move relative to own ship.

[SOURCE: IMO Resolution MSC.192(79):2004, Appendix 2 – added Note 1 to entry]

3.68
relative speed
speed of a target relative to own ship's speed data

[SOURCE: IMO Resolution MSC.192(79):2004, Appendix 2]

3.69
relative vector
predicted movement of a target relative to own ship's motion

[SOURCE: IMO Resolution MSC.192(79):2004, Appendix 2, see "Vector modes"]

3.70
SART
search and rescue transponder
radar transponder capable of operating in the 9 GHz band

3.71
speed and distance measuring equipment
SDME
speed and distance measuring equipment which complies with IMO Resolution MSC.96(72)

3.72
sea state
status of the sea condition due to the weather environment, expressed as a sea state 0 for flat conditions with minimal wind, to sea state 8 for very rough sea conditions

3.73
selected target
manually selected target for the display of detailed alphanumeric information in a separate data display area

Note 1 to entry: *The target is displayed by a "selected target" symbol.*

[SOURCE: IMO Resolution MSC.192(79):2004, Appendix 2, modified – added Note 1 to entry]

3.74
sleeping AIS target
target indicating the presence and orientation of a vessel equipped with AIS in a certain location

Note 1 to entry: *The target is displayed by a "sleeping target" symbol.*

Note 2 to entry: *No additional information is presented until* the target is *activated*.

[SOURCE: IMO Resolution MSC.192(79):2004, Appendix 2, modified – added Note 1 and 2 to entry]

3.75
sea stabilisation
display mode in which speed and course information are referred to the sea, using gyro or equivalent and water speed log input as reference

[SOURCE: IMO Resolution MSC.192(79):2004, Appendix 2, see "Stabilization modes"]

3.76
safety of life at sea
SOLAS
International Convention for the Safety of Life at Sea adopted by the International Conference on Safety of Life at Sea convened by the International Maritime Organization (IMO) in 1974

[SOURCE: IMO Resolution MSC.192(79):2004, Appendix 2, modified – added adoption]

3.77
speed over ground
SOG
speed of the ship relative to the earth, measured on board of the ship

[SOURCE: IMO Resolution MSC.192(79):2004, Appendix 2]

3.78
speed through water
STW
speed of the ship relative to the water surface

[SOURCE: IMO Resolution MSC.192(79):2004, Appendix 2]

3.79
standard display
ECDIS standard display
level of information that should be shown when a chart is first displayed on ECDIS or ECS

Note 1 to entry: *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.*

[SOURCE: IMO Resolution MSC.192(79):2004, Appendix 2, modified – added ECS and Note 1 to entry]

3.80
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*

[SOURCE: IMO Resolution MSC.192(79):2004, Appendix 2]

3.81
stern line
graphic line drawn from the consistent common reference point to the bearing scale, on a reciprocal bearing to the heading line

3.82
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

[SOURCE: IMO Resolution MSC.192(79):2004, Appendix 2]

3.83
target's predicted motion
prediction of a target's future course and speed based on its present motion as determined by past measurements of its range and bearing on the radar

[SOURCE: IMO Resolution MSC.192(79):2004, Appendix 2]

3.84
target tracking
TT
computer process of observing the sequential changes in the position of a radar target in order to establish its motion

Note 1 to entry: *Such a target is a Tracked Target.*

[SOURCE: IMO Resolution MSC.192(79):2004, Appendix 2, modified – added Note 1 to entry]

3.85
task at hand
specific activity being performed by the user, for example collision avoidance, route planning, route monitoring, grounding avoidance

3.86
test target
radar target of known characteristics used for test requirement

3.87
trails
tracks displayed by the radar echoes of targets in the form of an afterglow

Note 1 to entry: *Trails may be true or relative*.

Note 2 to entry: Relative trails are as they would be presented in relative motion.

Note 3 to entry: True trails are as they would be presented in true motion.

[SOURCE: IMO Resolution MSC.192(79):2004, Appendix 2, modified – added Notes 1, 2 and 3 to entry]

3.88
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

[SOURCE: IMO Resolution MSC.192(79):2004, Appendix 2]

3.89
true bearing
direction of a target from own ship's CCRP *or from another target's position, expressed as an angular displacement from true north*

[SOURCE: IMO Resolution MSC.192(79):2004, Appendix 2, modified – added CCRP]

3.90
true course
direction of motion relative to ground or to sea, of a target expressed as an angular displacement from north

[SOURCE: IMO Resolution MSC.192(79):2004, Appendix 2]

3.91
true motion
TM
combination of true course and true speed

Note 1 to entry: On the display own ship moves with its own true motion.

Note 2 to entry: A continuously updated position report is not required.

[SOURCE: IMO Resolution MSC.192(79):2004, Appendix 2 – added Note 1 and Note 2 to entry]

3.92
true speed
speed of a target relative to ground, or to sea

[SOURCE: IMO Resolution MSC.192(79):2004, Appendix 2]

3.93
true vector
vector representing the predicted true motion of a target, showing course and speed with reference to the ground or sea

[SOURCE: IMO Resolution MSC.192(79):2004, Appendix 2, see "Vector modes"]

3.94
user configured presentation
display presentation configured by the user for a specific task at hand

Note 1 to entry: *The presentation may include radar and/or chart information, in combination with other navigation or ship related data.*

[SOURCE: IMO Resolution MSC.192(79):2004, Appendix 2, modified – added Note 1 to entry]

3.95
user-defined
result of a function or parameter selected or defined by the user within the confines of specific equipment

3.96
user dialogue area
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

[SOURCE: IMO Resolution MSC.192(79):2004, Appendix 2]

3.97
VDR
voyage data recorder
voyage data recorder which complies with the requirements of IMO resolution MSC.333(90) and IEC 61996-1.

4 General

4.1 Overview

(MSC.192/5) *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.*

(MSC.192/1) *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 (ENC) and other vector chart information may also be provided to aid navigation and for position monitoring. Radar is a technology that should be applied together with other sensor information applicable for the task in hand.

Radar is a system and its performance is a factor of all of its component parts. The type test includes the radar sensor, ancillary units and display, complete with its processing and presentation display. All of these component parts contribute to the requirements and approval to these radar standards. Other navigational systems and equipment that provide radar and/or target tracking functions, complies with the relevant clauses of this standard according to the guidelines in Annex A. A navigation display or INS may be approved as part of a radar system when tested with the specific radar sensor and relevant ancillary units. Where the intended application for a navigation system is for collision avoidance, as a minimum requirement, the radar image is always presented, together with the relevant functionality and performance as described in Annex A.

4.2 Purpose

(MSC.192/1) *The radar combined with other sensor, or reported information (for example 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.*

4.3 Application of these standards

(MSC.192/2) *The Performance Standards defined by MSC.192(79)* shall *apply to all shipborne radar installations used in any configuration mandated by SOLAS independent of the type of ship, frequency band in use and the type of display, providing that no special requirements are specified in* Table 1 *and that additional requirements for specific classes of ship (in accordance with SOLAS Chapters V and X) are met.*

(MSC.192/2) *Close interaction between different navigation equipment and systems makes it essential to consider this standard in association with other relevant IMO* and IEC *standards.*

This standard applies to radar systems, navigation systems and navigation equipment which have the task of target detection and collision avoidance. Any equipment which combines these tasks and meets all of the requirements in this standard is regarded as a radar system. In support of the Collision Regulations, all available means shall be used to enhance the role of radar for safe navigation and collision avoidance. The usage of other sensors should, where practical, observe the requirements of the standards associated with those sensors. This standard also provides guidelines and requirements for radar functionality on all navigational displays supporting the tasks of target detection, collision avoidance, general navigation and position referencing on the bridge of a ship.

The successful integration of radar with AIS, charts, databases and other sensors demands that the radar equipment is correctly set up with special attention to the critical alignment of heading(s), system index delay(s), CCRP offsets and gyro. Failure to align these parameters may cause unacceptable registration with other information and may detract from the purpose of integration. This standard has mandated requirements to provide for these alignments.

NOTE Radar systems carried on SOLAS ships have traditionally used non-coherent modulation derived from magnetron transmitters which produce narrow high power pulses together with mechanically rotating antennas. New technology radars are becoming available which use coherent modulation, for example pulse compression, and may use electronically steerable antennas. All tests (or their equivalent) in this standard apply to both non-coherent and coherent radar systems and different types of antennas. At the present time X-band radar systems are required to remain compatible with radar beacons, SARTs and radar enhancers which are designed to operate with conventional non-coherent pulse systems, S-band systems are not limited by this restriction.

4.4 Equipment categories

This standard covers the testing of all SOLAS shipborne radar equipment. Individual equipment may be tested for a specific category of vessel. Table 1 provides a summary of the categories and basic differential capabilities for each category further specified in 11.5.2 and Table 26. The category should be indicated on the type label of the main radar electronics unit and on the related test certificate. Equipment approved for high speed applications should include a suffix H (for example CAT 1H) and equipment approved with a chart option should include a suffix C (for example CAT 1HC).

(MSC.192/5.3.1.1) *Recognising 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).*

The additional characteristics for equipment qualified to be approved for HSC and/or for chart radar are identified in this standard. For example, HSC equipment should be compatible with own ship speeds of up to 70 kn, should be capable of tracking targets with a 140 kn relative speed and should operate between latitudes of 70° N and 70° S.

A chart radar should conform to all the requirements of Clause 12 in this standard. References are made to IEC 61174 (ECDIS) for specific and standalone chart functionality.

Table 1 – Performance requirements for categories of ship/craft for SOLAS V

	Category of ship/craft		
	CAT 3	**CAT 2**	**CAT 1**
Size of ship/craft	500 gross tonnage	500 gross tonnage to 10 000 gross tonnage and HSC 10 000 gross tonnage	All ships/craft ≥10 000 gross tonnage
Minimum operational display area diameter	180 mm	250 mm	320 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
Minimum total AIS target and reports capacity	120	180	240
Trial manoeuvre	–	–	Yes
NOTE The minimum display area requirement in the first edition of this standard has been removed as it is not a requirement of the display standards given in Resolution MSC.191(79).			

4.5 Establishing equipment type and status

The manufacturer shall state the intended system content and the category of equipment under test (EUT). Specific requirements, which shall include intended equipment category, are listed below:

- high speed or normal speed;
- frequency band (X-band and/or S-band) and operational frequency limits;
- declaration of any novel processing, new technology or additional functionality which requires alternative testing or claims equivalency to the requirements;
- list all variants (up-mast/down-mast, split processor/displays, chart option, etc.);
- identification of all antennas available with the radar. The smallest antenna (or its properties) shall be used for all relevant performance testing. Environmental testing (vibration and shock) shall use the largest antenna available;
- all ancillary units (inter-switching, buffer amplifiers, etc.);
- units intended for protected (from the weather) or exposed (to the weather) application;
- the intended separation (cable, network or transmission line/feeder) between units. When equipment with separate transmitter and antenna is tested in accordance with this

standard, the transmitter/receiver shall be connected to the antenna by a 20 m (minimum) of feeder. The display shall be connected to other units by 65 m of cable. Where equipment is type tested, in which the transmitter and receiver are always installed within the antenna/pedestal combination, the 20 m of antenna feeder shall be omitted. Where necessary, the manufacturer shall supply the appropriate cable and antenna feeder. The manufacturer, or its representative, may propose to the test authority for consideration, a greater distance by which units of the equipment may be separated and still comply with the requirements of this standard. The actual distance requested and tested shall be recorded;

- power supply requirements and declared nominal voltage/frequency of operation. The supply voltage applied to the equipment during the tests shall be the nominal voltage, and alternating current (a.c.) supplies shall be at nominal frequency unless specified otherwise;
- intended equipment configuration(s), either as standalone or as part of a system;
- the manufacturer’s code numbers for each piece of equipment and its ancillaries;
- familiarisation documentation or media;
- evidence of sea trials as required by 6.9.3.

4.6 Conditions of measurement and related definitions

All the general requirements of IEC 60945 shall be carried out on the same type of EUT to verify whether the EUT meets these technical requirements. The equipment shall comply with those requirements of IEC 60945 appropriate to its category, i.e. 'protected' (from the weather) or 'exposed' (to the weather). Accordingly, the manufacturer shall declare which equipment or units are intended to be ‘protected’ or ‘exposed’. The manufacturer shall declare any ‘preconditioning’ required before environmental checks.

4.7 Quality requirements

The equipment and documentation shall be developed, produced and written in accordance with a recognised quality procedure, for example ISO 9000 or an equivalent recognised quality standard.

5 Tests

5.1 Test sites and simulation

5.1.1 Environmental and RF testing

Testing for general, environmental and radio frequency measurements shall be conducted in a test house, or location, accepted by the test authority and by competent persons familiar with the radar application.

5.1.2 Over-sea radar performance tests

Many of the tests may be conducted on land at a test site accepted by the test authority. Specific testing shall be required over sea and these may be shore based or at sea on a test ship.

Radar performance tests will normally be carried out at test sites selected by the type test authority. These test sites shall provide an over water test range with test targets and the features required for specified tests. The operational performance testing in this standard shall be conducted with a nominal antenna height of 15 m.

The manufacturer shall, unless otherwise agreed, set up the equipment and ensure that it is operating normally before type testing commences.

The value of radar as a secondary position source is based on independence from GNSS. Tests of detection, resolution, and tracking shall exclude connection of any GNSS position and timing interfaces to the radar system during those tests. If a GNSS receiver is integrated into the radar system, it shall be deactivated during these tests.

5.1.3 Test targets and target simulation for performance tests

Standard targets used for the radar performance measurement and assessment are described in the relevant tests.

The target scenario simulator provides test scenarios to assess the tracking performance of the EUT, in accordance with Annex F.

The reported target simulator provides the test scenario for testing the AIS target functions and for target association, in accordance with Annex F.

Simulators used for testing shall be suitably calibrated or verified before use for measurement.

5.2 Test terminology and format

5.2.1 General

For each test subject, there is a requirement subclause (for example referenced to (MSC.192/clause) and a corresponding compliance subclause, which includes a test method and the required result.

5.2.2 Test requirement terminology

For the purposes of this standard, the following test terminology shall apply:

- *performance check* – reconfiguration of the EUT and checking by non-quantitative visual checks that the system is still operative for the purposes of IEC 60945. This shall include the operation of basic functionality to confirm normal operation;
- *performance test* – for the radar EUT, shall be of an identical standard to that used in the performance check for the purposes of IEC 60945, with the addition of a specified test as described in Clause 16;
- *clear indication or visibility of test targets* – visible for at least 8 out of 10 of the antenna scans, or an indication of 5 out of 10 with past positions, synthetic afterglow and trails facility switched off;
- *simple operator action* – procedure achieved by no more than two hard-key or soft-key actions, excluding any necessary cursor movements, or by voice actuation using programmed codes or equivalent alternative means;
- *single operator action* – the use of a single hardware key or, the use of the cursor to select a single display icon or window followed by the operation of a key;
- *dedicated control function* – the use of a dedicated single hardware key or, the use of the cursor to select a single dedicated display icon or window followed by the operation of a key;
- *momentary control function* – the use of a dedicated single hardware key or, the use of the cursor to select a single dedicated display icon or window followed by the operation of a key. The control function shall only operate while the key is pushed;
- *readily available* – applies to information or to a function for the selected application, which is available in a top level menu and accessed directly from a screen function or icon, or by a dedicated control;
- *permanent indication* – applies to a status indication permanently or persistently available (as appropriate) and visible at any time that the equipment is operational;

- *protected menu* – is one which is not easily accessed by the user and protected for example, by a password, internal switch or hardware link;
- *means* – "a means to" do something is equivalent to "a method of" something, for example "a means to measure between two points" is the same as "a method of measuring".

5.2.3 Testing method terminology

Testing method terminology is derived from ISO 9241-12 and for application to this radar standard, terms are defined as:

- *measurement* – refers to measurement or calculation of a variable concerning the presentation of information, accuracy, or the equipment performance;
- *observation* – means to examine or inspect the equipment to confirm that a particular observable condition has been met. Observations can be made by anyone who has the necessary skill to systematically check the presentation of information and make the determination;
- *document inspection* – means to confirm by inspection that any relevant documented information, facility or function is compliant with the requirement;
- *analytical evaluation* – requires the informed judgement of equipment performance from a study of observations or measurements by an expert, a suitably qualified person who has the necessary skill and experience to judge the relevant property in the relevant subject. The method is typically used for the evaluation of properties which can be judged only in the context of other information or knowledge.

6 Radar performance

6.1 General

The performance test shall include measurement of the transmission frequency spectrum, familiarisation of the controls and signal processing functions, followed by minimum range, discrimination and accuracy measurements. The performance assessment in an over-sea environment shall exercise the signal processing and associated control functions. During this assessment, the test authority shall familiarise themselves with the gain and anti-clutter functions. Detection performance testing is provided in 6.9.

NOTE Radar provides the primary means to detect surface hazards for safe navigation and therefore the detection of surface hazards is a primary element in the task of collision avoidance. The performance requirements address the fundamental radar transmission, detection and signal processing capability of the radar system.

6.2 Transmission and interference

6.2.1 Transmission frequency

6.2.1.1 Requirements

(MSC.192/5.1.1) *The radar* shall *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.*

(MSC.192/5.1.2) *Radar systems of both X-band and S-band 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 selected shall *be indicated.*

6.2.1.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by measurement and analytical evaluation that the EUT meets the results required by the method described in Annex B of this standard. The test authority shall record the transmitted frequency or frequencies;

b) confirm by observation that there is an indication of the selected frequency band in use.

6.2.2 Interference

6.2.2.1 Requirements

(MSC.192/5.1.3) *The radar* shall *be capable of operating satisfactorily in typical interference conditions* as encountered in a normal marine radar environment.

6.2.2.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by analytical evaluation that the radar system has a method to substantially reduce interference from other approved marine radar transmitting in the frequency bands allocated to marine radar;

b) confirm by analytical evaluation that the radar system can transmit in the vicinity of other approved marine radar systems without causing significant interference or significant degradation in performance.

NOTE Radar detection performance specified in this standard may be degraded by third party interference, possibly by equipment other than marine radar, see Annex J.

6.3 Performance optimisation and monitoring

6.3.1 General

The radar system shall provide the means to optimise detection performance and to identify a significant drop in performance, as tested in 6.3.2.

6.3.2 Optimum performance

6.3.2.1 Requirements

(MSC.192/5.7.1) *Means* shall *be available to ensure that the radar system is operating at the best performance. Where applicable to the radar technology, manual tuning* shall *be provided and additionally, automatic tuning may be provided.*

(MSC.192/5.7.2) *An indication* shall *be provided, in the absence of targets, to ensure that the system is operating at the optimum performance.*

(MSC.192/5.7.3) *Means* shall *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.*

6.3.2.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by observation that the operation of the tuning function (or equivalent as applicable to the technology) is effective. The user manual shall describe how optimum performance is maintained;

b) confirm by observation there is a manual or automatic means to indicate that the radar system is operating at the optimum performance, even in the absence of targets, for example with the provision of a tuning indicator;

c) if automatic tuning is provided, confirm by analytical evaluation that it is not inferior to the performance achieved with manual tuning;

d) confirm by observation, that an indication is provided to the operator when the overall performance reduction is reduced by 10 dB using an attenuator or equivalent means. An up-mast system may be accepted by analogy with a down-mast system, given an equivalent implementation and equipment design.

6.4 Gain and anti-clutter functions

6.4.1 General

This standard specifies control functions associated with processing or controlling the radar signals. If alternative means to achieve equivalent functionality is provided, the manufacturer shall identify the means and shall demonstrate equivalence, supported by the relevant user documentation and to the satisfaction of the test authority.

(MSC.192/5.3.2.1) *Means* shall *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.*

Conformance with these requirements is addressed in 6.4.2 to 6.5.8 and the operation of functions is assessed in 6.9.

6.4.2 Gain function

6.4.2.1 Requirements

(MSC.192/5.3.2.2*) A gain control function* shall *be provided to set the system gain or signal threshold level.* A permanent indication of the gain level or setting of the signal threshold shall be given.

6.4.2.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by observation that there is a permanent indication of the gain level;

b) confirm by observation that the control function is directly accessible;

c) confirm by observation on a 24 NM range scale that the gain control varies from a minimum level where only the highest signal levels are presented to a maximum level providing visible receiver noise;

d) confirm by observation that, if a preset gain adjustment is provided for installation or maintenance use, it is located in a set-up menu protected from user access as described in the equipment manual.

6.4.3 Manual and automatic sea anti-clutter

6.4.3.1 Requirements

(MSC.192/5.3.2.3) *Effective manual and automatic anti-clutter sea functions* shall *be provided.*

(MSC.192/5.3.2.4) *A combination of automatic and manual anti-clutter sea functions is permitted.*

(MSC.192/5.3.2.5) *There* shall *be a clear and permanent indication of the status for gain and all anti-clutter sea control functions.*

6.4.3.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by observation that both “manual sea” and “automatic sea” functions are provided;
b) confirm by document inspection that the user manual describes any installation and operational adjustments associated with these functions and any performance limitations associated with their use;
c) confirm by document inspection that the user manual describes the operation of the manual and automatic anti-clutter sea control functions, including any advantages and limitations;
d) confirm by observation that the status and level of the functions are permanently indicated.

6.4.4 Rain anti-clutter

6.4.4.1 Requirements

An effective manual means of suppressing rain clutter shall be provided. Automatic rejection of rain clutter may also be provided. There shall be a clear and permanent indication of the status of the anti-clutter rain function.

6.4.4.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by observation the availability and operation of the rain anti-clutter control functions;
b) confirm by observation that the status and level of the rain anti-clutter function is permanently indicated;
c) confirm by document inspection that the user manual describes the use of the manual rain anti-clutter control (and automatic where provided), together with any performance limitations associated with its use.

6.5 Signal processing

6.5.1 General

Signal processing functions serve to improve target visibility and detection performance.

6.5.2 Target enhancement

6.5.2.1 Requirements

(MSC.192/5.3.1.3.2) *The radar system* shall *provide the means to enhance the visibility of targets in adverse clutter conditions at close range.*

(MSC.192/5.3.3.1) *Means* shall *be available to enhance target* visibility *on the display*. If selectable, the target enhance status shall be indicated and the user manual shall describe the operation and principles of the target enhance functions.

The function to enhance the visibility of targets at close ranges may use other processing techniques than those for standard navigation purposes.

6.5.2.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by observation that there are means to enhance target visibility in the clutter environment. The target enhancement functions may be selectable or permanent. If any

associated functions are provided, for example to reduce a high false alarm rate, they may be enabled to reduce degradation of target visibility;

b) confirm by document inspection that the user manual describes the enhancement function(s) and principles, including any associated functions and their use;

c) confirm by observation that the target-enhance status is indicated.

6.5.3 Radar signal correlation

6.5.3.1 Requirements

Correlation of consecutive transmissions shall be provided to reduce unwanted interference from other radar systems. Scan to scan correlation may be used to reduce echoes from clutter.

6.5.3.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by document inspection and observation that a means is provided for the effective reduction of interference generated by other marine conventional (magnetron) radar;

b) confirm by document inspection that where correlation techniques are provided, for example to reduce clutter, any advantages and limitations are described in the user manual.

6.5.4 Signal processing and radar image latency

6.5.4.1 Requirements

(MSC.192/5.3.3.2*) The effective* signal processing and radar image *update period* shall *be adequate, with minimum latency to ensure that the target detection* and associated processing *requirements are met.*

6.5.4.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by observation and measurement that the update of any target information has a latency of not more than the equivalent of one antenna scan. Alternative correlation techniques are permitted to have a latency of multiple scans;

b) confirm by observation that the status of any correlation function is indicated;

c) confirm by document inspection that the user manual describes the advantages and limitations of any alternative correlation applied.

6.5.5 Second-time-around echoes

6.5.5.1 Description

These echoes are a reflection of radar energy from a target due to a previous radar transmission which is prevalent in some atmospheric conditions. Second-time-around echoes appear as stable but false targets at any time (range) within the period between consecutive transmissions.

6.5.5.2 Requirements

A means of suppressing these second-time-around echoes may be provided and if provided, shall be tested.

6.5.5.3 Methods of test and required results

If a method for suppressing second time echoes is provided, then

a) confirm by observation, where conditions permit, during the testing of the radar equipment, that an effective means of suppressing second time echoes is provided;

b) confirm by document inspection that the means provided to suppress second time echoes is described in the user manual.

6.5.6 Transmission format

6.5.6.1 Requirements

To optimise detection performance for the weather conditions, the equipment may provide a means to change the transmission format, for example by providing the ability to increase or to decrease the pulse length.

6.5.6.2 Methods of test and required results

If a means to change the transmission format is provided, then

a) confirm by document inspection, observation and analytical evaluation that appropriate default transmission formats are provided for each range scale;

b) confirm by observation that inappropriate transmission formats are inhibited or are indicated to the user, for example the long pulse length should be prohibited on shorter range scales;

c) confirm by document inspection that the function of changing the transmission format, if provided, is described in the user manual and the basic concept, features, benefits and limitations are stated.

6.5.7 Picture update

6.5.7.1 Requirements

(MSC.192/5.3.3.3) *The picture* shall *be updated in a smooth and continuous manner.*

6.5.7.2 Methods of test and required results

Confirm by observation that the radar image is updated smoothly and the method of update is not distracting to the user.

6.5.8 Additional processing

6.5.8.1 Requirements

Additional signal processing provided by the equipment shall be evaluated.

6.5.8.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by document inspection what additional signal processing functions are provided;

b) record top level details of additional signal processing features and any observed impact they have on the radar detection performance.

6.5.9 Signal processing description

6.5.9.1 Requirements

(MSC.192/5.3.3.4) *The equipment manual* shall *explain the basic concept, features, benefits and limitations of any signal processing* functions.

6.5.9.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by observation that the status of all selectable active signal processing functions is indicated;

b) confirm by document inspection that the functions are described in the user manual and that basic concepts, features, benefits and limitations are stated.

6.6 Operation with SARTs, target enhancers (RTEs) and beacons

6.6.1 General

X-band radar systems shall be compatible with radar beacons, SARTs and radar enhancers, while S-band radar systems may adopt new technology which may not be compatible with these navigation aids.

6.6.2 Radar beacons, SARTs and enhancers

6.6.2.1 Requirements

(MSC.192/5.3.4.1) *The X-band radar system* shall *be capable of detecting radar beacons in the relevant frequency band.*

(MSC.192/5.3.4.2) *The X-band radar system* shall *be capable of detecting SARTs and radar target enhancers.*

(MSC.192/5.3.4.3) *It* shall *be possible to switch off those signal processing functions, including* alternative *polarisation modes*, *which might prevent an X-band radar beacon or SARTs from being detected and displayed. The status* of signal processing and polarisation (if selectable) shall *be indicated.*

The operation of the equipment with beacons, SARTS and target enhancers shall be described in the user manual.

6.6.2.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by observation that the X-band equipment operates with a typical radar beacon. The equipment shall be set working overlooking the sea and in the vicinity of known radar beacons, to demonstrate that the EUT is compatible with ITU-R M.824 (beacons);

b) confirm by observation that when the X-band equipment is set working overlooking a sea environment and in the vicinity of known SARTs and radar enhancers, the system detects SARTs and radar enhancers, as required by ITU-R M.628 (SARTs) and ITU-R M.1176 (radar target enhancers);

c) confirm by observation that the status of signal processing and polarisation (if selectable) is indicated;

d) confirm by document inspection that the operation of the equipment with beacons, SARTs and target enhancers is described in the user manual.

6.7 Minimum range and range compensation

6.7.1 General

The minimum detection range for the radar system shall be measured after the range index error has been compensated for the selected antenna position.

6.7.2 Range compensation

6.7.2.1 Requirements

(MSC.192/5.4.2) *Compensation for any range* index *error* shall *be automatically applied* and *where multiple antennas are installed,* shall *be automatically applied for each selected antenna.*

6.7.2.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by document inspection that the equipment provides the means to compensate for the range index for the position of each antenna and that the settings are protected in a non-volatile memory. Adjust the range compensation for each sensor (as applicable) so that the range of a known target is correct;

b) confirm by document inspection and observation that the compensation setting for each sensor is retained in a non-volatile memory and that it is automatically applied when each sensor is selected.

6.7.3 Minimum range

6.7.3.1 Requirements

(MSC.192/5.3.1.2) *The short-range detection of the targets under the conditions specified in* Table 2 shall *be compatible with the requirement.*

(MSC.192/5.4.1) *With own ship at zero speed* (or at a fixed land-based site)*, an antenna height of 15 m above the sea level and in calm (*minimal clutter*) conditions, the navigational buoy* (with corner reflector) *in* Table 2 shall *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.*

Ensure that the range index compensation is set correctly (as described in 6.7.2) before measurements are made.

A test target (equivalent to the navigational buoy with corner reflector) having a known RCS of 10 m^2 at X-band (having a known RCS of 1 m^2 at S-band) and mounted at a height of 3,5 m shall be used.

6.7.3.2 Methods of test and required results

The minimum range is the shortest distance at which, using a mandatory range scale of not more than 1,5 NM, a stationary target is presented separately from the position and image representing the antenna position. The separation distance is measured horizontally from the sea/ground level at the antenna position.

For this measurement, only the range scale selector may be changed. The sea and gain controls may be adjusted before commencing this test. After adjustment, the test target shall be visible at the minimum range and at 1 NM with the same setting of the sea and gain control. An off-centred presentation is permitted for this measurement.

The methods of test and the required results are as follows:

a) confirm by observation and document inspection that if a down-mast transceiver is an option for the radar under test, the test is conducted using a down-mast transceiver, or otherwise the test shall be conducted with an up-mast unit. If the implementation of up-mast and down-mast systems is different, both types of systems shall be tested;

b) confirm by observation that a reference test target is available having the same properties as the mobile test target. The reference test target shall be stationary and positioned at

1 NM range. Adjust the radar system so that the reference test target at approximately 1 NM is clearly visible;

c) confirm by measurement that with the radar antenna mounted at the specified height, the separation of a mobile test target (representative of a navigational buoy) and the antenna position can be decreased to the closest point at which the target can be identified within 40 m of the antenna position. Record the result. After adjustment, the mobile test target at the minimum range and the reference target at 1 NM shall be visible with the same setting of the gain and clutter controls;

d) alternatively a mobile target with an RCS of 10 m^2 at X-band may be used and moved from the closest point at which the target is visible up to 1 NM with the same settings of the gain and clutter controls.

6.8 Range and bearing discrimination

6.8.1 General

Point test targets used for the range and bearing discrimination measurements shall be equivalent to the navigational buoy with corner reflector defined in Table 2 and 6.7.3, having a known RCS of 10 m^2 at X-band or having a known RCS of 1 m^2 at S-band and mounted at a height of 3,5 m.

6.8.2 Measurement conditions

(MSC.192/5.5) *Range and bearing discrimination* shall *be measured in calm* (minimal clutter) *conditions, on a range scale of 1,5 NM or less and at between 50 % and 100 % of the range scale selected.* An off-centred presentation is permitted for this test.

6.8.3 Range discrimination

6.8.3.1 Requirements

(MSC.192/5.5.1) *The radar system* shall *be capable of displaying two point targets on the same bearing, separated by 40 m in range, as two distinct objects.*

6.8.3.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm the range discrimination by measurement. The radar shall be set to a range scale of 0,75 NM. Two test targets as defined in 6.7.3 shall be placed on the same bearing with respect to the radar antenna, at a distance of between 0,375 NM and 0,75 NM, and separated from each other by a distance of not more than 40 m. The rain control and the effective pulse length of the radar shall be set to their minimum values. The sea and gain controls shall be adjusted to show separation of the two targets on the display;

b) when the two targets are visibly separated for at least 8 scans out of 10, the linear distance between the two targets shall be measured. Confirm that the distance is not greater than 40 m.

6.8.4 Bearing discrimination

6.8.4.1 Requirements

(MSC.192/5.5.2) *The radar system* shall *be capable of displaying two point targets at the same range, separated by 2,5° in bearing, as two distinct objects.*

6.8.4.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm the bearing discrimination by measurement. The radar shall be set to the range scale of 1,5 NM or less and the test targets positioned at between 60 % and 100 % of the

range scale selected. Two test targets of equal radar cross-section and as defined in 6.7.3, shall be placed at the same distance and shall be separated in bearing with respect to the radar antenna. The measurement may be made at any convenient bearing from the antenna location. The angular separation between the two targets shall be decreased until they cease to be displayed separately. When the two targets are visibly separated for at least 8 scans out of 10 the linear distance between the two targets shall be measured;

b) confirm by calculation that the angle calculated with respect to the known range of the test targets does not exceed 2,5° and record the calculated angular separation.

6.8.5 Fundamental radar accuracy

6.8.5.1 Requirements

(MSC.192/5.2) *The radar system range and bearing accuracy* shall *be*:

Range: within 30 m or 1 % of the range scale in use, whichever is greater;

Bearing: within 1°

in typical operational and environmental conditions.

6.8.5.2 Methods of test and required results

The methods of test and the required results are as follows:

a) bearing: confirm by measurement that when operating on a stationary platform, the overall accuracy of taking bearings by the radar system meets the bearing accuracy required. Measurement shall be by comparing the actual bearings of identifiable point targets with bearings obtained using the radar equipment. The comparison shall be made at sample bearings distributed over 360° and the distance of each target from the radar antenna shall be between 80 % and 100 % of the range scale in use. The bearing measurement can be made either by using a single point target positioned at a series of known bearings relative to the radar antenna pedestal, or by taking the radar bearing of a series of point targets at known surveyed bearings around the radar antenna pedestal;

b) range: confirm by measurement from a stable platform using actual ranges of identifiable point targets, that when operating on a stationary platform, the overall accuracy of making range measurements by the radar system meets the range accuracy required. Measurement shall use at least two known targets, the first at nominally 1 NM, the second at nominally 10 NM. The range accuracy shall be within 30 m or 1 % of the range scale in use, whichever is the greater, and record the result. The radar transceiver shall operate with the appropriate transmission format for this test.

6.9 Target detection performance assessment

6.9.1 General

This standard specifies the minimum range of first detection performance in clear conditions and in addition, defines clutter conditions in which compliance with the detection performance requirements are tested, measured or assessed, including:

a) measurement of the range of first detection in minimal clutter conditions. Observations shall be made to confirm the visibility of a test target and in addition, shall be generally consistent with the IMO requirements as in Table 2;

b) measurement/predictions of the range of first detection in the presence of clutter (between the antenna and the target) and the assessment of the target visibility in clutter conditions by observing test targets within the clutter field and/or rain extent, using sea states and rainfall rates of opportunity.

For all radar performance tests, the radar antenna shall be installed on a platform either at sea or shore-based. The antenna shall be mounted at a height as close as practical at 15 m above mean sea level, recognising that even small deviations in antenna and/or target height can influence target detection performance and will reposition multi-path nulls. To achieve

consistency, the tests shall ensure that observations and measurements are made with the test targets positioned for detection at multi-path peaks. The radar antenna height and target parameters shall be documented by the test authority for each test. All test results shall be made available to the equipment manufacturer.

If a representative radar system is used as a further means to assess detection performance, the antenna of both the test radar and the reference radar should be at the same height and as near as practical, co-located. A reference-radar should be demonstrated to have met the minimum requirements in this standard. It could provide an indication of the relative propagation and clutter conditions at the time of the test measurements. A pass/fail decision should not only rely on the comparison with a reference-radar.

NOTE All radar performance documentation requirements are addressed in 6.9.4.

6.9.2 Range of first detection in minimal clutter

6.9.2.1 Requirements

(MSC.192/5.3.1.1*) In the absence of clutter, for long range* and small *target and shoreline detection, the requirement for the radar system is based on normal propagation conditions, in the absence of* significant *sea clutter, precipitation and evaporation duct, and 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 shall *be met as specified for X-band and S-band equipment. The detection performance* shall *be achieved using the smallest antenna that is supplied with the radar system.* A probability of a radar false alarm rate of 10^{-4} can be assumed when a light and even background noise speckle is presented on the display.

If the set-up of false alarm rate of 10^{-4} visible as a light and even background noise speckle is not applicable for the radar under test, the manufacturer should provide a method to achieve an equivalent set-up.

Table 2 – Range of first detection in clutter-free conditions

Target description [e]	Target feature height above sea level m	Detection range [f]	
		X-band NM	S-band NM
Shorelines[g]	Rising to 60	20	20
Shorelines [g]	Rising to 6	8	8
Shorelines [g]	Rising to 3	6	6
SOLAS ships (5 000 gross tonnage) [g]	10	11	11
SOLAS ships (500 gross tonnage) [g]	5,0	8	8
Small vessel with radar Reflector meeting IMO P.S.[a]	4,0	5,0	3,7
Navigation buoy with corner reflector [b]	3,5	4,9	3,6
Typical navigation buoy [c]	3,5	4,6	3,0
Small vessel of length 10 m with no radar reflection [d]	2,0	3,4	3,0
Channel markers [c]	1,0	2,0	1,0

[a] IMO revised performance standards for radar reflectors (resolution MSC.164(78)) – radar cross-section is defined as (RCS) 7,5 m^2 for X-Band, 0,5 m^2 for S-Band. The reflector used should not exceed the stated RCS by more than 50 %.

[b] Target is taken as 10 m^2 for X-band and 1,0 m^2 for S-band.

[c] 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 m, a detection range of 2,0 NM and 1,0 NM respectively.

[d] 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 distributed target).

[e] 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).

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

[g] See Clause D.7.

NOTE 1 RCS values can vary by as much as 30 dB according to target characteristics and aspects, resulting in changes in detection range (see Annex D).

NOTE 2 Detection performance predictions for the range of first detection are derived from CARPET software calculations (CARPET: radar analysis software: Computer Aided Radar Performance Evaluation Tool).

6.9.2.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by observation and document inspection that the smallest antenna (at the test frequency band) available for use with the radar system is installed. Adjust the system for best target visibility with a light and even background noise speckle to provide good detection sensitivity. The sea conditions shall be calm for assessing the range of first detection (maximum sea state 1, see Table 6 for guidance on sea states). The test may be conducted from a land site overlooking the sea or from a stable platform at sea. All observations shall be conducted in clear conditions;

b) confirm by observation and evaluation in a test environment approved by the test authority, that using a live radar system positioned to scan over sea and using targets of opportunity, the range of first detection is generally consistent with the examples in Table 2.

In addition, and as far as is practical, observations and measurements shall also include:

– established targets at various ranges up to 10 NM;

– known shorelines at various ranges above 3 NM and up to 20 NM.

Shoreline and surface objects shall be clearly visible for at least 16 scans within an observation period of 20 scans (80 % visibility) at ranges generally consistent with those specified in Table 2. Measurements shall be made over at least 4 observation periods and the results shall be assessed. The aggregate result of the 4 periods shall satisfy the detection ratio criteria

As the same criteria for detection applies to all targets, a sample of targets (not the full content of Table 2) over the observation period shall be sufficient to demonstrate meeting the range of first detection. However, a calibrated test target (equivalent to an omni-azimuth Luneberg Lens as described in 6.9.3.3.2) may be included as follows. A reflector, with an RCS of 10 m^2 for X-band (1 m^2 for S-band) and mounted at a height of 3,5 m, may be used to replicate a navigation buoy with a reflector. Alternatively, this test may be conducted using a reflector with an RCS of 1 m^2 for X-band (0,1 m^2 for S-band) and mounted at a height of 1,0 m to replicate a channel marker.

6.9.3 Assessment of target detection with clutter

6.9.3.1 Clutter – general

6.9.3.1.1 Requirements

(MSC.192/5.3.1.3) *Performance limitations caused by typical precipitation and sea clutter conditions will result in a reduction of target detection capabilities relative to those defined in* 5.9.2 and Table 2.

(MSC.192/5.3.1.3.1) *The radar equipment* shall *be designed to provide the optimum and most consistent detection performance, restricted only by the physical limits of propagation.*

(MSC.192/5.3.1.3.3) *Degradation of detection performance (related to figures in* Table 2) *at various ranges and target speeds under the following conditions,* shall *be clearly stated in the user manual:*

– *light rain (4 mm/h) and heavy rain (16 mm/h);*
– *sea state 2 and sea state 5; and*
– *a combination of these.*

(MSC.192/5.3.1.3.4) *The determination of performance in clutter and specifically range of first detection, as defined in the clutter environment in MSC.192/5.3.1.3.3* above*,* shall *be tested and assessed against a benchmark target, as specified in this standard.*

(MSC.192/5.3.1.1 part) *The detection performance* shall *be achieved using the smallest antenna that is supplied with the radar system.*

6.9.3.1.2 Methods of test and required results

The manufacturer shall, unless otherwise agreed, set up the radar system to optimise performance and shall confirm that the EUT is operating satisfactorily before tests are conducted. The manufacturer shall provide supporting evidence of the radar performance in various operational weather conditions (within the range specified by IMO) and in various sea areas, for example using fast-sample VDR recordings, video recording of the screen, screen shots or witnessed sea trials. Such evidence shall be submitted prior to performance tests and shall include full technical details of the installed radar system used to gain the results, the location of the recordings and the prevailing environmental conditions. The test authority shall assess such evidence, together with test measurements and observations required in this test section, to determine if the radar performance is satisfactory.

6.9.3.2 Rain clutter

6.9.3.2.1 Requirements

Rain clutter creates a high return of noise-like reflections that effectively decreases the signal to noise levels within the radar receiver. In addition, it creates an attenuation of the radar signal, which also decreases the signal to noise levels. Both these effects reduce the target detection capability of a radar system. Assuming a rain height of 1 000 m, and constant rainfall within the detection range, the effect on the range of first detection is as given in Figure 1 for S-Band and Figure 2 for X-Band. As well as frequency of operation, the effect depends on antenna horizontal and vertical beam widths and the pulse length in operation. Radar parameters are assumed to be as described in Clause D.7.

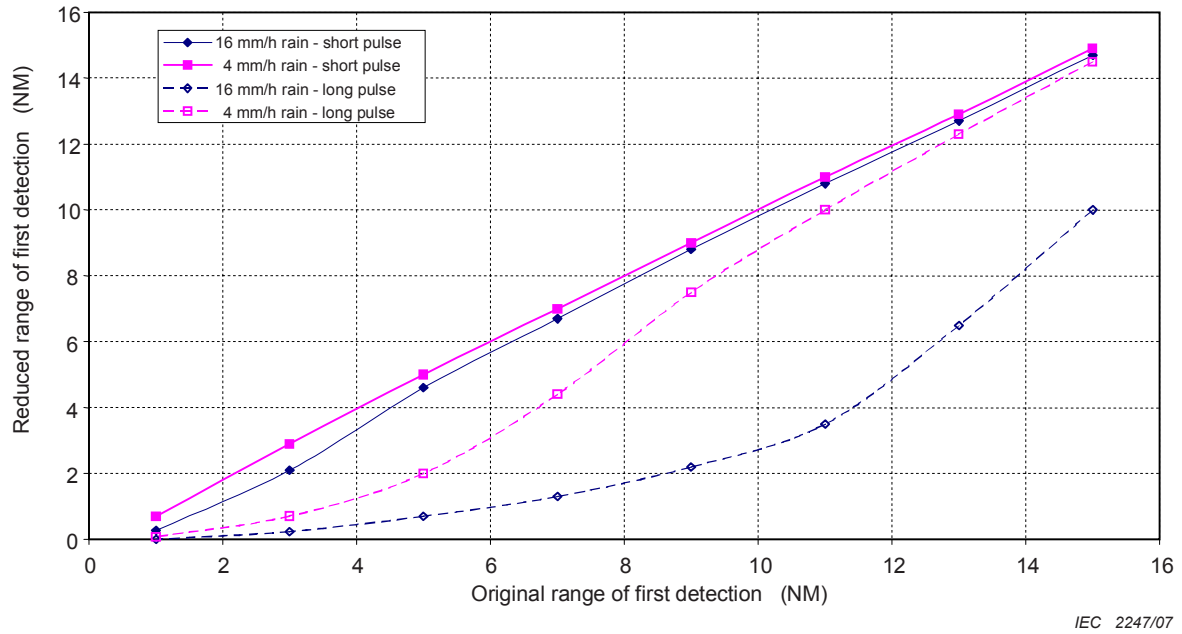


Figure 1 – Reduction of range to first detection due to rain at S-band

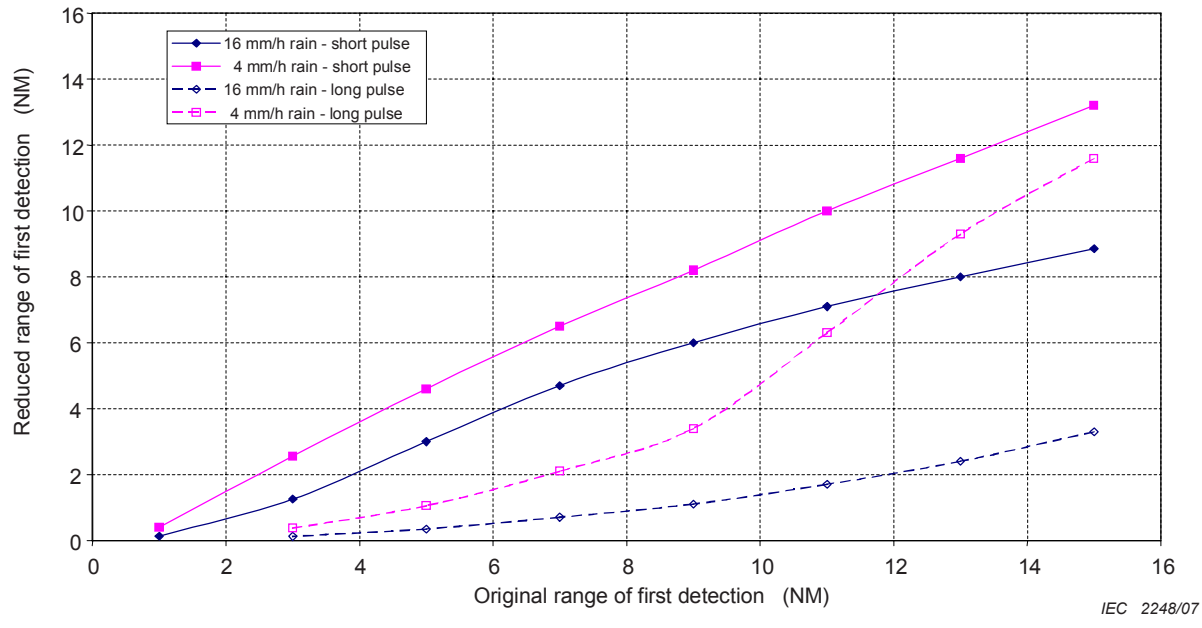


Figure 2 – Reduction of range to first detection due to rain at X-band

The radar manufacturer shall include techniques, such as differential processing and the use of an automatic threshold that allows the radar to optimise its performance in rain. The manufacturer shall provide supporting evidence from sea trials that the system performance in rain is generally consistent with the theoretical data given in Figure 1 and Figure 2.

6.9.3.2.2 Methods of test and required results

For this test, correct use shall be made of the equipment's anti-clutter control functions and the setting of these control functions shall be generally consistent with the guidance provided in the manufacturer's instructions:

a) confirm by observation of a target that is not detectable in rain conditions of opportunity that use of the equipment's anti-clutter controls allows that target to be detected. The setting of these control functions shall be generally consistent with the guidance provided in the manufacturer's instructions. All manual and automatic rain anti-clutter control functions provided by the radar system shall be evaluated;

b) confirm by analytical evaluation of submitted data that the evidence submitted by the manufacturer is generally consistent with the degradation in performance predicted in Figure 1 and Figure 2, as appropriate for the transmission frequency band. The manufacturer shall supply reasonable evidence to the test authority, as far as possible within 4 mm/h to 16 mm/h rainfall rate, for a number of representative targets and ranges and using a similar radar system.

6.9.3.3 Sea clutter

6.9.3.3.1 Requirements

The presence of sea clutter degrades the detection performance of radar. Three main effects cause this degradation:

a) large waves can obscure targets. There is no generally applicable and reliable way of overcoming this effect;

b) waves reflect radar energy that competes with the reflection from the target. This increases the noise levels that the target is embedded within. However, the statistical nature of the wave-reflected signal differs from that of the target and various combinations of signal processing techniques can help to make the target more visible;

c) some waves can exist over several scans and during this time exhibit a target-like behaviour. This causes sea "spikes" that can obscure or be confused with real targets. Appropriate signal processing can sometimes reduce this effect but not consistently.

As far as possible, tests shall be made when the targets are upwind from the radar antenna position. Crosswinds and downwind will improve target detection; in this case, the test results may exceed the minimum requirement. Deviations from the direction of the wind related to the antenna position shall be noted in the test report.

At longer distances, typically over 1 NM or 2 NM (depending for example on antenna height), the effect of b) above is greatly lessened. At shorter distances, this effect becomes very marked and the radar manufacturer shall include signal processing in order to improve the detection performance of the radar in conditions of sea clutter caused by this effect. This needs to include the provision of a manual control and an automatic anti-clutter control that affect the threshold and the range dependence of the threshold (Sensitivity Time Control).

The manufacturer shall include processing to enable optimisation of the performance of the radar for effects caused by b) and c) above.

Signal processing, for example scan-to-scan correlation, can reduce the effect of c) above. The manufacturer should include a means to apply such techniques in order to reduce the effect. Side effects of this technique such as limitations in the detection of fast targets shall be noted in the user manual.

6.9.3.3.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by observation and evaluation that the following performance is achieved under the defined test conditions:

- tests shall be performed in different sea states of opportunity between 2 and 5. At least one test shall be performed in sea state 3 or greater. Tests at the higher level of sea states are more significant and should be used whenever possible. The sea state used when commencing the test shall be noted in the test report. The nominal height of the radar antenna should be set to 15 m above actual sea height. The nominal height of the test radar target should be set to 3,5 m above actual sea level;
- the nominal range of the test targets shall be at 0,4 NM for S-band and at 0,7 NM for X-band systems. Three radar test targets with characteristics equivalent to an omni-azimuth (horizontal plane) Luneberg lens reflector shall be used. The radar cross-section of the three reflectors at the frequency of measurement shall be 1 m^2, 5 m^2 and 10 m^2 for X-band and 0,1 m^2, 0,5 m^2 and 1 m^2 for S-band.

To achieve a consistent target performance, an omni-azimuth (horizontal plane) lens reflector (featuring a metal grid reflector to provide a stable and a consistent RCS) is recommended for the test targets. The design is based on a dielectric sphere with a permittivity varying with the distance from the centre, providing a focal point located at the peripheral of the lens. Alternative reflectors that can maintain the same tolerance of 2,0 dB on the radar cross-section, over 360° in azimuth and 15° elevation, may also be used. The reflector gives a wide response, wide bandwidth and compact size. The tight tolerances of this reflector make it suitable as a benchmark target. Standard octahedral radar reflectors and other Luneberg lenses are not suitable.

The test shall be set up to ensure that there is confidence that all measurements will be taken at the peak of the multi-path pattern (see Annex D). Minor adjustments in the antenna height and target range/height figures given above may need to be made for each set of measurements (observation period) to ensure that the measurements continue to be made at the multi-path peak.

With the radar set at the 6 NM range, with no precipitation within this range and with no sea or rain clutter processing applied, the radar gain control function shall be set so that there is a light noise speckle at longer ranges, outside the range where sea clutter is visible (at this stage there could be significant sea clutter visible at shorter ranges). The range scale shall then be set to 3 NM and the manual sea clutter control function adjusted to make the target optimally visible in a light clutter speckle. Test targets shall be continuously optically visible during these tests;

b) confirm by observation that the manufacturer has included processing to enable optimisation of the performance of the radar for effects;

c) confirm by observation that a skilled user can adjust the manual anti-clutter control function to reduce the visible level of sea clutter around the target for the best target visibility. Ensure that the target is visible to a skilled user and is assessed to be generally consistent with Table 3 and Table 4, with visibility for at least 80 % of scans (tabulated as V) or at least 50 % of scans (tabulated as M) as appropriate for the sea state and target radar cross-section as described in Table 5.

In these tests, no allowance has been made for wave obscuration. If significant wave obscuration is present, the results will need to be interpreted accordingly.

NOTE Performance predictions are only indicative of the performance achieved in the real world and hence are only provided for guidance.

Each visibility test shall be conducted over at least twenty scans and once set for the observation period the anti-clutter control functions shall not be readjusted. The test shall be repeated for a minimum of three times and the calculated average probability-of-detection (Pd) shall be recorded. For marginal pass/fail results, this procedure shall be repeated for at least 5 times for each sea state measured. To aid a marginal pass/fail decision, results may be assessed by bracketing results gained from two different reflector sizes, for example a 1 m^2 and a 5 m^2 target. The target visibility test results, the description of the environment and the test location shall be recorded;

d) confirm by observation that the automatic anti-clutter control functions are effective in improving target visibility when following the manufacturer's defined procedures;

e) confirm by analytical evaluation that the radar manufacturer has submitted recorded evidence from trials conducted in a variety of sea clutter conditions and that the supplied sea clutter control functions are effective in improving target visibility;

f) confirm by observation that limitations such as the detection of fast vessels when scan to scan techniques are used are noted in the user manual.

6.9.3.4 Performance in sea and rain clutter

6.9.3.4.1 Requirements

Control functions supplied by the manufacturer for optimising radar performance in sea and rain clutter shall also be effective in conditions that have a mixture of both types of clutter. In these conditions, detection performance will be further degraded.

6.9.3.4.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by observation that in conditions of opportunity the clutter controls can be set to improve target visibility when there is both rain and sea clutter present. Ensure that the performance is generally consistent with the tests undertaken separately for rain and sea clutter (see 6.9.3.2.2 and 6.9.3.3.2);

b) confirm by observation that the automatic anti-clutter control functions improve target visibility in general accordance with the manufacturer's documentation and that the performance is generally consistent with the tests undertaken separately for rain and sea clutter (see 6.9.3.2.2 and 6.9.3.3.2).

NOTE These tests need not be conducted if the manufacturer has provided sufficient evidence of performance in combined sea and rain conditions.

Table 3 – X-band pass/fail assessment criteria

X-band test target RCS:	Target visibility in Douglas sea states			
	1 to 2	2 to 3	3 to 4	4 to 5
1 m^2	V-M	M-NV		
5 m^2	V	V-M	M-NV	
10 m^2	V	V	V	V-M
NOTE Test target range is nominally positioned at 0,7 NM.				

Table 4 – S-band pass/fail assessment criteria

S-band test target RCS:	Target visibility in Douglas sea states			
	1 to 2	2 to 3	3 to 4	4 to 5
0,1 m^2	V	V-M	M-NV	
0,5 m^2	V	V	V-M	M-NV
1,0 m^2	V	V	V	V-M
NOTE Test target range is nominally positioned at 0,4 NM.				

Table 5 – Pass/fail assessment

Abbreviation	Interpretation
V	Target visible for at least 80 %
M	Target visible for at least 50 %
NV	Target visible for less than 50 %
NOTE Results are derived by averaging the Pd for all observations in each condition.	

Table 6 – Douglas sea state parameters

Douglas sea state	Mean wind speed kn	Significant wave height m	Sea state description
0	4	0,2	Flat, very calm
1	5-7	0,6	Smooth
2	7-11	0,9	Slight
3	12-16	1,2	Moderate
4	17-19	2,0	Rough
5	20-25	3,0	Very rough
6	26-33	4,0	High
NOTE 1 Significant wave height is defined as the average height (crest to trough) of the one-third highest waves. Individual waves and/or swell can combine to significantly increase the wave height and may result in obscuration of the target. This table only applies to waves formed by local wind. NOTE 2 The table values are approximate due to the subjective nature of the sea state assessment. NOTE 3 Sea swell will make assessment of wave height very difficult.			

6.9.4 Radar performance documentation

6.9.4.1 Requirement

(MSC.192/5.3.1.3.5) *Degradation in performance due to a long transmission line, antenna height or any other factors* shall *be clearly stated in the user manual.*

Relevant factors shall also be included in the installation instructions.

The radar manufacturer shall include in the user manual a description of the effects that reduce the performance of the radar in sea clutter and emphasise that in increasing levels of sea clutter some targets will become difficult or impossible to detect. A description of how the detection of targets in sea clutter can be optimised shall be given.

The user manual shall include the relevant data and operational techniques for optimising performance relating to Figure 1 and Figure 2 (degradation of performance in rain). Documentation shall include a description of the degradation of radar performance in rain in a manner that would be understood by the user.

6.9.4.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by document inspection that factors which could degrade radar performance are described in the user manual;

b) confirm by document inspection that installation-related factors which could degrade radar performance are described in the installation manual;

c) confirm by document inspection that the manufacturer has included techniques for optimising the performance of the radar in rain to achieve, as a minimum, performance generally consistent with Figure 1 and Figure 2, as appropriate;

d) confirm by document inspection that the user manual includes relevant data relating to Figure 1 and Figure 2 and that there is a description of the degradation of radar performance in rain in a manner that would be understood by the user;

e) confirm by document inspection that the user manual provides a description of the effects that reduce the performance of the radar in sea clutter and emphasises that in increasing levels of sea clutter, some targets will become difficult or impossible to detect. A description of how the detection of targets in sea clutter can be optimised shall be provided;

f) confirm by document inspection that the user manual has a description of the effects that sea clutter has on the detection performance of radar (see 6.9.3.3.1) and that a description is given of the equipment control functions and of the recommended user procedures to reduce the effects of clutter. The documentation shall include a warning on the limitation of such controls and that wanted targets may remain or become invisible. In particular, unless the manufacturer can show otherwise, it should be stated that the use of control functions to reduce sea clutter spikes may make some targets invisible, particularly targets with higher speeds;

g) confirm by document inspection that the user manual explains that further degradation in detection performance will be experienced when the radar is operating in simultaneous conditions of precipitation and sea clutter;

h) confirm by document inspection that the radar manufacturer has submitted sufficient evidence from tests conducted in a variety of combined sea and rain clutter conditions.

6.10 Radar antenna (including pitch and roll)

6.10.1 General

The radar antenna is fundamental to the radar performance and shall be tested to provide information for specific tests required within this standard.

6.10.2 Vertical radiation pattern/pitch and roll

6.10.2.1 Requirements

(MSC.192/5.6) *The target detection performance of the equipment* shall *not be substantially impaired when own ship is rolling or pitching up to 10°*.

The vertical radiation pattern shall be designed to permit the pitch and roll of a ship without undue loss of performance, while providing a main beam pattern to limit degradation in performance due to nearby structures and to reduce the illumination of precipitation.

Providing that the radar system meets the rolling and pitching requirements, alternative methods may be used to permit a narrower vertical antenna beam width. However, the detection performance, bearing accuracy and bearing discrimination shall then be evaluated in the same conditions of ship motion.

6.10.2.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by measurement, the vertical radiation pattern (one way) of the radar antenna, measured either in the far field region or in a region that can be referenced to it. The measurement shall be carried out at the upper and lower frequency band declared by the manufacturer. The vertical plots shall be recorded;

b) confirm by document inspection of the measured result in a), that the –3 dB beam width encompasses 10° in elevation.

c) compliance of alternative methods shall be demonstrated by measurements of the antenna radiation pattern at the upper and lower frequency band declared by the manufacturer and submission of test evidence documenting that requirements for detection performance, bearing accuracy and bearing discrimination are achieved in dynamic conditions with the specified rolling and pitching ship motion and that a warning alert to the operator is provided of a degradation in performance of the alternative methods implemented.

6.10.3 Antenna horizontal pattern

6.10.3.1 Requirements

The X-band radar shall be capable of operating in a horizontally polarised mode. The far field horizontal pattern for an X-band antenna shall be measured at the upper and lower operational frequencies, as specified by the manufacturer. The measurements provide a performance check at the frequency extremes. The limits of the horizontal beam pattern specified in Table 7 shall be met. The figures relate to one way propagation. The limits in Table 7 shall also apply to an S-band antenna.

Table 7 – Main horizontal beam pattern

Power relative to maximum of main beam dB	**Maximum total beam width X-band** degrees (°)	**Maximum total beam width S-band** degrees (°)
–3	2	2
–20	10	10

6.10.3.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by document inspection that horizontal polarisation is available on X-band systems and record any alternative polarisation(s) that may be selected;

b) confirm by measurement in all polarisation modes that the horizontal beam limits given in Table 7 are met at the upper and lower operational frequencies;

c) verify that for the smallest radar antenna, including any design using new technology, meets the bearing discrimination requirement in 6.8.4.

Compliance for alternative tests of meeting the above requirements may be demonstrated by measurements of the antenna radiation pattern and submission of test data documenting the required results. Providing it can be demonstrated that the radar system meets the bearing discrimination requirements of 6.8.4, alternative processing may be used to permit a broader horizontal antenna beam width.

6.10.4 Antenna side lobes

6.10.4.1 Requirements

(MSC.192/7.4.3) *The antenna side lobes* shall *be consistent with satisfying the system performance as defined in this standard.*

As far as is practical, the design shall minimise the antenna side lobes. The measured side lobes shall be within the limits defined in Table 8.

Table 8 – Effective side-lobes

Position relative to maximum of main beam degrees (°)	**Maximum power relative to maximum of main beam** dB
Within ± 10	*– 23*
Outside ± 10	*– 30*

6.10.4.2 Methods of test and required results

The far-field horizontal radiation pattern of the radar antenna shall be determined either by direct measurement in the far field or by transforming an intermediate range measurement in the far field. This test shall be carried out at the upper and lower operating radio frequency limits of the nominal radio frequency declared by the manufacturer:

a) confirm by measurement that the far field horizontal radiation pattern conforms to Table 8, noting that the figures relate to one-way propagation only. The measured horizontal pattern (plot) of the antenna shall be recorded in the test report;

b) confirm by analytical evaluation that no significant side lobes exceed the limits defined in Table 8. The antenna horizontal radiation pattern shows the relative response of the antenna plotted against angular displacement in the horizontal plane. A significant side-lobe is defined as any positive excursion from the monotonically decreasing main beam pattern of more than 2 dB.

6.11 Radar availability – Standby and transmit

6.11.1 Requirements

(MSC.192/5.8) *The radar equipment* shall *be fully operational (run* or transmit *status) within 4 min after switch-on from cold. A standby condition* shall *be provided, in which there is no operational radar transmission. The radar* shall *be fully operational within 5 s from the standby condition.*

6.11.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by observation that a standby facility is provided;

b) confirm by measurement that the 4 min operational requirement from switch-on is met. The radar system shall be pre-conditioned by being disconnected from the power source for at least 1 h, then reconnected to a power source, switched on and a stopwatch started. As soon as the radar system indicates that it is available for operation, it shall be set to transmit mode. When the radar system is fully operational (produces radar video on correct bearing), the stop watch shall be stopped and the time recorded. The time from switch-on shall be within 4 min;

c) confirm by measurement that the 5 s operational requirement from standby is met. The radar system shall be set to the standby mode for at least 2 min, after which the radar system shall be set to transmit and the stopwatch started. When the radar system is fully operational (run or transmit status), the stopwatch shall be stopped and the elapsed time recorded. The average of up to 20 such measurements shall not exceed 5 s.

7 Display presentation

7.1 General

7.1.1 Requirements

(MSC.192(6.2.1) *The display presentation* shall *comply with the performance standards for the presentation of navigation-related information on shipborne navigational displays (MSC.191(79*)) as further clarified by the relevant clauses of IEC 62288.

Display requirements which are additional to those of IEC 62288 are described in this standard.

7.1.2 Methods of test and required results

Verify compliance with MSC.191(79) in accordance with IEC 62288.

NOTE All requirements of resolution MSC.192(79) are tested by this standard.

7.2 Linearity and index delay

7.2.1 Requirements

(MSC.192/5.9.5) *Radar targets* shall *be displayed on a linear range scale,* starting from zero range.

7.2.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by observation that the radar targets are displayed on a linear scale and without delay. Confirmation that the range scale is linear may be achieved by the use of calibrated markers or by observing a radar picture based on a known locality;

b) additional and auxiliary radar presentation windows, with or without a range index delay, are permitted outside of the designated operational display area. As far as practical and size permitting, the permitted auxiliary window shall use this radar standard as guidance for functionality and presentation.

7.3 Use and discrimination of colour

7.3.1 Requirements

If the display equipment is not intended to support the presentation of charted information then the colours used shall be based upon the colours defined in IEC 62288 and for radar maps as defined in 9.12, along with a range of shades based upon the following colours – white, grey, black, blue, magenta, green, yellow, orange and red – or a subset of them, provided they are visually distinguishable from each other and identifiable (see also ISO 9241-8).

7.3.2 Methods of test and required results

The methods of test and the required results are as follows:

a) verify compliance in accordance with the test methods and required results of IEC 62288 for discrimination of colours and for multi-coloured display equipment;

b) confirm that the use of colour for radar maps is in accordance with the considerations listed in 9.12.

8 CCRP and own ship

8.1 Consistent common reference point (CCRP)

8.1.1 CCRP

(MSC.252/5.4.2.1) *The radar* shall *use a single consistent common reference point for all spatially related information. For consistency of measured ranges and bearings, the recommended reference location should be the conning position. Alternative reference locations may be used where clearly indicated or distinctively obvious. The selection of an alternative reference point should not affect the integrity monitoring process.*

8.1.2 CCRP position

8.1.2.1 Requirements

(MSC.192/5.9.3) *When the picture is centred, the position of the consistent common reference point* shall *be at the centre of the bearing scale.*

8.1.2.2 Methods of test and required results

Confirm by observation that with the picture centred, the CCRP is positioned at the centre of the bearing scale measurement reference.

8.1.3 Measurements

8.1.3.1 Requirements

(MSC.192/5.9.1) *Measurements from own ship (for example range rings, target range and bearing, cursor, tracking data)* shall *be made with respect to the CCRP (for example at the conning position).*

The equipment may also provide a function to enable measurements to be taken from another location on ship and in this case, there shall be a clear indication of the alternative reference position for instance the antenna position.

NOTE The use of radar antennas with a limited horizontal view are limited to certain applications, for instance a bow position. Therefore, measurements for such radars need not be referenced to central CCRP.

All data communicated between equipment shall be referenced to the CCRP (see Clause 10).

8.1.3.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by observation that the means of taking measurements are centred on the CCRP and not centred on any other position except where specifically selected and clearly indicated;

b) confirm by observation and measurement that the range and bearing measurements are correct to the CCRP position or, if provided, alternative reference position;

c) confirm by measurement that when switching from CCRP to an alternative reference position that displayed data is changing accordingly but data transmitted via the interface remains referenced to the CCRP.

d) confirm by document inspection and if provided, that the selection of an alternative CCRP position is indicated;

e) confirm by document inspection that the CCRP function is described in the user manual.

8.1.4 Antenna offset

8.1.4.1 Requirements

(MSC.192/5.9.1) *Facilities* shall *be provided to compensate for the offset between antenna position and the consistent common reference point on installation. Where multiple antennas are installed, there* shall *be provision for applying different position offsets for each antenna in the radar system. The offsets* shall *be applied automatically when any radar sensor is selected.*

8.1.4.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by observation that there are facilities in a non-operational menu to compensate for the offset between the antenna position and the consistent common reference point;
b) confirm by observation that where multiple antennas are installed, there is provision for applying different position offsets for each antenna;
c) confirm by observation that the offset is automatically applied for each selected antenna and that the offset values are maintained in non-volatile and transferable memory;
d) if a function for more than one CCRP is provided, confirm by observation that the antenna position offset is corrected according to the selected CCRP position;

8.2 Own ship

8.2.1 General

Own ship features include own ship's outline, heading line, and stern line.

8.2.2 Own ship's outline and minimised symbol

8.2.2.1 Requirements

(MSC.192/5.9.2) *Own ship's scaled outline* shall *be available on appropriate range scales. The CCRP and the position of the selected radar antenna* shall *be indicated on this graphic.*

8.2.2.2 Methods of test and required results

Verify compliant presentation of the own ship symbol in accordance with IEC 62288, including indication of CCRP and radar antenna positions on the symbol.

8.2.3 Heading line

8.2.3.1 Requirements

(MSC.192/5.14.1) *A graphic line* shall be provided originating *from the consistent common reference point* (CCRP) *to the bearing scale to indicate the heading of the ship.*

(MSC.192/5.14.2) *Electronic means* shall *be provided to align the heading line to a resolution of 0,1°. If there is more than one radar antenna, the heading skew (bearing offset)* shall *be retained and automatically applied when each radar antenna is selected.*

(MSC.192/5.14.3) *Provision* shall *be made to temporarily suppress the heading line. This function may be combined with the suppression of other graphics.*

A means shall be provided to dim the heading line independently of the brightness of the radar image. It shall be permitted to combine the heading line dimming with other dimming functions of graphics. The heading line shall extend to the bearing scale. The brilliance (brightness) of the heading line shall not be variable to extinction.

8.2.3.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by observation that the heading line extends from the CCRP to the bearing scale;

b) confirm by document inspection and observation of the equipment that there is a means to align the heading line with a resolution of 0,1°;

c) confirm by document inspection and observation of the equipment that if more than one radar antenna is provided, the heading skew (bearing offset) is retained and automatically applied when each radar antenna is selected;

d) confirm by observation that the heading offset values are retained in transferable non-volatile memory or equivalent means;

e) confirm by observation that a temporary (momentary) heading line suppression function is available. The same function may be used to suppress other graphical information;

f) confirm by observation that a means is provided to dim the heading line independently of the brightness of the radar image; the function may be combined with dimming other graphics but shall not dim the heading line to extinction.

8.2.4 Stern line

8.2.4.1 Requirements

A stern line, drawn on a reciprocal bearing to the heading line, may be provided. If provided, it shall be possible to switch the stern marker on and off. The stern line shall extend from the CCRP to the bearing scale when the display presentation is in a radar mode. When the stern line is displayed, the heading line shall not be suppressed.

The brilliance (brightness) of the stern line shall not be variable to extinction.

8.2.4.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by observation that if a stern line is provided, it can be switched on and off;

b) confirm by observation that the stern line extends to the bearing scale and that the line style conforms to IEC 62288;

c) confirm by observation that the heading line is not suppressed when the stern line is active;

d) verify by observation that the brightness of the stern line cannot be adjusted to the point of extinction.

9 Navigation tools

9.1 General

Navigation tools which are common to all navigation displays are harmonised for presentation and function in IEC 62288. This Clause 9 gives the specific requirements for navigation tools used with radar equipment.

9.2 Units of measurement

9.2.1 Requirements

(MSC.192/5.9.4) *Range measurements* shall *be in nautical miles* (NM). *In addition, facilities for metric measurements* (km, m) *may be provided on lower range scales* as applicable for estuary, river or similar coastal applications. *All indicated values for range measurement* shall *be unambiguous.*

9.2.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by document inspection, the range measurement units and the associated range scales provided by the equipment. Confirm that the user manual describes alternative units;

b) confirm by observation that range measurements use consistent units and are unambiguous.

9.3 Presentation

9.3.1 Requirements

Navigation tools, for example cursor, VRM, EBL, ERBL and parallel index lines, shall be presented with their relevant symbols according to IEC 62288.

A numerical readout shall be provided for each active navigational tool.

9.3.2 Methods of test and required results

The methods of test and the required results are as follows:

a) verify that each navigation tool is presented with the relevant symbol(s) in accordance with IEC 62288;

b) confirm by observation that the brightness of the navigation tools, as a group or subgroups, can be adjusted independently of the brightness of the radar image and of other graphics within the operational display area;

c) confirm by observation that a numerical readout is provided for each active navigation tool.

9.4 Display range scales

9.4.1 Mandatory range scales

9.4.1.1 Requirements

(MSC.192/5.10.1) *Range scales of 0,25 NM, 0,5 NM, 0,75 NM, 1,5 NM, 3 NM, 6 NM, 12 NM and 24 NM* shall *be provided. Additional nautical mile range scales are permitted outside the mandatory set. Low metric range scales may be offered in addition to the mandatory set.*

(MSC.192/5.10.2) *The range scale selected* shall *be permanently indicated.*

NOTE Low metric range scales are taken as those used for estuary and river applications.

9.4.1.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by inspection of the EUT that the mandated range scales are available;

b) confirm by observation the selected range scale is permanently indicated in a prominent position;

c) confirm by inspection of the EUT that additional range scales provided are separate and outside of the mandatory range scales (below 0,25 NM and/or above 24 NM) and do not interrupt the consecutive sequence of mandatory range scales. Low metric range scales are permitted in addition to the mandatory set;

d) confirm by observation that the display is not blanked for more than 1 scan after a change in range scale and within that period, full functionality is restored (charts, where provided, are permitted to redraw over a longer period; see Clause 12);

e) confirm by observation that with the CCRP centre, the actual range displayed within the operational area is within 0 % and 8 % of the range scale, as measured at the cardinal points.

9.5 Variable range marker (VRM)

9.5.1 General

The VRM provides the means to measure the range of a feature or target and a means to set a range reference from own ship for navigation.

9.5.2 VRM measurements

9.5.2.1 Requirements

(MSC.192/5.12.1) *At least two variable range markers (VRM)* shall *be provided. Each active VRM* shall *have a numerical readout and* shall *have a resolution compatible with the range scale in use.*

Each active VRM shall be capable of adjustment to a resolution of 0,01 NM, or the appropriate metric equivalent. A coarser resolution may be provided for higher range scales. The readout shall be available in the user dialogue area or additionally adjacent to the cursor when the cursor lies over the ERBL/EBL/VRM.

A function to switch each VRM on and off shall be provided.

(MSC.192/5.12.2) *The VRMs* shall *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 selected or 30 m, whichever is the greater distance.* Where metric range measurements are required, the accuracy shall not be inferior to other range measurements.

It shall be possible to position each VRM to any point within the operational area and with the specified accuracy within 5 s.

The VRM range set by the user shall be retained when there is a change in range scale.

If means are provided to move VRM origin from the CCRP to other points within the operational display area, geographically fixed or moving at velocity of own ship, then a means shall be provided to reset the VRM origin to the CCRP position by a simple operator action.

9.5.2.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by observation that at least two VRMs are available;

b) confirm by observation that a dedicated readout is available for each active VRM. Confirm that the VRMs are capable of adjustment to a resolution of 0,01 NM (or the appropriate metric equivalent). A coarser adjustment may be provided for ranges greater than 24 NM or appropriate metric equivalent;

c) confirm by observation that a function to switch each VRM on and off is provided;

d) confirm by measurement that the accuracy of the VRMs meet the requirement using a calibrated target or marker;

e) confirm by measurement that when metric measurements are provided, the readout and accuracy is equivalent to those relevant to nautical miles;

f) select the 24 NM range scale and set a VRM to 24 NM range. Select the 6 NM range scale and confirm by observation that it is possible to set the position of the VRM to 3 NM (1 %) within 5 s;

g) confirm by measurement that the VRM origin can be positioned within 5 s;

h) confirm by observation that it is possible to position the VRM at any range within the operational display area, and with the required accuracy of 1 % within 5 s;

i) confirm by observation that a VRM range that is set by the user is maintained when there is a change of the range scale;

j) confirm by observation that if means are provided to move VRM origin from the CCRP to other points means are provided to reset the VRM origin to the CCRP position by a simple operator action.

9.6 Electronic bearing line (EBL)

9.6.1 General

The EBL provides the means to measure the bearing of a feature or target and as a means to set a bearing reference from own ship for navigation and for basic collision avoidance.

9.6.2 EBL measurements

9.6.2.1 Requirements

(MSC.192/5.15.1) *At least two electronic bearing lines (EBLs)* shall *be provided to measure the bearing of any point object within the operational display area, with a maximum radar system error of 1°* based on a measurement uncertainty of 0,5° *at the periphery of the display.*

(MSC.192/5.15.6) *Each active EBL* shall *have a numerical readout with a resolution adequate to maintain the system measurement accuracy requirements.*

(MSC.192/5.15.2) *The EBLs* shall *be capable of measurement relative to the ships heading and relative to true north. There* shall *be a clear indication of the bearing reference (i.e. true or relative).*

A means to switch each EBL on and off shall be provided.

It shall be possible to set an EBL to any bearing to within 0,5° in less than 5 s.

9.6.2.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by observation that two EBLs are provided and confirm that geographical features on a known bearing can be measured with the required accuracy;

b) confirm by observation that a numerical readout, with adequate resolution, is provided for each active EBL;

c) confirm by observation that the functions are available to permit measurement relative to the ship's heading and relative to north. Check that an indication of the bearing reference is provided;

d) confirm by observation that a means to switch each EBL on and off is provided;

e) confirm by measurement that the EBL adjustment is progressive, and the incremental adjustment is sufficiently adequate to permit setting an EBL to any bearing to the required accuracy;

f) confirm by measurement that the EBL can be set to any bearing to within 0,5° in less than 5 s.

9.6.3 EBL origin position

9.6.3.1 Requirements

(MSC.192/5.15.3) *It* shall *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.*

(MSC.192/5.15.4) *It* shall *be possible to fix the EBL origin or to move the EBL origin at the velocity of own ship.*

(MSC.192/5.15.5) *Means* shall *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.*

9.6.3.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by observation that it is possible to move the EBL origin from the CCRP to any point within the operational display area and that a means are provided to reset the EBL origin to the CCRP position by a simple operator action either directly or within an associated menu;
b) confirm by observation that it is possible to geographically fix the EBL origin and to move the EBL origin at the velocity of own ship;
c) confirm by measurement that the EBL origin can be positioned within 5 s. Confirm by measurement that the EBL can be positioned to 0,5° of a given bearing within 5 s .

9.7 Cursor

9.7.1 General

A user cursor has numerous functions, providing the means to measure range and bearing, either to own ship or between two remote points, and to determine the latitude/longitude position of any point. The cursor may be used to designate a position, select a feature or target within the operational display area. The cursor may also be used to select a function or menu and its attributes within the display user dialogue area.

9.7.2 Cursor measurement

9.7.2.1 Requirements

(MSC.192/5.18.1) *A user cursor* shall *be provided to enable a fast and concise means to designate any position on the operational display area.*

(MSC.192/5.18.4) *Means* shall *be provided to easily locate the cursor position on the display.*

(MSC.192/5.18.2) *The cursor position* shall *have a continuous readout to provide the range and bearing, measured from the consistent common reference point, and the latitude and longitude of the cursor position, either alternatively or simultaneously.*

(MSC.192/5.18.5) *The accuracy of the range and bearing measurements provided by the cursor* shall *meet the relevant requirements for VRM and EBL.*

9.7.2.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by measurement that the cursor can be positioned at the CCRP and then repositioned on the outer range ring at a mid (inter) cardinal point within 5 s;

b) confirm by measurement the cursor accuracy in range and bearing by comparison with a known target or by use of a calibrated source. The accuracy shall not be inferior to the VRM and EBL (see 9.5.2 and 9.6);

c) confirm by observation that the cursor readout of the cursor position is available in range and bearing, and in latitude and longitude, either alternatively or simultaneously;

d) confirm by observation that the position of the cursor on the screen is readily identified.

9.7.3 Selection by cursor

9.7.3.1 Requirements

(MSC.192/5.18.3) *The cursor* shall *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.*

9.7.3.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by inspection that all cursor selection and de-selection functions are readily available, easy to use and support the efficient operation of the equipment;

b) confirm the cursor operation within the operational display areas and where provided, outside of the operational area to select modes, functions, vary parameters and to control menus.

9.8 Offset measurement of range and bearing

9.8.1 General

The cursor or the electronic range and bearing line (ERBL), for example, may be used as a means to measure the range and bearing between two remote positions within the operational display area. The functionality of the cursor is described in 9.7.

9.8.2 Electronic range and bearing line (ERBL)

9.8.2.1 Requirements

(MSC.192/5.17) *There* shall *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.*

Where provided, each active ERBL shall have a numerical range and bearing readout, and shall be capable of adjustment to 0,01 NM (or the appropriate metric equivalent) and 0,1°. A coarser range resolution may be provided for range scales higher than 24 NM. The range and bearing readout shall be available in the user dialogue area and may also be made temporally available in the operational display area (for example adjacent to the cursor when the cursor lies over the ERBL).

9.8.2.2 Methods of test and required results

Where provided:

a) confirm by measurement and observation that the ERBL can be used to measure the range and bearing of one position on the display relative to any other position, and also from own ship, within the operational display area;

b) confirm by observation that it is possible to move the ERBL origin from the CCRP to any point within the operational display area and that means are provided to reset the ERBL origin to the CCRP position by a simple operator action;

c) confirm by observation that it is possible to geographically fix the ERBL or to move the ERBL origin at the velocity of own ship;

d) confirm by measurement that the ERBL origin can be positioned within 5 s and a measurement of range or bearing can be taken within 5 s

e) confirm by observation that the active ERBL has a dedicated numerical range and bearing readout. The range and bearing readout shall be available in the user dialogue area and may also be made available in the operational display area (for example adjacent to the cursor when the cursor lies over the ERBL);

f) confirm by observation that the active ERBL is capable of adjustment to 0,01 NM (or the appropriate metric equivalent) in range and 0,1° in bearing. A coarser resolution may be provided for range scales higher than 24 NM;

g) confirm by observation that the presentation of the ERBL is in accordance with IEC 62288.

9.9 Parallel index lines (PI)

9.9.1 General

PI lines are used for blind pilotage, often in conjunction with VRM and EBL. PI lines are presented as a straight lines set at a distance from own ship and set to a true bearing. Two index lines are set in parallel, as a pair, so that one line may indicate the intended ground track and the second may indicate a safety limit. The ranges set do not change when the operator changes the range scale of the display. The bearings set do not change when own ship heading changes.

Parallel Index techniques provide a means of continuously monitoring a vessel's position in relation to the ground track of a pre-determined passage plan. The distance perpendicular to the bearing of the PI line may be set to the planned passing distance from a fixed radar object or a charted object, creating a visual reference such that the object should never cross the PI line. Any deviation due to set and drift or position sensor errors can be readily identified.

In a relative motion display mode, observation of the fixed object's echo moving along the index line will indicate whether the ship is maintaining the planned track. A displacement of the echo from the index line will immediately indicate that own ship is not maintaining the desired ground track.

In a true motion display mode, PI lines move with own ship. As long as the ship remains on track, the echo of the mark will stay on the index line as the index line moves across the display.

9.9.2 PI lines and positioning

9.9.2.1 Requirements

(MSC.192/5.16.1) *A minimum of four independent parallel index lines with a means to truncate, and switch off individual lines,* shall *be provided*.

(MSC.192/5.16.2) *Simple and quick means of setting the bearing and range of a parallel index line* shall *be provided. The bearing and range of any selected index line* shall *be available on demand.*

PI line range settings shall remain constant when the operator changes the range scale of the display and PI line bearing settings shall remain constant when own ship heading changes.

Means shall be provided to reset individual index lines parallel to the own ship heading by a simple operator action.

In addition to on/off selection of individual PI lines, means shall be provided to turn on/off all PI lines as a group.

The operation and use of parallel index lines shall be described in the user manual.

NOTE Navigation lines or fairways, if provided, are subject to the requirements for radar maps (see 9.12).

9.9.2.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by observation that a minimum of four independently adjustable PI lines are available and that they are selectable for display on/off individually and as group including all PI lines;

b) confirm by observation that means are provided to truncate the length of each PI line;

c) verify that the presentation of separately distinguishable PI lines is in accordance with IEC 62288;

d) confirm by measurement that it is possible to set the bearing or range of a PI line within 5 s from selecting the PI function;

e) confirm by measurement with VRM or ERBL that the distance of a PI line from own ship does not change and the true bearing of a PI line does not change when a different range scale is selected, when own ship heading changes, and during true motion operation;

f) confirm by document inspection that the operation and use of PI lines is described in the user manual;

g) confirm by observation that resetting the index lines parallel to ship's heading is provided by a simple operator action;

h) confirm by observation that means are provided to display the bearing and range set for any selected bearing line.

9.10 Bearing scale

9.10.1 General

The bearing scale provides a quick method to assess the bearing of own ship's heading or the bearing of an object, within the operational display area.

9.10.2 Bearing scale presentation

9.10.2.1 Requirements

(MSC.192/5.13.1) *A bearing scale around the* periphery *of the operational display area* shall *be provided. The bearing scale* shall *indicate the bearing as seen from the common consistent reference point (CCRP).*

(MSC.192/5.13.2) *The bearing scale* shall *be outside of the operational display area. It* shall *be numbered at least every 30 degrees and have division marks of at least 5°. The 5° and 10° division marks* shall *be clearly distinguishable from each other. The 1° division marks may be presented where they are clearly distinguishable from each other.*

If the position of the CCRP results in part of the bearing scale not being distinguishable (compressed), that section of the bearing scale shall be indicated with the appropriate reduced detail.

If the CCRP is positioned outside of the operational area the user manual shall describe how this is addressed and any subsequent limitations in the use of the bearing scale.

9.10.2.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by observation that the bearing scale is provided outside and around the perimeter of the operational display area;

b) confirm by observation that the bearing scale is numbered at least every 30° and has division marks of at least every 5°;

c) confirm by observation that the 5° division marks are clearly distinguishable from the 10° division marks;

d) confirm by observation that where presented, the 1° division marks are clearly distinguishable from each other;

e) confirm by observation that the bearing scale shows the bearing with respect to the CCRP;

f) confirm by observation or by document inspection that if the position of the CCRP results in part of the bearing scale not being distinguishable (compressed), that section of the bearing scale is indicated with the appropriate reduced detail;

g) confirm by document inspection that if the CCRP is positioned outside of the operational area, the user manual describes how this is addressed and any subsequent limitations in the use of the bearing scale.

9.11 Range rings

9.11.1 General

Range rings provide a calibrated and visual range indication of the range scale selected.

9.11.2 Range ring presentation and measurement

9.11.2.1 Requirements

(MSC.192/5.11.1) *An appropriate number of equally spaced range rings* shall *be provided for the range scale selected. When displayed, the range ring scale* (separation) shall *be indicated.*

(MSC.192/5.11.2) *The system accuracy of fixed range rings* shall *be within 1 % of the maximum range of the range scale in use or 30 m, whichever is the greater distance.*

Range rings shall always be centred at the CCRP.

Range rings shall be spaced to logically separate the range scale into equal divisions. Typically from two to six range rings would be provided for nautical mile range scale units, and up to five rings for metric range scale units.

(MSC192/5.11.2) *The system accuracy of range rings* shall *be within 1 % of the maximum range of the range scale in use or 30 m, whichever is the greater distance*.

A means of switching the set of equally spaced range rings on and off shall be provided.

9.11.2.2 Methods of test and required results

The methods of test and the required results are as follows:

a) verify that range rings are presented in accordance with IEC 62288. Confirm by observation that if range rings are selected for display the separation (distance) between the range rings is indicated;

b) confirm by observation that the number of range rings provides a logical calibration and subdivision of the range scale, with typically two to six rings for nautical mile range scales, and up to five range rings for metric range scales;

c) confirm by observation that range rings are always centred at CCRP;

d) confirm by measurement to a calibrated reference, a known feature or target that the system accuracy of fixed range rings is within 1 % of the maximum range of the range scale in use or 30 m, whichever is the greater distance. Confirm that the accuracy meets

the requirement using a calibrated signal generator or equivalent verified signal source, for example a target or feature with an accurately known range;

e) confirm by inspection that a means of switching the set of range rings on and off is provided.

9.12 Radar maps

9.12.1 General

A radar map is a combination of user-defined map lines and symbols. User-generated features shall be retained in a non-volatile memory.

9.12.2 Map functions and display simple user-defined maps

9.12.2.1 Requirements

(MSC.192/5.32.1) *It* shall *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* shall *be possible to remove the display of this data by a simple operator action.*

The map information displayed is limited to items in Table 9;

9.12.2.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by observation that the map functions provided meet the requirements stated;

b) confirm by document inspection that the user manual clearly describes these functions, their application, and any limitations that may apply;

c) confirm by observation that functions to suppress maps and to switch maps on and off are provided. The map suppression function may be combined with the suppression of other functions and shall be permanently available as a temporary suppress control function when maps are in use. The map on/off functions shall at least be available in a top level menu;

d) verify that any provision for vector charts is compliant with Clause 11 in this standard;

e) other external features or layer-structured sources of mapping data may be provided.

9.12.3 Map memory and transfer

9.12.3.1 Requirements

(MSC.192/5.32.5) *The maps /navigation lines / routes* shall *be retained when the equipment is switched off.*

(MSC.192/5.32.6) *The maps/navigation lines/route data* shall *be transferable whenever a relevant equipment module is replaced.*

9.12.3.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by observation that when maps are constructed and saved, they are retained in non-volatile memory;

b) confirm that maps are available after the equipment is switched off and switched on again;

c) confirm by document inspection that instructions for transferring saved map data to a replacement module are provided.

9.12.4 Map presentation properties

9.12.4.1 Requirements

(MSC.192/5.32.2) *The maps / navigation lines / routes may consist of lines, symbols and reference points.*

(MSC.192/5.32.3) *The appearance* (presentation) *of lines, colours and symbols* shall be *as defined in* IEC 62288.

(MSC.192/5.32.4) *The maps /navigation lines /routes* shall *not significantly degrade the radar information.*

The map symbols used to display the information shall be similar in shape to those defined for chart objects in Annex A of IHO S-52.

The colours listed in Table 9 shall be used. Where these are not automatically selected, the operating manual shall clearly show how this is to be achieved. Alternatively, radar maps may use the colours specified for chart features in IHO S-52.

Table 9 – Features and colours to be used for radar maps

Mapping feature	Colour to be used
Coastline (high water)	White
Own ship safety contour [a]	Grey
Indication of isolated underwater dangers of depths less than the safety contour which lie within the safe water defined by the safety contour	Magenta
Indication of isolated dangers which lie within the safe water defined by the safety contour such as bridges, overhead wires, etc.	Magenta or grey
Buoys and beacons, whether or not these are being used as aids to navigation	Red or green
Traffic routeing systems	Magenta
Prohibited and restricted areas	Magenta
Boundaries of fairways and channels	Grey
Radar background	Black or blue
[a] When the “own ship safety contour” feature is used, the dangerous side should be clearly indicated, for example by colour fill, hatching, double lines, or broken line on the dangerous side.	

9.12.4.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by observation that map features, navigation lines, routes symbols and colours conform to these requirements

b) confirm by observation that the map features, navigation lines and routes do not significantly degrade the radar information.

9.13 Navigation routes

9.13.1 General

A navigation route is provided, for example by a chart display, an electronic position fixing system, or from an integrated navigation system.

9.13.2 Route display and monitoring

9.13.2.1 Requirements

The capability of displaying routes on the radar may be provided. If provided, tests shall be conducted to ensure that the routes are correctly calculated, and they are presented according to IEC 62288.

If a route monitoring facility is provided, it shall comply with the requirements of IEC 61174 and with Clause 12 in this standard.

9.13.2.2 Methods of test and required results

The methods of test and the required results are as follows:

a) if route functions are provided, confirm by observation that a means to load/enter routes is provided;
b) confirm by observation and simulation that an entered simulated route is correctly displayed and that the simulated route is calculated correctly according to a known solution;
c) confirm by observation that the presentation of route information is according to IEC 62288;
d) confirm by observation that if the function provided, the process of monitoring the loaded route operates correctly in terms of waypoint calculation, and that the monitoring process operates in compliance with IEC 61174;
e) confirm by observation that the radar presentation is not significantly degraded by the presentation of a route.

10 Orientation, motion and stabilisation

10.1 General

The radar system is required to support various azimuth orientation, motion and stabilisation modes.

10.2 Azimuth orientation

10.2.1 Accuracy of alignment

10.2.1.1 Requirements

(MSC.192/5.19.1) *The heading information* shall *be provided by a gyrocompass or by an equivalent sensor with a performance not inferior to the relevant standards adopted by the* IMO (IMO A.424(XI), A.821(19) and MSC.116(73)).

(MSC.192/5.19.2) *Excluding the limitations of the stabilising sensor and type of transmission system, the accuracy of azimuth alignment of the radar presentation* shall *be within 0,5° with a rate of turn likely to be experienced with the class of ship.*

The radar system shall be designed to operate with a rate of turn of 20°/s, irrespective of the class of equipment.

10.2.1.2 Methods of test and required results

NOTE This test is divided into three sections to address different heading sensor interfaces. It is not mandatory to supply all interfaces.

10.2.1.2.1 Common to all heading sensor interfaces

The methods of test and the required results are as follows:

a) confirm by observation that the equipment continues to operate satisfactorily in the head up mode (unstabilised azimuth) when the heading-sensor input is inoperative;

b) confirm by observation that when the heading-sensor simulator is switched off, or the data connection removed, the equipment reverts to the backup mode (head-up) and that a warning is indicated;

c) confirm by document inspection that the functional limitations and instructions for interfacing with different types of gyro-compasses or heading sensors are described;

d) confirm by document inspection that a statement is included within the installation manual that requires a gyro-compass or equivalent heading sensor having an update rate that is adequate for the ship's rate of turn.

10.2.1.2.2 Analogue heading sensor interfaces

The display presentation mode of the radar shall be set to north-up. The output from a gyro-compass, or compass simulator, or other equivalent heading source shall be applied to the radar. The heading change shall be applied in a clockwise direction and shall increase from 0°/s to 20°/s in approximately 3 s.

The methods of test and the required results are as follows:

a) confirm by measurement that with a rotation rate of 20°/s applied for at least 60 s and then stopped after an appearance of the heading line, at the next appearance of the heading line, the error in alignment in degrees does not exceed 0,5°;

b) confirm by measurement, that repeating the procedure in a) and by applying the heading change in an anti-clockwise direction, the error in alignment in degrees does not exceed 0,5°;

c) confirm by measurement that when the tests are repeated with the display presentation orientation mode of the radar changed to course-up, the error in alignment in degrees does not exceed 0,5°;

d) confirm by measurement that when the changeover from one orientation presentation mode to another (for example north-up to course-up), there is an accuracy of 0,5° achieved within 5 s.

If analogue interfaces are provided for heading systems which do not provide a turn rate up to 20°/s, for instance synchro-servo gyro systems, the minimum turn rate should be 12°/s. The manufacturer should state any limitations in the equipment manual.

10.2.1.2.3 Digital heading interfaces

The methods of test and the required results are as follows:

a) confirm that when the serial heading information update rate is set to the minimum as specified by the manufacturer, it complies with the tracking accuracy required, by using scenario 2 in 11.3.14.4 and scenario 3 in 11.3.14.5;

b) confirm by observation that heading sensor parameters which are available in a menu are located in an installation menu and are protected against inadvertent changes.

10.2.2 Heading readout and reference

10.2.2.1 Requirement

(MSC.192/5.19.3) *The heading information* shall *be displayed with a numerical resolution to permit accurate alignment with the ship gyro system.*

(MSC.192/5.19.4) *The heading information* shall *be referenced to the consistent common reference point (CCRP).*

For analogue systems alignment of the heading shall be done in such a way as to prevent inadvertent adjustment of the heading reference.

10.2.2.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by observation that the heading refers to the CCRP and that the readout has a resolution to 0,1°;

b) confirm by observation that for analogue systems the inadvertent alignment of the heading is prevented, for example by the use of two operator actions.

10.2.3 Azimuth stabilisation update

10.2.3.1 Requirements

For digital interfaces, the heading data update rate shall be sufficient to maintain the tracking accuracy required.

10.2.3.2 Methods of test and required results

Confirm by measurement that the heading data update is adequate by conformance with scenario 2 in 11.3.14.4.

10.3 Motion and orientation modes

10.3.1 General

Display modes include the required own ship motion and azimuth orientation modes.

10.3.2 True and relative motion

10.3.2.1 Requirements

(MSC.192/5.20.1) *A true motion display mode* and relative motion mode shall *be provided.* The mode shall be indicated.

10.3.2.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by observation that a true motion mode is provided and an indication of the mode is provided;

b) confirm by measurement that the error in speed does not exceed 1 % when the motion of the trace origin at 45 kn shall be measured in true motion over a 6 min period with the 6 NM range scale selected;

c) confirm by measurement that the error in the motion of the trace origin does not exceed 1°, when compared with the compass input to course value;

d) confirm by observation that the relative motion function is available, in which own ship remains stationary on the display and radar video is presented and has a motion relative to own ship position.

10.4 Off-centring

10.4.1 General

The off-centring function provides the means to position the radar antenna and CCRP location within the operational area of the display.

10.4.2 Manual and automatic off-centring

10.4.2.1 Requirements

(MSC.192/5.21.1) *Manual off-centring* shall *be provided to locate the selected antenna position at any point within at least 50 % of the radius,* measured *from the centre of the operational display area.*

(MSC.192/5.21.2) *On selection of off-centred display,* fixed or True Motion*, the antenna position* shall *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.*

(MSC.192/5.9.3) *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* shall *apply to the position of the selected antenna,* not the CCRP.

10.4.2.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by observation that the manual off-centring can position the radar antenna to at least 50 % of the radius relative to the centre of the bearing scale;

b) confirm by observation that if an automatic positioning function is provided for selection of a maximum view-ahead the position of own ship antenna provides the maximum view along the observing ship's course;

c) confirm by observation that automatic off-centring for maximum view ahead and for True Motion provide offset of the antenna position of at least 50 % and not more than 75 % of the distance from the centre of the operational display area;

d) confirm by document inspection that when the manual or automatic off-centring position results in the CCRP being outside of the operational display area, the user manual shall describe how this is addressed and any subsequent limitations in the use of the bearing scale;

e) confirm by observation that the off-centre limits shall apply to the position of the selected antenna, not the CCRP.

10.4.3 Automatic reset

10.4.3.1 Requirements

(MSC.192/5.20.1) *In true motion* (TM), *the automatic reset of own ship may be initiated by own ship's position on the display, or time related, or both.*

(MSC.192/5.21.3) *In true motion* (TM), *the selected antenna position* shall *automatically reset up to* at least *a 50 %,* and not more than 75 %*,* of the radius from the centre of the operational display area, *to a location giving the maximum view along the own ship's course. Provision for an early reset of the selected antenna position* shall *be provided.*

10.4.3.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by observation that the TM reset is positioned to provide maximum look ahead;

b) confirm by observation that all functions which provide an early reset (i.e. a reset before the maximum offset limit with respect to the full off-centring limit that is permitted) operate correctly;

c) confirm by document inspection that the user manual describes the reset options for own ship.

10.4.4 Display orientation

10.4.4.1 Requirements

(MSC.192/5.20.2) *North up and course up orientation modes* shall *be provided.* An azimuth-stabilised *Head-up mode* (see 3.33) *may be provided when the display mode is equivalent to True Motion with a fixed origin (in practice equivalent to the relative motion Head Up mode*);

Head-up mode (see 3.32) shall be provided as a selectable operational mode and as a fallback mode when heading sensor data becomes unavailable; refer to 3.32 head-up (see 10.2.1.2 and 16.2.1).

The user manual shall describe the operation of each mode.

(MSC.192/5.20.3) *A* permanent *indication of the motion and orientation mode* in use shall *be provided.*

10.4.4.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by observation that north-up, course-up and head-up orientation modes are provided and that a permanent indication of the mode selected is given;

b) confirm by document inspection that each mode is described in the user manual;

c) confirm by observation that when north-up is selected:
   - it is an azimuth-stabilised presentation in which north on the bearing scale remains fixed vertically above the CCRP;
   - the heading line points from the CCRP to own ship’s referenced heading on the bearing scale;
   - the true bearing of any target on the display is measured from north.

d) confirm by observation that when course-up is selected:
   - it is an azimuth-stabilised presentation in which the bearing scale can be oriented so that own ship’s course on the bearing scale is vertically above the CCRP;
   - the heading line points from the CCRP to own ship’s referenced heading on the bearing scale. If own ship’s heading differs from the course, then the heading line does not point vertically upwards from the CCRP until the bearing scale is reset (manually or automatically) to reflect the course alteration.

e) Confirm by observation that when head-up (H UP) is selected:
   - it is a presentation mode not stabilised in azimuth with fixed origin in which the radar image is oriented “up” toward the top of the bearing scale;
   - radar echoes and tracked targets are shown at their measured distances and moving in a direction relative to own ship’s heading;
   - the heading line points from the CCRP to the top of the bearing scale showing 000° relative bearing;
   - target trails are relative.

f) confirm by observation that, if provided, when head-up stabilised (STAB H UP) is selected:

- there is a stabilised head-up status indication that is distinct from head-up;
- it is a presentation mode stabilised in azimuth with fixed origin in which the radar image is oriented “up” toward the top of the bearing scale;
- radar echoes and tracked targets are shown at their measured distances and moving in a direction relative to own ship’s heading;
- the heading line points from the CCRP the top of the bearing scale showing own ship’s heading in true bearing;
- the target trails are true or relative.

10.5 Ground and sea stabilisation

10.5.1 Mode and source

10.5.1.1 Requirements

(MSC.192/5.22.1) *Ground and sea stabilisation modes* shall *be provided.*

(MSC.192/5.22.2) *The stabilisation mode and stabilisation source* shall *be clearly indicated.*

(MSC.192/5.22.3) *The source of own ship’s speed* shall *be indicated and provided by a sensor approved in accordance with the requirements of the IMO for the relevant stabilisation mode.*

10.5.1.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by document inspection and by observation, that both sea and ground referenced stabilisation modes are provided and can be selected, and there is an indication of the mode selected and of the stabilisation source;

b) confirm by observation that the stabilisation mode is consistently applied. If different stabilisation modes are applied to specific functions, those functions and modes shall be identified and indicated;

c) confirm by observation that the source of own ship’s speed is indicated and confirm that the installation manual requires that a sensor is connected which is approved in accordance with the requirements of IMO.

10.5.2 Ground stabilisation

10.5.2.1 Requirements

A ground stabilisation mode (i.e. ground-referenced velocity) shall be provided. Ground stabilisation requires an external sensor signal capable of providing an input and an indication of own ship’s speed over ground, for example from an EPFS, SDME or use of stationary tracked reference targets. Any limitations associated with the method of ground stabilisation shall be described in the user manual. If a ground-referenced speed log is used, it shall be dual axis.

10.5.2.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by observation and by using a test signal that own ship data readout provides the speed and course over ground information as COG and SOG, or ship’s speed readout is displayed in longitudinal and athwart ship components;

b) confirm by document inspection that the installation and user manual describes a requirement for connection of an EPFS, SDME or INS equipment approved in accordance with the requirements of the IMO;

c) confirm by document inspection that the user manual describes limitations associated with EPFS or an alternative two dimensional ground stabilising SDME;

d) confirm by observation that the speed source is indicated;

e) confirm by observation that, if a VBW message does not provide valid information for both axes, a warning alert is provided and the received data is not used.

10.5.3 Sea stabilisation

10.5.3.1 Requirements

A sea stabilisation mode (i.e. water-referenced velocity, STW) shall be provided. Sea stabilisation requires an external sensor signal capable of providing an input and an indication of own ship's speed through the water; for example an SDME. Limitations associated with the method of sea stabilisation shall be described in the user manual.

10.5.3.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by document inspection that the installation and user manual describes a requirement for connection of SDME or INS equipment approved in accordance with the requirements of the IMO;

b) confirm by analytical evaluation that when sea stabilisation is selected and a significant set (for example broad on the bow or beam) and drift (for example 5 kn) are applied, the equipment correctly converts water referenced course and speed data to ground referenced values;

c) confirm by observation that the tracked target vectors and related target information equate to the sea stabilisation applied;

d) confirm by document inspection that the user manual includes any limitations associated with the method of sea stabilisation, for example that single axis water logs cannot detect the effect of leeway;

e) if provided, confirm by observation the operation of the pulsed/contact signal input;

f) confirm that the speed on the display log readout is correct and the source is indicated.

11 Aids for collision avoidance

11.1 General

IMO recognises radar as an important tool to aid collision avoidance. Its use is explicitly referenced in Rules 6, 7, 8 and 19 of the International regulations for preventing collision at sea.

The task of collision avoidance shall engage radar targets, target trails, past positions, target tracking and reported AIS targets. A navigational display that provides functionality for the task of collision avoidance, including the provision of CPA and TCPA information, shall as a minimum be compliant with Annex A. Calculations for navigational displays providing and presenting tracked target and AIS information shall be validated according to this clause.

11.2 Target trails and past positions

11.2.1 General

The radar system provides target trails as appropriate for radar echoes and past positions at least for activated AIS targets. Past positions may also be provided in addition to radar trails for tracked targets.

11.2.2 Time and plot requirements

11.2.2.1 Requirements

(MSC.192/5.23.1) *Variable length (time) target trails* shall *be provided, with an indication of time and mode.* An automatic adjustment of time may be provided. *It* shall *be possible to select true or relative trails from a reset condition for all* azimuth-stabilised *true motion* and relative motion *display modes.*

(MSC.192/5.23.2) *The trails* shall *be distinguishable from targets and* shall *be clearly visible under all light conditions.*

Past positions for radar targets may be provided. In this case, variable past positions with an indication of the total plot time and the mode shall be provided.

Automatic values for trail and plot intervals according to the range scale selected may be provided.

11.2.2.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by observation that a function is provided to vary trail time and where available, the past position plot interval;

b) confirm by observation that an indication of time and interval is available as applicable to the functionality provided;

c) confirm by observation that trails and past positions are provided in a consistent mode, either as true or relative;

d) confirm by observation of the equipment and documentation, that if an automatic adjustment of trail time and plot interval is provided, the period is compatible with each range scale;

e) confirm by observation that when provided, there is a means provided to vary the plot total period of past positions. In this case, confirm that the presentation of the total period is readily available;

f) confirm by document inspection that the user manual describes the build-up of trails and past positions during specific conditions, for example from the standby condition. In these circumstances, the indicated trail or past position duration may not have achieved the specified time and a cautionary note shall be provided;

g) confirm by observation that relative trails and past positions are unaffected by the selection of ground or sea stabilisation mode;

h) confirm by observation that true trails are correct when ground and sea stabilisation modes are selected. When ground stabilisation is selected, confirm that ground fixed echoes have no trails, and that when sea stabilisation is selected, a trail is shown related to a set and drift value;

i) confirm by observation that it is possible to select true or relative trails from a reset condition for all stabilised true motion and relative motion display modes. Where the option is provided, true trails are permitted in a stabilised head-up mode;

j) verify in accordance with IEC 62288 that trails and past positions are presented, are clearly visible under all light conditions and are distinguishable from targets.

11.2.3 Trails/past position availability

11.2.3.1 Requirements

(MSC.192/5.23.3) *Either scaled trails or past positions or both,* shall *be maintained and* shall *be available for presentation within 2 scans or equivalent, following* a change of the following conditions:

– *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.*

11.2.3.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by observation that trails and/or past positions (as applicable) are maintained after a reduction or increase of one range scale, after the offset and reset of the radar picture position, and after a change between true and relative trails;
b) confirm by observation that following a change in the offset position of the radar picture and following a true motion reset, trails or past positions are available, if previously visible, within 2 scans. Trails/past positions within the selected range scale shall be maintained even if off-screen due to true motion movement or off-centring;
c) confirm by observation that, following a change between true and relative trails, the selected trail/past position mode is available within two scans if previously visible;
d) confirm by observation that the trails and/or past position functions are maintained on all range scales which provide a tracking function. As a minimum, these range scales shall include the 1,5 NM, 3 NM, 6 NM, and 12 NM range scales.

11.3 Target tracking (TT)

11.3.1 General

11.3.1.1 Requirements

Acquired radar targets are tracked by the radar system based on the target position relative to own ship.

(MSC.192/5.25.1) *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.*

(MSC.192/5.24.3*) The operation of the radar tracking function and the processing of reported AIS information is defined in this standard.*

11.3.1.2 Methods of test and required results

These requirements are tested in 11.3, starting at 11.3.3.

NOTE The target tracking state diagram is shown in Annex G.

11.3.2 Presentation of targets

11.3.2.1 Requirements

(MSC.192/5.24.1) *Targets* shall *be presented in accordance with the performance standards for the Presentation of Navigation-related Information on Shipborne Navigational Displays adopted by the IMO (MSC.191(79)) and with their relevant symbols according to SN/Circ.243*, as referenced in this standard.

(MSC.192/5.24.2) *The target information may be provided by the radar target tracking function (TT) and by the reported target information from the Automatic Identification System (AIS).*

(MSC.192/5.27.2) *The course and speed of a tracked radar target or reported AIS target* shall *be indicated by a predicted motion vector. The vector time* shall *be adjustable and valid for presentation of any target regardless of its source.* The presentation mode shall be clearly

indicated, including, for example true/relative vector, vector time and vector sea/ground referenced stabilisation.

(MSC.192/5.24.5) *As far as practical, the user interface and data format for operating, displaying and indicating AIS and radar tracking information* shall *be consistent.*

11.3.2.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by observation that in testing according to this clause, as far as practical and in support of harmonisation, the user interface and data format provided is similar for target tracking and AIS functions;

b) confirm by observation that when testing according to 11.3, the display and presentation of target tracking and AIS information complies with IEC 62288.

11.3.3 Tracking calculations

11.3.3.1 Requirements

(MSC.192/5.25.1.1) *The automatic target tracking calculations* shall *be based on the measurement of radar target relative position and own ship motion.*

(MSC.192/5.25.1.2) *Any other sources of information, when available, may be used to support the optimum tracking performance* by target association and in the task of collision avoidance.

The manufacturer shall declare the method used and shall provide evidence that the method used is supporting the noted process.

11.3.3.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by document inspection that related collision avoidance information is described in the user manual, and that the user manual describes the use of own ship motion and relative target positions for collision avoidance purposes and target acquisition in accordance with the requirements. The user manual shall include how other sources of information may be used to support optimum tracking performance by target association and in the task of collision avoidance, and should identify any limitations when other sources are used;

b) if other sources of optimum tracking are used, confirm by document inspection and by the manufacturer’s declaration, that they include the other sources used and that the working principles are noted;

c) confirm by analytical evaluation, for example modified tracking scenarios as appropriate, that the methods used by the manufacturer do not degrade the tracking and association results.

11.3.4 Target tracking availability

11.3.4.1 Requirements

(MSC.192/5.25.1.3*) TT facilities* shall *be available on at least the 3 NM, 6 NM, and 12 NM range scales. Tracking range* shall *extend to a minimum of 12 NM*, irrespective of the range scale in use.

11.3.4.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by document inspection and by observation that TT functionality is provided for at least the 3 NM, 6 NM and 12 NM range scales. Record those range scales on which TT functionality is available and record the maximum TT range that the manufacturer's documentation states is available;

b) confirm by document inspection and by observation, using a target simulation as defined in Annex F (or live targets), that the TT function is available up to at least 12 NM, irrespective of the range scale in use;

c) confirm by observation that targets which are outside of the selected range scale continue to be tracked out to the range limit. Observe targets being tracked on the 12 NM range scale and at a range of greater than 3 NM. Select a 3 NM range scale for a period of 1 min and reselect the 12 NM range scale. Confirm that the targets have continued to be tracked.

11.3.5 Classification and tracked target capacity

11.3.5.1 Requirements

(MSC.192/5.24.4) *The number of targets presented, related to display size* and equipment category, shall be as *defined in* Table 1.

(MSC.192/5.25.2.1*) In addition to the requirements for processing of targets reported by AIS, it* shall *be possible to track and provide full presentation functionality for a minimum number of tracked radar targets according to* Table 10.

(MSC.192/5.25.2.2) *There* shall *be a* caution *alert when the target tracking capacity is about to be exceeded and a* warning *alert when it has been exceeded. Target overflow* shall *not degrade the radar system performance.*

Table 10 – Tracked target capacity (subset of Table 1)

	Category of ship/craft		
	CAT 3	**CAT 2**	**CAT 1**
Size of ship/craft	500 gross tonnage	500 gross tonnage to 10 000 gross tonnage and HSC 10 000 gross tonnage	All ships/craft ≥10 000 gross tonnage
Minimum tracked radar target capacity	20	30	40

11.3.5.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by document inspection, that the equipment classification is declared when it is submitted for test and note the Table 10 requirements according to equipment category;

b) confirm by observation and using the target simulator, the radar system can process and track the required number of radar targets as specified in Table 10. The simulator shall provide the required number of test targets arranged (for example in groups) to permit an easy assessment of target count;

c) confirm by observation and using a simulated scenario that there is an caution indication at a nominal 95 % full capacity and that a warning alert is provided when the display presentation capacity is expected to be exceeded. For example with a declared capacity of 40 targets, an caution alert is required at 38 targets and a warning when the 41st target is attempted to be acquired;

d) confirm by observation that there is no obvious degradation in radar system performance under the conditions of target overflow, either in presentation or in processing of information.

11.3.6 Manual acquisition

11.3.6.1 Requirements

(MSC.192/5.25.3.1) *Manual acquisition of radar targets* shall *be provided with provision for acquiring at least the number of targets specified in* Table 1. The specified minimum number of targets to be tracked may be acquired manually, automatically, or a combination of these.

11.3.6.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by observation, the operation and capacity of the manual acquisition function using a test scenario or live targets. The target capacity available using manual acquisition shall be at least that required according to the equipment classification in Table 10;

b) confirm by observation, that a combination of manual acquisition and automatic acquisition (where provided) permits at least the target capacity required according to the equipment classification.

11.3.7 Automatic acquisition

11.3.7.1 Requirements

(MSC.192/5.25.3.2) Automatic acquisition shall be provided where specified in Table 1. In this case, there shall be means for the user to define the boundaries of the auto-acquisition area. The boundaries of the auto-acquisition zone and any exclusion zones shall be clearly identified.

11.3.7.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by observation and using the target scenario simulator, that where applicable in Table 1 (i.e. CAT 1), the automatic acquisition function is available and that the target capacity is compliant to Table 10 above;

b) confirm by observation that any target entering, or detected within, the automatic acquisition area is automatically acquired. A new target symbol compliant with IEC 62288 and a warning shall be provided;

c) confirm by observation that the auto-acquisition zone and any exclusion zone are clearly identified on the display according to IEC 62288.

11.3.8 Motion trend

11.3.8.1 Requirements

(MSC.192/5.25.4.1) *When a target is acquired, the system* shall *be capable of providing the trend of the target's motion within 1 min and the prediction of the targets' motion within 3 min*.

11.3.8.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by observation that once targets are acquired, the system provides the trend of the target's motion within 1 min and a prediction of a target's motion targets within 3 min. The target motion trend and accuracy is measured in 11.3.14;

b) confirm by observation that targets continue to be tracked and that target information is updated automatically.

11.3.9 Visibility of 50 %

11.3.9.1 Requirements

(MSC.192/5.25.4.3) *The system* shall *continue to track radar targets that are clearly and individually distinguishable on the display for 5 out of 10 consecutive scans or equivalent*.

11.3.9.2 Methods of test and required results

Confirm by observation that the relevant test scenario demonstrates that the radar target is continually tracked when it is a clear and individual radar target available for 5 out of 10 scans, or its equivalent, as verified by target 6 in scenario 5 (see 11.3.13).

11.3.10 Tracking algorithm

11.3.10.1 Requirements

(MSC.192/5.25.4.4) The TT design shall be such that target vector and data smoothing is effective, while target manoeuvres shall be detected as early as possible.

When a tracked target or own ship has completed a manoeuvre, the system shall 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.

11.3.10.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by observation that when tracking test scenarios 2 and 3 are exercised, target vector stability is maintained and data is smoothed according to the limits specified in 11.3.13;

b) confirm by observation that the trend and prediction comply with the accuracies required in each test scenario, as defined in 11.3.13.

11.3.11 Target swap

11.3.11.1 Requirements

(MSC.192/5.25.4.5) *The possibility of tracking errors, including target swap,* shall *be minimised by design*.

11.3.11.2 Methods of test and required results

Confirm by observation that target swap does not occur when tracking scenario 4 in 11.3.13 is exercised.

11.3.12 Cease tracking

11.3.12.1 Requirements

(MSC.192/5.25.4.6) *Separate facilities for cancelling the tracking of any one and of all target(s)* shall *be provided*.

11.3.12.2 Methods of test and required results

Confirm by observation and using scenario 5 in 11.3.13, that the functionality for cancelling any one target and also for cancelling all tracked targets is provided.

11.3.13 Target tracking scenarios

Five tracking scenarios are provided to test the target tracking performance:

- scenario 1 applies the sensor errors as defined in Annex E;
- scenarios 2 and 3 test own ship turns in both directions, without sensor errors;
- scenario 4 tests for target swap, without sensor errors;
- scenario 5 provides 10 targets, including one having a 50 % visibility. No sensor errors are applied.

11.3.14 Target motion and tracking accuracy

11.3.14.1 Requirements

(MSC.192/5.25.4.2) *TT* shall *be capable of tracking and updating the information of all acquired targets automatically.*

(MSC.192/5.25.4.7) *Automatic tracking accuracy* shall *be achieved when the tracked target has achieved a steady state, assuming the sensor errors allowed by the relevant performance standards of the* IMO.

(MSC.192/5.25.4.7.1) *The testing standard* shall *have detailed target simulation tests as a means to confirm the tracking accuracy of targets with relative speeds of up to 100 kn. Individual accuracy values shown in* Table 11 *may be adapted to account for the relative aspects of target motion with respect to that of own ship in the testing scenarios used.*

(MSC.192/5.25.4.7.1) *For ships capable of up to 30 kn true speed, the tracking facility* shall *present, within 1 min steady state tracking, the relative motion trend and after 3 min, the predicted motion of a target, within the following accuracy values (95 % probability).*

(MSC.192/5.25.4.7.1) *Accuracy may be significantly reduced during or shortly after acquisition, own ships manoeuvre, a manoeuvre of the target, or any tracking disturbance and is also dependent on own ship's motion and sensor accuracy*. Table 11 provides an indication of typical tracking accuracy, averaged over several tracking scenarios and with minimal sensor errors as described in Annex E. Sensor errors with long periods are not relevant for the tracking scenarios.

Table 11 – Typical tracked target accuracy (95 % probability figures)

Time of steady state min	**Relative course** degrees (°)	**Relative speed**	**CPA** NM	**TCPA** min	**True course degrees** (°)	**True speed**
1 min: trend	11	1,5 kn or 10 % (whichever is greater)	1,0	–	–	–
3 min: prediction	3	0,8 kn or 1 % (whichever is greater)	0,3	0,5	5	0,5 kn or 1 % (whichever is greater)

The radar shall be designed in such a manner that under the most favourable conditions of own ship motion, the error contribution from the radar tracking shall remain insignificant compared to the errors associated with the input sensors.

(MSC.192/5.25.4.7.2) *For ships capable of speeds in excess of 30 kn (typically high-speed craft (HSC)) and with speeds of up to 70 kn, there* shall *be additional steady state measurements made to ensure that the motion accuracy, after 3 min of steady state tracking, is maintained with target relative speeds of up to 140 kn.*

(MSC.192/5.25.1.4) *The radar system* shall *be capable of tracking targets having the maximum relative speed relevant to its classification for normal and for high own ship speed.*

11.3.14.2 Methods of test and required results

The test scenarios differentiate standard and high speed craft by the parameters used. The tests simulate own ship travelling at up to 30 kn (or up to 70 kn for HSC), whilst tracking targets with a speed of up to 70 kn. High rate of turn, own ship and target manoeuvring, target swap, multiple targets on a bearing, acceleration and fading are simulated. The simulator assumes a 2,0° antenna (–3 dB point) horizontal beam width, an antenna rotation rate compatible with the category of equipment, and at a pulse length and pulse repetition frequency as specified by the manufacturer. The operation is tested in a noise free environment, with sensor errors only applied to scenario 1. The equipment is set to the 12 NM range scale, north-up, true vectors (set at 6 min) and relative motion mode with true trails. The scenarios are defined for both standard craft and high speed craft options.

Confirm by measurement, that using the relevant test scenarios for all categories of equipment, the accuracy requirement is met as specified in each scenario:

11.3.14.3 TT Scenario 1

Own ship is travelling at 20 kn. Sensor errors are applied as defined in Annex E. Three targets are tracked as defined in Table 12 and shown in Figure 3. All measurements are relative to own ship.

Table 12 – TT scenario 1, with sensor errors applied

Target number	Speed kn	Course degrees (°)	Start range NM	Start bearing degrees (°)	3 min: end range NM	3 min: end bearing degrees (°)
1	28,3	45	9,5	270	8	270
2	22,4	27	1,12	333	1	0
3	15,3	293	9,25	45	8	45

Table 13 – TT scenario 1, times of measurement task

Time s	Time min: s	Target number	Test task notation	Test Task
0	00:00	T2	A	Acquire target
45	00:45	T3	A	Acquire target
60	01:00	T2	M1	1 min measurement
90	01:30	T1	A	Acquire target
105	01:45	T3	M1	1 min measurement
150	02:30	T1	M1	1 min measurement
180	03:00	T2	M3	3 min measurement
225	03:45	T3	M3	3 min measurement
270	04:30	T1	M3	3 min measurement

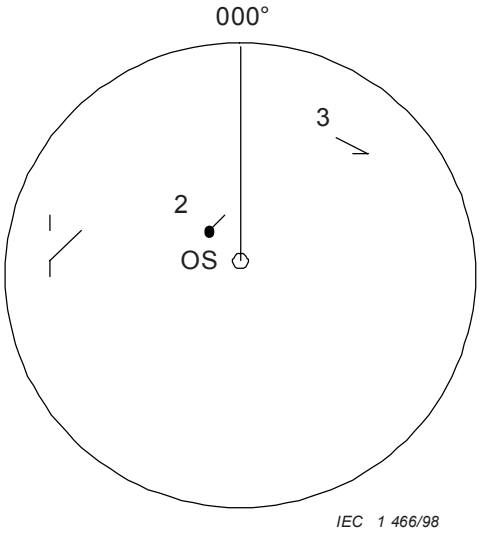


Figure 3 – TT scenario 1

The TT function shall provide accuracies not less than those given in Table 14. The scenario applies the sensor errors defined in Annex E and includes conditions of 10° of roll. Therefore, the limits given in Table 14 will exceed those in Table 11.

For steady state tracking, both own and target ship follow a straight line course at a constant speed. Using the scenarios in Table 13, a TT shall achieve, 1 min after acquisition, the relative motion trend of a target and within 3 min shall achieve the motion of a target, with the following accuracy values (probability values and confidence levels are 95 %).

Table 14 – TT scenario 1, accuracies after 1 min and 3 min (all values)

	Relative course degrees (°)	**Relative speed** kn	**True course** degrees (°)	**True speed** kn	**CPA** NM	**TCPA** min
Target 1						
1 min	11	1,5			1,5	1,8
3 min	3	0,8	5	0,8	0,4	0,5
Target 2						
1 min	11	1,5			1	1
3 min	3	0,8	3	0,8	0,3	0,5
Target 3						
1 min	11	1,5			1	1
3 min	3	0,8	2,5	0,8	0,4	0,5

Scenario 1 shall be repeated 20 times.

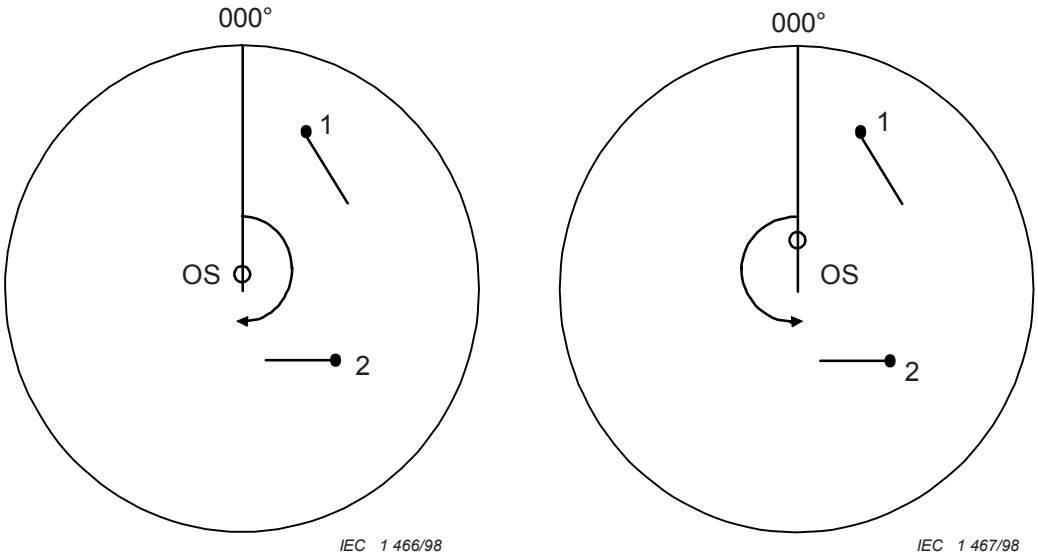
11.3.14.4 TT scenario 2

This scenario 2, shown in Figure 4, simulates own ship, while on an initial heading of 000° and stationary, rotating through 180°, at a turn rate of 10°/s for standard vessels 20°/s for HSC. No sensor errors are applied. Two targets are acquired and tracked for at least 2 min before own ship executes a turn to starboard (scenario 2 – clockwise). The test is repeated with own ship turning to port (scenario 2 – anticlockwise). Initial target data is given in Table 15:

Table 15 – TT scenario 2, own ship turning through 180°

Parameter	Target	
	1	2
Range (NM)	8	5
True bearing (degrees)	23	135
True course (degrees)	135	270
True speed (kn)	30	20

During both scenarios, the targets shall be tracked continuously. The tracking accuracy 1,5 min after the turns have been completed, shall be within 5 % or 1 kn in speed (whichever is the greater) and within 3° in course.



Clockwise Anti-clockwise

Figure 4 – TT scenario 2

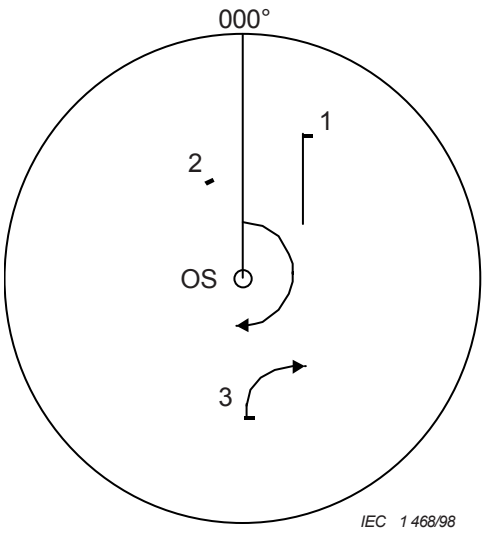
11.3.14.5 TT scenario 3

This scenario 3, shown in Figure 5, simulates own ship, with initial heading of 000° and a speed of 30 kn for standard craft and 45 kn for HSC, executing a turn of 180° at a turn rate of 10°/s. No sensor errors are applied. Three targets are acquired and tracked for at least 2 min before own ship and target 3 both turn to starboard at 10°/s (scenario 3 – clockwise). Own ship turns 180°, while target 3 turns 60°. The test is repeated with own ship and target 3 turning to port (scenario 3 – anticlockwise). Initial target data is given in Table 16.

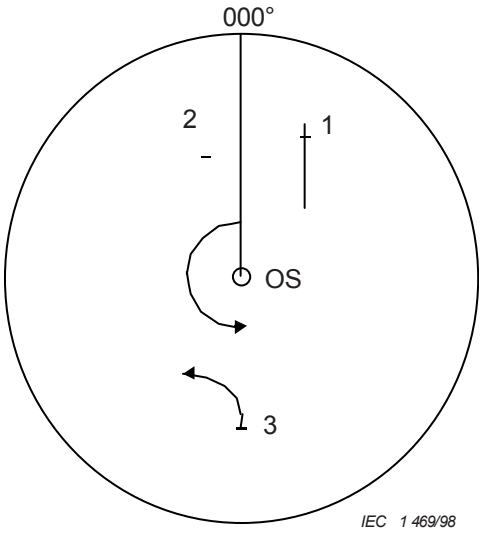
Table 16 – TT scenario 3, initial target data

Parameter	Target		
	1	2	3
Range (NM)	5	3	8
True bearing (degrees)	23	340	180
True course (degrees)	180	–	000
True speed (kn)	45	0	30

During both scenarios, the targets shall be tracked continuously. The tracking accuracy 1,5 min after the turns have been completed, shall be within 5 % or 1 kn in speed (whichever is the greater) and 3° in course.



Clockwise



Anti-clockwise

Figure 5 – TT scenario 3

11.3.14.6 TT scenario 4

This scenario 4 simulates a fast target approaching and passing own ship. No sensor errors are applied. Own ship travels on a heading of 45° at a speed of 28 kn for standard vessels and 70 kn for HSC, on a straight course. A target travels at 70 kn on a reciprocal course.

Own ship and the target's tracks are separated by a buoy. The buoy has a 0,5 NM CPA to both own ship and the target. The high speed target and the buoy are acquired immediately after the scenario has begun (see Figure 6). Initial target data is given in Table 17 and Table 18.

Table 17 – TT scenario 4, initial target data for fast targets (standard speed ships)

Parameter	Target	
	1	2
Range (NM)	2,02	7,01
True bearing (degrees)	031	037
True course (degrees)	0	225
True speed (kn)	0	70

Table 18 – TT scenario 4, initial target data for fast targets (HSC)

Parameter	Target	
	1	2
Range (NM)	5	10
True bearing (degrees)	040	040
True course (degrees)	0	225
True speed (kn)	0	70

The high-speed target and the buoy shall be tracked continuously and without target swap. The target data shall be checked 2 min after acquisition and again 5 min and 7 min after acquisition. The tracking accuracy shall be within 5 % or 1 kn in speed (whichever is the greater) and within 3° in course.

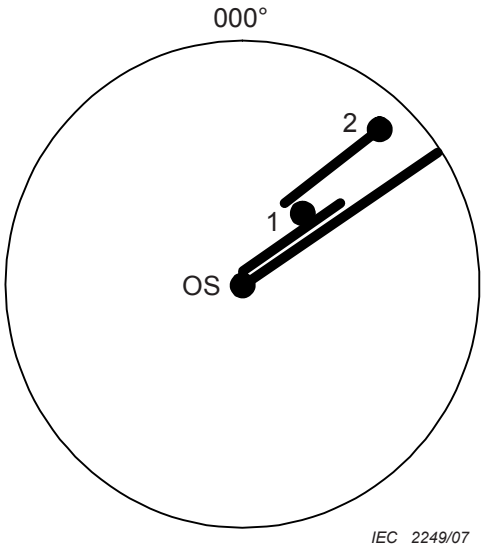


Figure 6 – TT scenario 4

11.3.14.7 TT Scenario 5

This scenario 5, shown in Figure 7, simulates a typical collision situation, with ten ships being tracked and one with zero CPA. No sensor errors are applied. During the scenario, four targets are tracked on a single bearing, tangential targets are tracked, own ship changes speed and performance is tested with a fading target. Own ship is off-centred 50 % towards a bearing of 135°. The heading is 315° true.

a) For standard ship speeds, own ship speed is initially 25 kn. This speed shall be maintained for 7 min. After 7 min own ship speed shall decrease linearly to 15 kn The deceleration shall be at a rate of 0,5 kn/s. The speed of 15 kn shall be maintained for the remainder of the test. Initial target data is given in Table 19.

Table 19 – TT scenario 5: initial target data for standard craft

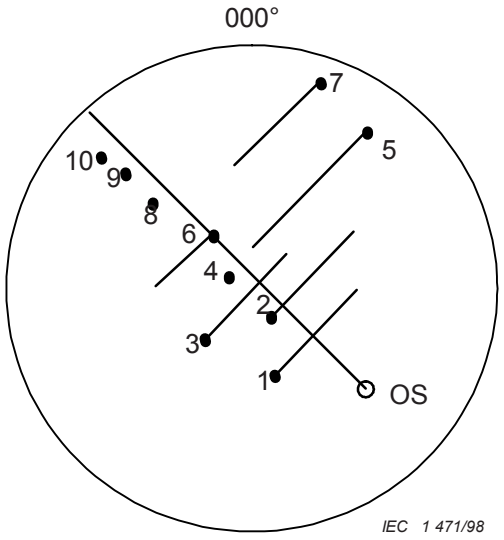
Parameter	Target									
	1	2	3	4	5	6	7	8	9	10
Range (NM)	4,47	5,10	6,71	7,07	12,0	11,0	14,4	8,0	9,0	10,0
True bearing (degrees)	288	304	288	307	352	315	349	318	318	318
True course (degrees)	045	045	045	–	200	225	190	–	–	–
True speed (kn)	20	30	40	0	60	20	40	–	–	–
NOTE Target 6 – fades and has only 50 % paint.										

Target 7 has a zero CPA before the speed change. Targets 4, 8, 9 and 10 are stationary, with targets 8, 9, and 10 on a similar bearing. Crossing targets then provide the fourth target on a bearing. The scenario shall run for 15 min from the start. All targets shall be acquired within the first minute at time t_0, the time when a target is initially tracked. No sensor errors shall be applied.

b) For HSC, own ship speed is initially 60 kn. This speed shall be maintained for 7 min. After 7 min own ship speed shall decrease linearly to 40 kn. The deceleration shall be at a rate of 1 kn/s. The speed of 40 kn shall be maintained for the remainder of the test. Initial target data is given in Table 20.

Table 20 – TT scenario 5: initial target data for collision scenario for HSC

Parameter	Target									
	1	2	3	4	5	6	7	8	9	10
Range (NM)	4,47	5,10	6,71	7,07	12,0	11,0	14,4	13,0	14,0	15,0
True bearing (degrees)	288	304	288	307	357	315	349	313	313	313
True course (degrees)	045	045	045	–	225	225	225	–	–	–
True speed (kn)	20	30	40	0	60	20	40	–	–	–
NOTE Target 6 – fades and has only 50 % paint.										



NOTE The position of targets 8, 9 and 10 are different for standard speed ships and high speed craft scenarios. OS is own ship

Figure 7 – TT scenario 5

For standard ships, own ship reduces speed at 7 min from 25 kn to 15 kn, hence CPA and TCPA will change. For HSC, own ship reduces speed at 7 min from 60 kn to 40 kn, hence CPA and TCPA will change. See Tables 21 to 24.

a) Confirm by observation and by measurement, that all targets are tracked continuously and without target swap. Target course, speed, CPA and TCPA shall be monitored at:

   t_0 3 min, t_0 6 min, t_0 11 min and t_0 14 min.

b) Confirm by measurement that monitored errors in target data shall be within:

   5 % or 1 kn for speed (whichever is greater),

   3° for course,

   5 % of the target range but not less than 0,1 NM for ranges under 6NM for CPA,

   0,3 NM for ranges over 6NM for CPA,

   1 min for TCPA.

Table 21 – Measurement points and results at 3 min and 6 min for HSC

Parameter	Target									
	1	2	3	4	5	6	7	8	9	10
CPA (NM)	0,67	1,37	0,78	0,98	0,63	3,48	0,08	0,45	0,49	0,52
TCPA at 0 min	4,19	4,39	5,55	7,00	8,47	9,90	11,98	12,99	13,99	14,99
TCPA at 3 min	1,19	1,39	2,55	4,00	5,47	6,90	8,98	9,99	10,99	11,99
TCPA at 6 min	–1,81	–1,61	–0,45	1,00	2,47	3,90	5,98	6,99	7,99	8,99

Table 22 – Measurement points and results at 11 min and 14 min for HSC

Parameter	Target									
	1	2	3	4	5	6	7	8	9	10
CPA (NM)	1,10	0,79	0,38	0,98	0,98	3,85	1,06	0,45	0,49	0,52
TCPA at 7 min 20 s	–4,20	–4,12	–2,36	–0,41	1,24	3,00	5,87	8,57	10,07	11,57
TCPA at 11 min	–7,87	–7,79	–6,02	–4,08	–2,43	–0,67	2,20	4,90	6,40	7,90
TCPA at 14 min	–10,87	–10,79	–9,02	–7,08	–5,43	–3,67	–0,80	1,90	3,40	4,90

Table 23 – Measurement points and results at 3 min and 6 min for standard craft

Parameter	Target									
	1	2	3	4	5	6	7	8	9	10
CPA (NM)	0,90	3,22	3,46	0,98	2,12	6,87	0,09	0,42	0,47	0,52
TCPA at 0 min	8,20	6,07	7,32	16,80	9,56	16,10	14,88	19,17	21,57	23,97
TCPA at 3 min	5,20	3,07	4,32	13,80	6,56	13,10	11,88	16,17	18,57	20,97
TCPA at 6 min	2,20	0,07	1,32	10,80	3,56	10,10	8,88	13,17	15,57	17,97

Table 24 – Measurement points and results at 11 min and 14 min for standard craft

Parameter	Target									
	1	2	3	4	5	6	7	8	9	10
CPA (NM)	1,03	3,00	3,43	0,98	2,45	7,87	0,94	0,42	0,47	0,52
TCPA at 7min 20 s	0,62	–2,70	–0,95	16,00	2,25	6,83	8,73	19,95	23,95	27,94
TCPA at 11 min	–3,06	–6,39	–4,64	12,32	–1,43	3,14	5,04	16,27	20,26	24,26
TCPA at 14 min	–6,07	–9,39	–7,64	9,31	–4,44	0,14	2,04	13,26	17,26	21,25

11.3.14.8 Tracking in an over-sea environment

In addition to tracking system tests using simulated targets generated by a target simulator in a noise-free environment, the tracking system shall demonstrate tracking capability in a noisy environment and additionally in a clutter environment.

11.3.14.9 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by observation that when the test targets in scenario 5 are set to 10 dB above peak noise level, they are tracked without degradation of the tracking performance;

b) confirm by observation that when the tracking system is operated in a typical clutter environment and using targets of opportunity (targets of different sizes, speeds and trajectories), continue to be tracked with minimal degradation to tracking performance.

11.3.15 Tracker range and bearing accuracy

11.3.15.1 Requirement

(MSC.192/5.25.4.7.1) *The measured target range* shall *be within 50 m or 1 % of target range, whichever is greater, and the bearing* shall *be within 2°* with the own ship sensor *errors* listed in Annex E (without glint, pitch and roll).

11.3.15.2 Methods of test and required results

Confirm by measurement that two simulated targets as defined in Table 25 meet the accuracy requirements of within 50 m or 1 % of target range, whichever is greater, and within 2° in bearing. The scenario uses two targets which are motionless relative to own ship, and own ship has a speed of 15 kn. Target 1 has a side aspect and target 2 has an end-on aspect.

Table 25 – Measurement of tracked target accuracy

Parameter	Target	
	1	2
Range (NM)	3,0	3,0
True bearing (degrees)	270	000
True course (degrees)	000	000
True speed (kn)	15	15
Aspect	Side	End on

NOTE The target range and bearing accuracy is very dependent on the magnitude of sensor errors and the stability of a tracked target. Accuracy is optimum in a steady state tracking condition and using a stable radar platform. Range and bearing accuracy improve with minimal sensor errors and where there are no sensor errors is comparable with navigation tools, once steady state tracking has been achieved.

11.3.16 Reference target

11.3.16.1 Requirements

(MSC.192/5.25.4.8) *A ground referencing function, based on a stationary tracked target,* shall *be provided. Targets used for this function* shall *be marked with the relevant symbol defined in IEC 62288.*

11.3.16.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by document inspection and by observation, that the ground referencing function, based on one or more stationary tracked targets, is available;

b) confirm by observation that the reference target function is either inhibited when AIS is switched on, or the use of the reference target is limited for the calculation of true speed and course but not for the calculation of relative values of speed, course and CPA/TCPA;

c) confirm by observation that stationary tracked reference targets are labelled with the specified reference target symbol in IEC 62288;

d) confirm by document inspection that the user manual provides a warning that the loss of a reference target may have a major impact on the accuracy of the results for true speed and true course of the target and that own speed will be degraded;

e) confirm by observation that a warning is provided when tracking accuracy is degraded by the loss of the reference target(s). The manufacturer shall declare and explain the techniques used to detect the loss of a reference target;

f) confirm by document inspection that the user manual describes the functionality, limitations and possible loss of accuracy, when the reference target is lost;

g) confirm that the user manual advises that reference targets are only used for the calculation of true speed and how calculation of the relative speed can be dangerous.

11.4 Tracking limitations

11.4.1 Tracking warnings

11.4.1.1 Requirements

(MSC.192/5.25.4.7.1) The testing standard shall have detailed target simulation tests as a means to confirm the accuracy of targets with relative speeds of up to 100 kn. The test programme(s) shall be available so that the overall performance of tracking can be assessed periodically against a known solution. The system shall provide suitable warnings of a tracking malfunction to enable the observer to monitor the correct operation of the system.

11.4.1.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by observation that a test(s) simulation is provided to a known solution and that the simulation, together with the solution, is described in the user manual;

b) confirm by observation that the relevant symbol is indicated for a simulation function according to IEC 62288 and that the malfunction warnings are correctly indicated;

c) confirm by document inspection that the user manual describes warnings of a tracking malfunction;

d) the simulation facility may also provide a familiarisation function as described in 18.1.

11.4.2 Documentation

11.4.3 Requirements

(MSC.192/6.3.2) *The* equipment documentation shall *include a description of the limitations of the tracking process.*

11.4.4 Methods of test and required results

Confirm by document inspection that the limitations of the tracking process are described in the users' manual.

11.5 Automatic identification system

11.5.1 General

(MSC.192/5.26.1) *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.*

AIS can assist in safe navigation and can provide additional information to support the task of collision avoidance. Class A AIS is provided for SOLAS ships and provides full data. Class B AIS is for non-SOLAS craft providing a subset of that data. Different messages for Class A and Class B allow the target category to be identified. The AIS data reporting rate varies according to the status and motion of the ship.

AIS base stations may provide a repeater function so that ships can receive AIS information about other vessels that are not within line-of-sight. However, this can also result in reception of duplicate messages with different latency and different update rates for the same ship as well as reception of delayed AIS messages from own ship.

Where reported AIS targets are provided on a navigational display and the purpose of that display is for collision avoidance, radar video shall be provided and tracked target data from a radar system shall be used. In this case, the reported AIS information shall be time-stamped and the position of the AIS symbology shall be progressively moved according to lapsed time so as to be collocated with the radar video in accordance with 11.8. The navigational display shall not track targets or provide target association functionality unless it is fully compliant with this standard.

NOTE The AIS target state diagram is shown in Annex G.

11.5.2 AIS targets and data report capacity

11.5.2.1 Requirements

(MSC.192/5.26.2) *In addition to the requirements for radar tracking, it* shall *be possible to display and provide full presentation functionality for a minimum number of sleeping and activated AIS targets and AIS data reports according to Table 26. There* shall *be a caution indication when the capacity of processing/display of AIS targets and data reports is about to be exceeded.*

(MSC.191/6.4.2.2) *There* shall *be a* warning alert *when the AIS reported target processing/display capacity has been exceeded.*

The AIS target display capacity defines the minimum number of AIS targets which can be displayed. The equipment shall provide the capability to display a minimum number of AIS target and data reports according to Table 26.

The AIS target processing capacity of the equipment shall provide the capability to process the number of VDM (VHF Data-link Messages) corresponding to 90 % of fully loaded VDL

(VHF Data-link). In that condition, continuous and smooth update of displayed targets and AIS data reports shall be maintained. The worst case conditions result from a very large number of anchored targets or a smaller number of fast moving targets and/or manoeuvring targets.

The user manual shall describe the display capacity and the processing capacity for the equipment and, in addition, shall describe the operation in the event that capacity is at or close to, the maximum provided in each case.

NOTE IEC 61162-1 describes the AIS interface as having a maximum data rate of 4 500 messages per minute.

Table 26 – AIS display capacity (subset of Table 1)

	Category of ship/craft		
	CAT 3	**CAT 2**	**CAT 1**
Size of ship/craft	500 gross tonnage	500 gross tonnage to 10 000 gross tonnage, and HSC 10 000 gross tonnage	All ships/craft ≥10 000 gross tonnage
Minimum part of the total capacity which may be activated AIS ship targets, Class A and Class B	20	30	40
Minimum total capacity for all Class A (active and sleeping), Class B (active and sleeping), AIS AtoN, AIS Base Station, AIS-SART and SAR Aircraft.	120	180	240

11.5.2.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by document inspection that the manufacturer's stated AIS display processing capacity conforms to Table 26;

b) confirm by document inspection, that the user manual describes the operation of the equipment when the display capacity for activated targets has been exceeded and when the total display capacity has been exceeded;

c) confirm by observation, using the reported target simulator (RTS) as described in Annex F and without any AIS target filtering applied (see 11.5.3), that an indication is given at 95 % of the manufacturer capacities;

d) confirm by observation, using the reported target simulator (RTS) as described in Annex F and without any AIS target filtering applied, that the full display capacities are achieved;

e) confirm by observation, using the RTS simulator to provide more than 100 % of the total display capacity and without any AIS target filtering applied, that a warning is provided;

f) confirm by observation with fully loaded VDL, using the RTS simulator to generate a scenario of VDM messages (Message 1 and Message 5) for 130 moving AIS targets updated every 2 s corresponding to approximately 90 % of a fully loaded VDL (VHF Data-link), that the displayed update shows smooth and continuous updates;

g) confirm by observation with very large number of AIS targets, using the RTS simulator to generate a scenario of VDM messages (Message 1 and Message 5) for 6 000 AIS targets at anchor updated every 3 min with one or more moving AIS targets updated every 2 s, that the displayed update of a sample set of 10 displayed AIS targets of both types selected at random shows smooth and continuous updates.

11.5.3 AIS target filtering

11.5.3.1 Requirements

(MSC.192/5.26.3) *To reduce display clutter, a means to filter the presentation of sleeping AIS targets* shall *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* shall *not be possible to remove individual AIS targets from the display.* AIS target filtering provides means for an operator to control the number of displayed AIS targets and data reports within the limits of the display capacity.

The filter criteria in use shall be readily available.

A permanent indication of the filter status shall be provided when the filter is active.

Criteria for filtering to reduce display clutter shall only include sleeping Class A or sleeping Class B when combined with one or more other factors, for example including: CPA/TCPA Speed, Range, Course.

AIS shore based stations may repeat AIS information and target reports with a lower update rate than transmitted from the sending vessel and with latency that is significant and variable. If both repeated and direct AIS reports are received for the same target, the repeated reports shall not be processed for CPA/TCPA or display of AIS target or information. A repeated target report from own ship shall not be processed for CPA/TCPA or display.

11.5.3.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by document inspection that the user manual describes the functionality of the available filters and filter criteria;

b) confirm by observation and using the RTS simulator, the filter provides and conforms to the functions described in the user manual;

c) confirm by observation that it is not possible for the user to select a target manually to remove individual AIS targets from the display;

d) confirm by observation that a permanent indication of the filter status is provided when the filter is active;

e) confirm by observation that means are provided to access display of the filter criteria in use;

f) confirm by observation and using the RTS simulator that selectable criteria for filtering to reduce display clutter only includes sleeping Class A/B when combined with one or more other factors;

g) confirm by analytical evaluation and using the RTS simulator to produce repeated AIS reports for own ship, AIS reports for a nearby AIS target moving at 24 kn and repeated AIS reports for this target with delayed and reduced update rate (for example: delayed by 30 s with a 10 s update rate), that the repeated data is not displayed and does not produce CPA/TCPA data or alarms.

11.5.4 Activation and deactivation of AIS targets

11.5.4.1 Requirements

(MSC.192/5.26.4) *A means to activate a sleeping AIS target and to deactivate an* activated AIS target shall be provided. If zones for the automatic activation of AIS targets are provided, they shall 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). Automatic activation is independent of AIS target filtering. If means are provided for automatic activation of AIS targets, then means for disabling that function shall be provided and the disable status shall be indicated. The

manufacturer shall state what user defined parameters are available and shall show that they are described in the user manual.

11.5.4.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by observation that a function is provided to activate a sleeping target and to deactivate an activated target;
b) confirm by observation that where automatic activation zones are provided, they have the same properties as those provided for automatic radar target acquisition;
c) confirm by observation that a function is provided to automatically activate sleeping AIS targets when those targets meet user defined parameters for activation;
d) confirm by document inspection that the user defined parameters for automatic activation and the associated functionality, if provided, are described in the user manual;
e) confirm by observation that if means are provided for automatic activation, then means for disabling that function and indicating the disable status are provided.

11.5.5 AIS functionality and presentation

11.5.5.1 Requirements

(MSC.192/5.27) *Targets* shall *be presented with their relevant symbols according to the performance standards for the Presentation of Navigation-related Information on Shipborne Displays as described in IEC 62288.*

NOTE Table 4 in MSC.192/5.26.5, AIS presentation status, is not duplicated here as the functionality is included otherwise within this standard.

(MSC.192/5.27.1) *AIS targets that are displayed* shall *be presented as sleeping targets by default.*

(MSC.192/5.27.2) *The course and speed of a tracked radar target or reported AIS target* shall *be indicated by a predicted motion vector. The vector time* shall *be adjustable and valid for presentation of any target regardless of its source.*

(MSC.192/5.27.3) *A permanent indication of vector mode, time and stabilisation* shall *be provided. The AIS vector properties* shall *be generally consistent with those of TT vectors.*

(MSC.192/5.27.4) *The consistent common reference point* shall *be used for the alignment of tracked radar and AIS symbols with other information on the same display.*

(MSC.192/5.27.5) *On large scale / low range displays, a means to present the true scale outline of an activated AIS target* shall *be provided.*

(MSC.192/5.27.5) *It* shall *be possible to display the past track of activated targets*.

To provide co-location for radar video and for AIS symbology, the reported AIS information shall be time-referenced so that AIS symbology shall be progressively positioned according to its velocity.

The co-location for radar video and for AIS symbology shall be provided independently from the selected speed reference.

Radar shall be able to handle and display the following VDL messages for AIS targets and AIS data reports:

a) Messages 1, 2, 3 and 5 (class A AIS and AIS-SART);

b) Messages 18, 19 and 24 (class B AIS);

c) Message 4 (AIS Base stations);

d) Message 9 (AIS on Airborne SAR craft);

e) Message 21 (AIS for ATON);

f) Messages 12 and 14 (Safety related messages).

NOTE The description of these messages is given in Recommendation ITU-R M.1371.

11.5.5.2 Methods of test and required results

The methods of test and the required results are as follows:

a) Verify in accordance with IEC 62288 that the symbology presented is compliant with requirements for presentation of AIS targets and AIS information;

b) confirm by observation and using the AIS target simulator (RTS simulator described in Annex F) that the AIS processing function provides a sleeping target status by default, and that a symbol compliant with IEC 62288 is provided;

c) confirm by observation that a permanent indication of vector mode (true/relative) and stabilisation reference (sea/ground) is provided, and as a minimum, vector time is readily available in a top level menu;

d) confirm by observation and using the target simulator, that TT and AIS targets' course and speed are represented by a vector which represents predicted motion and that the vector velocity is modified correctly according to the sea/ground stabilisation selected. Confirm that with ground stabilisation selected, ground-fixed targets do not have trails displayed;

e) confirm by observation, that a function is provided for the adjustment for the vector time (length) and that the vector time applies to any target, regardless of source;

f) confirm by observation that the vector presentation properties are according to IEC 62288;

g) confirm by observation that the CCRP is used for the alignment (relevant positioning) of AIS symbols;

h) confirm by observation, that a means to provide a true scale outline of an activated target is available and that the presentation is according to IEC 62288. The outline of the target may be presented automatically, for example by range scale, or can be manually selected;

i) confirm by observation, that the equipment provides functionality to support past track positions for activated AIS targets, and that the past track plot intervals provided are compatible with the range scale selected. Confirm by inspection, that the past track symbols conform to IEC 62288;

j) confirm by observation and using the RTS simulator or live radar target signals that the equipment provides co-location for radar video and for AIS symbology by time-referencing the reported AIS information so that AIS symbology is progressively positioned according to its velocity. The AIS position shall be observed to be co-located with the related radar video on each scan;

k) check by using an RTS simulator or real targets that co-location for radar video and for AIS is present when the target is moving with low speed in an environment with set and drift and a water tracking log is selected on the radar under test;

l) confirm by using an AIS simulator or real AIS targets and data reports that the system is capable of receiving, processing and displaying the following AIS messages in accordance with IEC 62288:

   1) Messages 1, 2, 3 and 5;

   2) Messages 18, 19 and 24;

   3) Message 4;

   4) Message 9;

   5) Message 21;

   6) Messages 12 and 14.

11.6 Radar and AIS target data

11.6.1 Requirements

(MSC.192/5.28.1) *It* shall *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* shall *be identified by the relevant symbol. If more than one target is selected for data display, the relevant symbols and the corresponding data* shall *be clearly identified. There* shall *be a clear indication to show that the target data is derived from the radar or from AIS.*

(MSC.192/5.28.2) *For each selected tracked radar target, the following data* shall *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.*

(MSC.192/5.28.3) *For each selected AIS target the following data* shall *be presented in alphanumeric form:*

– *source(s) 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* shall *also be made available. Additional target information* shall *be provided on request. An indication* shall *be provided in the alphanumeric display when additional information is available. Where sea stabilisation is selected, the CTW and STW* shall *be presented in place of COG and SOG.*

The calculation of data from AIS information shall be verified.

(MSC.192/5.28.4) *If the received AIS information is incomplete, the absent information* shall *be clearly indicated as 'missing' within the target data field.*

(MSC.192/5.28.5) *The data* shall *be displayed and continually updated, until another target is selected for data display or until the window is closed.*

(MSC.192/5.28.6) *Means* shall *be provided to present own ship AIS data on request.*

11.6.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by observation that the equipment provides function to select a target and that when selected, a target data field is provided for that target;

b) confirm by observation that the equipment provides the functionality to support TT information and that the data provided conforms to the requirement;

c) confirm by observation that the target parameters are presented in accordance with the above;

d) confirm by observation that the equipment provides the functionality to support AIS information and that the data provided conforms to the requirement. If the received AIS information is incomplete, confirm that the absent information is clearly indicated as "missing" within the data field;

e) confirm by analytical evaluation and by measurement that the data derived from calculations on AIS information are correct. Verify the calculations by simulating the reported message for 10 AIS targets. The data and graphical presentation resulting from the calculations shall be verified against the known simulation solution. The verification shall include target data, AIS target vectors and the conversion from ground stabilised to sea stabilised information. The accuracy of AIS calculations is verified in 11.8;

f) confirm by observation and by analytical evaluation that the AIS graphical and target related information responds correctly when sea stabilisation is selected. A significant set (for example broad on the bow or beam) and drift (for example 5 kn) shall be applied;

g) confirm by observation and using the target simulator, that it is possible to select TT or AIS information by a simple user action;

h) confirm by observation that a selected target data is displayed and is continually updated, until another target is selected or until the window is closed;

i) confirm by observation that if the EUT provides a function to select multiple targets simultaneously, as a minimum a subset of paired target data is provided, for example CPA/TCPA, range and bearing, course and speed, bow crossing range and bow crossing time (BCR/BCT, see 11.6.3). If more than one target is selected for data display, the relevant symbols and the corresponding data shall be clearly identified;

j) confirm by observation that functionality is available to present own ship data and that the data presentation is in accordance with IEC 62288.

11.6.3 Bow crossing range and time (BCR/BCT)

11.6.3.1 General

The radar system may provide a function to measure bow crossing range and time.

11.6.3.2 Methods of test and required results

Confirm by measurement that when the bow crossing function is provided, all crossing range and time measurements are referred to the ship's bow and not to the CCRP.

11.7 Operational target alerts

11.7.1 CPA and TCPA

11.7.1.1 Requirements

(MSC.192/5.29.1) *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* shall *be given* and shall be identified as such and *the target* causing the alarm shall *be clearly indicated*. CPA and TCPA calculations shall only be provided on navigation displays in compliance with 11.5 and Annex A of this standard.

(MSC.192/5.29.2) *The preset CPA/TCPA limits applied to targets from radar and AIS* shall *be identical. As a default state, the CPA/TCPA alarm functionality* shall *be applied to all activated AIS targets. On user request, the CPA/TCPA alarm functionality may also be applied to sleeping targets.*

AIS ship outline dimension data is not required to be considered in CPA/TCPA for AIS targets. Such capability, if provided, should be described in the user manual.

NOTE Some AIS outlines will be oriented by course over ground and others by heading as SOLAS does not require AIS installations to connect a gyrocompass.

11.7.1.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by observation and using the target simulator that a selection of TT and activated AIS targets which are set to approach own ship and are within the CPA and TCPA limits, shall cause a visual and audio alarm to be activated. The target causing the alarm shall be clearly indicated;

b) confirm by inspection that when the AIS automatic activation for targets meeting CPA/TCPA limits is disabled, the status is indicated;

c) confirm by observation and by document inspection that it is not possible to switch off the TT visual alarm, unless tracking is ceased, or the alarm condition no longer applies. The audio alarm may be disabled for TT;

d) confirm by observation that the same CPA and TCPA function limits are applied to both TT and AIS targets;

e) confirm by observation that the CPA and TCPA function limits apply to all activated AIS targets and sleeping targets on user request;

f) confirm by observation that CPA and TCPA calculations are only provided on navigation displays in compliance with Annex A of this standard;

g) confirm by observation that if AIS ship outline dimension data is considered in CPA/TCPA for AIS targets then this capability is described in the user manual.

11.7.2 New target warning

11.7.2.1 Requirements

(MSC.192/5.29.3) *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,* shall *be clearly identified with the relevant symbol and a warning alert* shall *be given. It* shall *be possible for the user to set ranges and outlines for the zone*. The zone shall be identified and shall be applicable to tracked radar and AIS targets. The zone may also be used as a guard zone for which entering targets give a warning alert but are not acquired (TT) or activated (AIS).

11.7.2.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by observation that where a user-defined acquisition/activation zone facility is provided, the user can set the ranges and boundaries for the zone;

b) confirm by observation where provided and using the target simulator, the operation of the auto-acquisition/activation function. A combination of simulated radar and AIS targets shall be used. The zone shall be set covering a range band from 3 NM to 4 NM, and the 6 NM range scale selected on the equipment. Radar targets shall be acquired as they enter or are detected within a defined zone and AIS targets shall be activated as they enter or are reported within the zone;

c) confirm by observation that the new target, not previously acquired/activated entering the zone, or is detected within the zone, is identified with a symbol in accordance with IEC 62288 and that a warning alert is given;

d) confirm by observation that when used as an activated guard zone, a target entering, passing through or identified within the zone, gives a new target warning.

11.7.3 Lost tracked radar target

11.7.3.1 Requirements

(MSC.192/5.29.4) *The system* shall *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* (known or predicted) *position* shall *be clearly indicated on the display.*

11.7.3.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by observation that using the target simulator and simulating the loss of a target, the last reported (known or predicted) target position is indicated and a lost target warning is given, unless the target has been excluded by a pre-determined range or by preset parameters;

b) confirm by observation and by document inspection that the lost target warning is not activated if the target properties are excluded by the lost target exclusion parameter as described in the user manual;

c) confirm by observation that a lost target symbol is indicated as defined in IEC 62288.

11.7.4 Lost AIS target criteria

11.7.4.1 Requirements

(MSC.192/5.29.5) It shall *be possible to enable or disable the lost target warning function for activated AIS targets. A clear indication* shall *be given if the lost target warning is disabled. A lost target warning function for sleeping targets may be provided.*

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

- *the AIS lost target warning 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 (see Table 27);*

then, the following applies:

- *the last known (or predicted) position* shall *be clearly indicated within the operational area as a lost target and warning* shall *be given;*
- *the indication of the lost target* shall *disappear if the signal is received again, or after the warning has been acknowledged;*
- *a means of recovering limited historical data from previous AIS reports* shall *be provided.*

Table 27 – AIS reporting rates

Category of ship	Nominal reporting interval Class A	Lost target maximum interval Class A	Nominal reporting interval Class		Lost target maximum interval Class	
			B"CS [a]	B"SO" [a]	B"CS" [a]	B"SO" [a]
Ship at anchor or moored and not moving faster than 3 kn (Class B not moving faster than 2 kn)	3 min	18 min	3 min	3 min	18 min	18 min
Ship at anchor or moored and moving at more than 3 kn	10 s	60 s	n/a		n/a	
Ship 0 kn – 14 kn (Class B: 2 – 14 kn)	10 s	60 s	30 s	30 s	180 s	180 s
Ship 0 kn – 14 kn and changing course (Class B: 2 – 14 kn)	3 1/3 s	60 s	30 s	30 s	180 s	180 s
Ship 14 kn – 23 kn	6 s	36 s	30 s	15 s	180 s	90 s
Ship 14 kn – 23 kn and changing course	2 s	36 s	30 s	15 s	180 s	90 s
Ship 23 kn	2 s	30 s	30 s	5 s	180 s	30 s
Ship 23 kn and changing course	2 s	30 s	30 s	5 s	180 s	30 s

[a] AIS Class B does not provide information about the navigational status, anchored or moored.

11.7.4.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by observation that it is possible to enable or disable the lost target warning function for activated AIS targets;

b) confirm by observation that a clear indication is available when the lost target warning function is disabled.

c) confirm by observation, the operation of the lost target warning functionality using the target simulator, and that the last reported (known or predicted) AIS target position is indicated with a lost target symbol according to IEC 62288.

11.8 Target association

11.8.1 General

This function provides the means to associate a tracked target and an activated or sleeping AIS target according to an association algorithm. Time referencing (time stamping) for reported AIS targets and for target tracking information is essential to perform this task.

11.8.2 Association and priority

11.8.2.1 Requirements

(MSC.192/5.30) *An automatic target association function* shall be provided *based on harmonised criteria.* When the function is enabled, it shall *avoid the presentation of two target symbols for the same physical target.* The user may disable the association process.

(MSC.192/5.30.1) *If the target data from AIS and radar tracking are both available, and if the association criteria (for example position, motion) are fulfilled such that the AIS and radar information are considered as one physical target, the activated AIS target symbol and the alphanumeric AIS target data* shall *be automatically selected and displayed*, with the provision of an alternative priority in MSC.192/5.30.2 below.

(MSC.192/5.30.2) *The user* shall *have the option to change the default condition to the display of tracked radar targets and* shall *be permitted to select either radar tracking or AIS alphanumeric data.*

(MSC.192/5.30.3) *For an associated target, if the AIS and radar information become sufficiently different, the AIS and radar information* shall *be considered as two distinct targets. One activated AIS target and one tracked radar target* shall *be displayed. No alert* shall *be raised.*

Association shall be tested in four basic scenarios using the radar's default values for the association criteria. If the difference between the TT and AIS target parameters used for association exceeds the default values, then the targets shall not become associated. Once a TT target and AIS target have become associated, hysteresis shall be applied to the criteria to set the new criteria for disassociation. For practical applications, it shall be permitted to vary the association and disassociation criteria by up to 300 % of the default values. Association for Class A and Class B AIS targets are permitted but the lower update rate on Class B AIS targets may limit or prevent association. The user manual shall describe the association parameter options.

The test scenarios shall use the target scenario simulator (TSS) and radar target simulator (RTS) as described in Annex F without sensor errors and the test shall be conducted when the tracked target has achieved a mature track status.

11.8.2.2 Methods of test and required results

By the means stated, when the EUT is tested to the scenarios provided, the methods of test and required results are as follows:

a) confirm by observation that the user can select either TT or AIS priority and that this default setting is applied to both the graphical and alphanumeric display of all associated targets;

b) confirm by observation that there is an indication available for the priority status, showing either TT or AIS as priority;

c) confirm by observation that the user is able to temporarily switch the alphanumeric and graphical display for an individual target, between AIS and TT information;

d) confirm by observation that when AIS is selected as having priority, and when the target association criteria is fulfilled, the activated AIS target symbol and the AIS target data are automatically selected. In this case, the radar target symbol(s) shall be suppressed or alternatively, the associated target symbol shall be presented according to IEC 62288.

e) confirm by observation that when TT is selected as having priority, and when the target association criteria is fulfilled, the TT target symbol and TT data are automatically selected. In this case, the AIS symbols shall be suppressed or alternatively, the associated target symbol is presented according to IEC 62288;

f) confirm by inspection that if an association disable function is provided and using a target association test scenario, that the association function can be enabled and disabled;

g) confirm by observation and measurement, using the target association test scenarios below that the target disassociation algorithm meets the requirements of target disassociation and in addition, demonstrates that hysteresis has been provided in order to limit the function from hunting (indecision) in the association/disassociation process;

h) confirm by observation that no alert is raised when the targets are disassociated;

i) confirm by observation that when the targets cease to be associated, the two separate targets resume their original symbology for TT and AIS, to demonstrate that the TT continues to track during and after the association period;

j) confirm by observation that the target association and disassociation function meets the requirements of the target test scenarios, each providing association and disassociation tests to known solutions.

11.8.2.3 Association scenario 1

This scenario provides a converging small (class A or class B) AIS target and tracked target with similar speeds, which associate along a parallel track and then diverge, causing the targets to disassociate. Disassociation is due to separation distance.

Table 28 – Association scenario 1, initial TT and AIS target position and data

Parameter	Target	
	TT	AIS
Range (NM)	4	4
True bearing (degrees)	340	340
COG (degrees)	90	90
SOG (kn)	10	10

During the test, own ship is stationary. Table 28 presents the initial target data for this test. The targets will initially follow this course and speed and shall appear in the same position on the display. After an elapsed time of approximately 3 min, the display shall indicate that the AIS target and TT target have become associated and that the appropriate symbol is displayed.

Table 29 presents the AIS target data throughout the test scenario. The TT data will remain constant over the test scenario as provided in Table 28.

Table 29 – Association scenario 1, AIS target data for diverging and converging tracks

Parameter	Elapsed time (min)								
	0	3	4	5	8	10	12	15	16
Range (NM)	4	3,86	3,82	3,77	3,67	3,63	3,72	3,90	3,98
True bearing (degrees)	340,0	347,0	349,4	351,9	359,5	4,7	9,8	16,9	19,1
COG (degrees)	90	90	98	98	98	82	82	82	82
SOG (kn)	10	10	10,1	10,1	10,1	10,1	10,1	10,1	10,1
Associated	NO	YES	YES	YES	NO	NO	NO	YES	YES

After a period of 4 min from the initial target position, the AIS target will diverge from the TT target track on a bearing of 98° maintaining a 10,1 kn speed. After a period of 5 min and not greater than 8 min from the initial target position, the targets shall disassociate due to the separation distance between the targets.

After 10 min of elapsed time, the AIS target shall change course to a bearing of 082° maintaining a 10,1 kn speed.

After 12 min of elapsed time and less than 15 min of elapsed time, the AIS and TT target shall become associated and the appropriate symbol displayed. The targets shall remain associated for the remainder of the test scenario.

11.8.2.4 Association scenario 2

This scenario provides a Class A target and a tracked target (TT) on a parallel track, with speed changes to cause association and disassociation. The resultant change in speed causes the target bearing difference to cause dissociation in this example. During the test, own ship shall be stationary. Table 30 presents the initial target data for this test.

Table 30 – Association scenario 2, initial TT and AIS target position and data

Parameter	Target	
	TT	AIS
Range (NM)	4	4
True bearing (degrees)	340	340
COG (degrees)	90	90
SOG (kn)	10	10

The targets will initially follow this course and speed and shall appear in the same position on the display. After an elapsed time of approximately 3 min, the display shall indicate that the AIS target and TT target have become associated and that the appropriate symbol is displayed.

Table 31 presents the AIS target data throughout the test scenario. The TT data will remain constant over the test scenario as provided in Table 30.

Table 31 – Association scenario 2, AIS target data for changing speed

Parameter	Elapsed time Min								
	0	**3**	**4**	**5**	**8**	**10**	**12**	**15**	**16**
Range (NM)	4	3,86	3,82	3,80	3,76	3,76	3,80	3,92	3,98
True bearing (degrees)	340,0	347,0	349,4	351,6	358,1	2,4	8,2	16,4	19,1
COG (degrees)	90	90	90	90	90	90	90	90	90
SOG (kn)	10	10	8,6	8,6	8,6	11,4	11,4	11,4	11,4
Associated	NO	YES	YES	YES	NO	NO	NO	YES	YES

After a period of 4 min from the initial target position, the AIS target will decrease speed to 8,6 kn and maintain a bearing of 90°. After a period of 5 min and not greater than 8 min from the initial target position the targets shall disassociate.

After 10 min of elapsed time, the AIS target shall change speed to 11,4 kn and maintain course on a bearing of 90°.

After 12 min of elapsed time and less than 15 min of elapsed time, the AIS and TT target shall become associated and the appropriate symbol displayed. The targets shall remain associated for the remainder of the test scenario.

11.8.2.5 Association scenario 3

This scenario tests for association when AIS and TT targets are very close together but have different course and speed. For this scenario, the TT target and AIS targets approach each other on a reciprocal course. During the test, own ship is stationary.

Table 32 presents the target data for this test.

Table 32 – Association scenario 3, TT and AIS target start position and data

Parameter	Target	
	TT	**AIS**
Range (NM)	3	3
True bearing (degrees)	340	20
COG (degrees)	90	270
SOG (kn)	10	10

The targets will follow this course and speed throughout the scenario and should both reach CPA at approximately 6 min of elapsed time. At the CPA, the range and bearing to the targets will be equal. Monitor the targets for a period of 12 min elapsed time. At no point shall the targets become associated.

11.8.2.6 Association scenario 4

This scenario tests for association as the AIS and TT targets undergo course and speed changes and tests for the continued association as the reporting interval of the AIS changes. Own ship is stationary throughout the test.

Table 33 presents the initial target data for this test.

Table 33 – Association scenario 4, initial TT and AIS target position and data

Parameter	Target	
	TT	AIS
Range (NM)	4	4
True bearing (degrees)	335	335
COG (degrees)	90	90
SOG (kn)	10	10

Targets will initially follow this course and speed and shall appear in the same position on the display. After an elapsed time of approximately 3 min, the display shall indicate that the AIS target and TT target have become associated and that the appropriate symbol shall be displayed.

Table 34 presents the AIS and TT target data throughout the course of the test scenario.

Table 34 – Association scenario 4, TT and AIS target with the same course and speed

Target parameter	Elapsed time Min					
	0	3	4	8	12	16
Range (NM)	4	3,82	3,75	3,45	3,77	4
True bearing (degrees)	335,0	341,8	345,5	0,7	15,8	25
COG (degrees)	90	90	100	80	90	90
SOG (kn)	10	10	15	15	10	10
Associated	NO	YES	YES	YES	YES	YES

During this scenario, both TT and AIS targets will follow the same course and speed as given in Table 34. After the initial association, the targets shall remain associated for the remainder of the test.

Note that In this scenario, dissociation can occur if there is any latency or poor handling of position data that arrives at different times due to changing reporting rates from the AIS. Design should ensure latency is minimal and position data is synchronised.

11.9 Trial manoeuvre

11.9.1 General

A trial manoeuvre function provides a graphical assessment of a predicted situation calculated from a change of own ship's motion.

11.9.2 Trial functions

11.9.2.1 Requirements

(MSC.192/5.31) *The system* shall*, where required by* its category *in* Table 1*, be capable of simulating the predicted effects of own ship's manoeuvre in a potential threat situation and* shall *include own ship's dynamic characteristics. A trial manoeuvre simulation* shall *be clearly identified. The requirements are:*

– *the simulation of own ship's course and speed* shall *be variable*;

– *a simulated time to manoeuvre with a countdown* shall *be provided*;

– *during simulation, target tracking* shall *continue and the actual target data* shall *be indicated;*

– *trial manoeuvre* shall *be applied to all tracked targets and at least to all activated AIS targets;*

– trial manoeuvre shall be permitted in either ground or sea stabilised modes;

– the user manual shall provide guidance for using the trial function.

11.9.2.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by observation and by document inspection that the trial manoeuvre function is provided as required by category of equipment in Table 1;

b) confirm by observation, that functions are provided to permit the user to simulate a change of own ship's course and speed;

c) confirm by observation that there is provision for a function to simulate time-to-manoeuvre;

d) confirm by observation that during simulation, target tracking continues and actual target data is indicated;

e) confirm by observation that trial manoeuvre is applied to all tracked targets and at least to all activated AIS targets;

f) confirm by observation that own ship's dynamic characteristics are included in the trial functionality in terms of turning performance and rate of change of velocity;

g) confirm by observation that the trial manoeuvre is applied graphically to all tracked targets and at least to all activated AIS targets, when relative vectors are selected, and that the vectors update as own ship's course and dynamic characteristics alter (for example rate of turn), as appropriate;

h) confirm by observation that the trial manoeuvre readout and the graphics within the operational display area, including the "trial" symbol, are presented according to IEC 62288;

i) confirm by document inspection that guidance is provided for the trial manoeuvre and that there is an advisory note stating that better information is provided by using relative motion and sea stabilisation (water tracking).

12 Chart radar (optional classification)

12.1 General requirements

12.1.1 General

Radar systems with chart functionality shall be tested in accordance with all of the requirements in this Clause 12. Raster nautical charts (RNC) are not permitted for chart radar applications. Chart presentation requirements are according to this Clause 12 and IEC 62288 and where applicable there is a direct reference to IEC 61174 (ECDIS). A chart radar shall have presentation colours calibrated in accordance with IEC 62288 requirements for testing for colours and intensity.

12.1.2 Chart operation and source

12.1.2.1 Requirements

(MSC.192/5.33.5) *The display of radar information* shall *have priority. Chart information* shall *be displayed such that radar information is not substantially masked, obscured or degraded. Chart information* shall *be clearly perceptible as such*.

(MSC.192/5.33.1) *The radar system may provide the means to display ENC* data *and other vector chart information within the operational display area to provide continuous and real-time position monitoring. It* shall *be possible to temporarily remove the display of chart data by a single operator action* and also to switch charts on and off.

(MSC.192/5.33.2) *The ENC information* shall *be the primary source of chart information and* shall *comply with IHO relevant standards. The status of other chart information* shall *be identified with a permanent indication. Source and update information* shall *be made available* to the user on demand.

12.1.2.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by document inspection that the category of equipment includes the optional chart functionality;

b) confirm by observation that the display of radar information has priority and that chart information is displayed within the operational area bounded by the bearing ring and that radar information is not substantially masked, obscured or degraded. Chart information shall be clearly perceptible as such;

c) confirm by document inspection, that the user manual describes all available chart functionality and that it prohibits the use of RNC charts;

d) confirm by observation that there is a means to temporarily suppress the chart data by a single operator action (as defined in this standard), and that there is a facility to switch charts on and off. The suppress function may be combined with other functions;

e) confirm by observation that the status of other (non-ENC) chart information is identified with a permanent indication when charts are switched on;

f) confirm by observation that an indication of chart source and update information is available to the user;

g) verify the testing colours and intensity in accordance with the test methods and required results of IEC 62288.

12.1.3 Chart elements and availability

12.1.3.1 Requirements

(MSC.192/5.33.3) *As a minimum, the elements of the ECDIS Standard Display* shall *be made available for individual selection by category or layer, but not as individual objects.*

(MSC.191/6.2.3) *The presentation of user-added charted information* shall *comply with the relevant IHO standards as far as practical.*

The selected parts of SENC shall be displayed with no reduction of the information content. Specific information available shall not be displayed as generic information, for example a lateral buoy starboard shall not be shown as a generic buoy.

When chart elements are displayed, additional map information may be provided and in this case, shall be additional to and shall not conflict with, the chart presentation.

The system may provide a function to query information associated with chart objects.

12.1.3.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by observation that the display of radar has priority and that chart information is displayed so that radar information is not substantially masked, obscured;

b) verify in accordance with IEC 62288 that control functions are provided to permit individual selection of chart features by category or layer but not as individual objects, as defined in IEC 62288 for display of chart information on radar;

c) confirm by observation that the selected parts of SENC are displayed with no reduction of the information content for example a lateral buoy starboard shall not be shown as a generic buoy;

d) confirm by observation that if radar maps are displayed at the same time as ENC navigational information, the map information is additional to chart data, colours and graphics are differentiated and that the map symbols shall not degrade the chart presentation;

e) confirm by observation that if a facility has been provided to call up information associated with an object by cursor enquiry on its symbol, then the data shall be presented either outside of the operational display area, as a transparent presentation, or temporarily presented so as to limit masking or degrading the radar image within the radar operational display area. Where this facility is provided, the text shall not appear automatically whenever the object with which it is presented appears on the display. If depth information is displayed, it shall only be presented as it has been provided in the ENC and unchanged by additional attributes, for example tidal information;

f) confirm by observation that, as far as is practical, the presentation of user-added charted information complies with the relevant IHO standards.

12.1.4 Chart reference

12.1.4.1 General

Reference management is required to ensure that the information displayed is correlated and in the same reference and coordinate system.

12.1.4.2 Requirements

(MSC.192/5.33.4) *The chart information* shall *use the same reference and coordinate criteria as the radar / AIS, including datum, scale, orientation, CCRP and azimuth stabilisation mode.*

12.1.4.3 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by observation that a caution alert is given if the input from the position sensor and ENC are of a different geodetic datum to WGS84;

b) confirm by document inspection that the user manual describes the way in which chart information uses the same reference, coordinate criteria and operational properties as the radar and AIS. Any limitations, including permitted range scales and modes, shall also be described in the user manual.

12.1.5 Primary chart information set

12.1.5.1 Requirements

On user request, it shall be possible to select display of the primary chart information set by a dedicated primary control function.

The primary chart information set, a subset of the ECDIS standard display, shall only include coastlines, own ship’s safety contour, dangers to navigation and fixed and floating aids to navigation, as further detailed in IMO Resolution MSC.232(82) Appendix 2: 1.1 coastline, 1.2 safety contour, 1.3 isolated underwater dangers (depth less than safety contour), 1.4 isolated dangers (within safe water as defined by safety contour) and 2.3 buoys, beacons, aids to navigation and fixed structures.

If the safety checking of routes and grounding alert capabilities of ECDIS are provided, then they shall comply with MSC.232(82) in accordance with IEC 61174. If a safety checking capability is not provided in accordance with IEC 61174, then the safety contour, isolated underwater dangers and isolated dangers shall not be displayed and all depth areas shall be represented as a radar background.

IEC 62288 specifies the chart symbols and features to be used for presentation of charted information.

The system may provide a momentary control function to reduce on demand the presented chart information to only coastlines to check the matching of chart information to the radar image.

12.1.5.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by observation and by document inspection that the chart radar provides chart features and symbols that make up the primary chart information set, based on those defined in source documents of IMO Resolution MSC.232(82) and IEC 61174;

b) verify in accordance with IEC 61174 that safety checking of routes and grounding hazards meets the requirements of MSC.232(82) or else confirm by observation that safety contour, isolated underwater dangers and isolated dangers are not displayed and all depth areas are represented as a radar background;

c) confirm by observation that it is possible to select the primary chart information set by a dedicated control function;

d) confirm by observation that areas where no chart data is provided is presented as a radar background;

e) confirm by observation that if provided, it is possible on user request to reduce the displayed chart content to only coastlines as long as the control function is pressed.

12.1.6 Chart stabilisation and chart redraw

12.1.6.1 Requirements

The equipment shall be capable of appropriately stabilising the radar image, tracked radar targets, reported AIS targets, AIS data reports and vector chart information. The operating mode shall be clearly indicated. The vector chart information shall be available in north-up and course-up azimuth stabilised orientation modes and on all appropriate range scales. After a change of range scale or upon radar origin resetting, the new chart shall be displayed at its correct scale within 5 s and that after initiating the change, the chart display shall be suppressed and an indication given until the new chart is fully available.

12.1.6.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by observation of the EUT that ENCs are available in all appropriate azimuth stabilised operational modes and applicable radar range scales;

b) confirm by observation that the ENC information is maintained or re-introduced when the user switches to an alternative method of azimuth stabilization and that the selected mode is indicated;

c) confirm by observation that if the position sensor fails or is switched off, the vector chart information is removed automatically within 30 s. An alternative position information source or dead reckoning (DR) may be provided together with a clear indication;

d) confirm by observation that if the azimuth stabilization sensor fails or is switched off, the vector chart information is removed automatically within 30 s;

e) confirm by observation and by functional test, that while exercising position and rotation at 20°/s and 30 kn, for equipment complying with requirements for standard ships, or 20°/s and 70 kn for equipment complying with high speed craft requirement, for at least 20 consecutive scans. During these tests, the chart and radar images shall remain matched by visual assessment;

f) confirm by observation that after a change of range scale or upon radar origin resetting, the new chart is displayed at its correct scale within 5 s and that after initiating the change, the chart display is suppressed and an appropriate indication is given until the new chart is fully available.

12.1.7 Chart position and latency

12.1.7.1 Requirements

The vector chart information shall be continuously displayed with minimal positioning error and azimuth latency compared with the radar image.

12.1.7.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by measurement on the 24 NM range scale and using ENC information covering the area surrounding 70° N or 70° S, with own ship simulated position to 70° N or 70° S respectively. Measuring the range and bearing to 4 points in the chart by using the radar navigation tools (EBL/VRM and/or cursor), the 4 points are placed at a range between 10 NM and 24 NM and bearings of 45°, 135°, 225° and 315° with a tolerance of 5°. Using the radar tools, the measurements shall be within 0,25 NM in range and 1° in bearing as compared to those taken from the ENC information;

b) confirm by measurement repeating the test above in the azimuth stabilised modes while exercising own ship position and rotation in an arbitrary area between 70° N or 70° S. Using the radar navigation tools, the measurements, shall be within 0,25 NM in range and 1° in bearing as compared to those taken from the ENC information. Rotation rate and speed shall be set to:

   - 20°/s and 30 kn, for equipment complying with requirements for non-high speed craft, or
   - 20°/s and 70 kn for equipment complying with high speed craft requirement,

c) Confirm by observation for at least 20 consecutive scans in each azimuth stabilised orientation mode that the chart and radar images remain matched after each radar update.

d) confirm by observation that the operating mode is indicated;

e) confirm by measurement, repeating the test with azimuth stabilisation off and stopping the rotation, that after 1 min the SENC positioning latency does not exceed one radar scan;

f) confirm by observation that when in the head up mode (unstabilised azimuth) while exercising position and rotation (up to 20°/s), the chart presentation is disabled for the case of the misalignment between ENC information and radar image exceeding 7,5°;

g) confirm by observation when in the head up mode (unstabilised azimuth) and when not changing course, the resulting misalignment between ENC information and radar image does not exceed 1,5°.

12.1.8 Matching and adjustment

12.1.8.1 Requirements

To compensate for any deviations between the chart image and the radar image through detectable causes, manual adjustment of the ENC shall be possible. Any manual adjustment shall be clearly indicated as long as it is activated. Resetting shall be possible in a simple manner.

The ENC information shall match, within appropriate tolerances, the range scale, orientation and projection of the radar information.

(MSC.191/7.1.2) *If a radar image and an electronic chart are displayed together, the chart and the radar image* shall *use a consistent common reference point and match in scale, projection and orientation. Any offset* shall *be indicated.*

(MSC.191/6.2.4) *If the chart data derived from different scales appear on the display, the scale boundary* shall *be clearly indicated.*

12.1.8.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by observation that manual adjustment of ENC information is available, that an indication is given, and that it is simple to reset the manual alignment;
b) confirm by observation that there is an indication when the ENC information is displayed at a larger scale than that contained in the ENC;
c) confirm by observation that the ENC matches the range, scale, orientation and projection of the radar information;
d) confirm by observation that if the chart data derived from different scales appear on the display, the scale boundary is clearly indicated.

12.1.9 Chart symbols, colours, and size

12.1.9.1 Requirements

(MSC.192/5.33.7) *Symbols and colours* shall *comply with the performance standards for the Presentation of Navigation-related Information on Shipborne Navigational Displays adopted by the* IMO (MSC.191(79)).

(MSC.191/5.4.2) *Symbols used for the display of charted information* shall *comply with relevant IHO standards.*

The equipment shall be tested by using the IHO test data sets, plain and encrypted S-57 data, for ECDIS or ENC plain and encrypted S-57 data.

Alternatively, electronic chart information may be presented in shades of grey. Where shades of grey are used, the shades shall be distinguishable between respective chart layers.

In areas where no ENC data is provided, means shall be provided for the operator to select between display of the NO-DATA-Pattern according to IHO S-52 and radar background.

The displayed chart area shall be not greater than the area available for presenting the radar image.

Chart symbols, graphics, data areas and related graphics shall not mask, obscure or degrade the radar image.

The user selection of safety depth may be provided as a single value to be used for both safety depth and safety contour.

12.1.9.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by observation that chart symbols and size are according to IEC 62288;

b) confirm by observation that the display presentation of chart symbols are within the SCAMIN / SCAMAX range as given in IEC 61174;

c) confirm by observation that the colours of chart features are according to IEC 62288. Contrasting colours for radar video shall be presented on a dark background. Display graphics and their colours shall not degrade chart or radar features;

d) confirm by observation that where grey is used for chart information (features), the shade is chosen to distinguish between the respective features and radar information;

e) confirm by observation that colour fill has been used where practical and appropriate, but not if the radar video is masked or degraded;

f) confirm by observation that the coastlines are drawn as a line, with the defined colours differentiating coastal areas;

g) confirm by observation that own ship's safety contour is identified by a line and is further differentiated by colour shade;

h) confirm by observation that radar background and water surfaces in the ENC information shall be in the same basic colour;

i) confirm by observation that day and night modes are provided and that the ENC day and night colours are selected simultaneously with the radar's day/night colour mode. It is permitted to use the same colours for all light conditions;

j) confirm by observation that if the ENC information covers only part of the radar video area, the limits for ENC information are clearly indicated when ENC information is present;

k) confirm by observation that for borderlines between No-Data, Official-Data and Non-Official-Data, the appropriate line styles defined in IHO S-52 are used;

l) confirm by observation that, for areas in which there is no chart data, means are provided for the operator to select between display of the NO-DATA-Pattern according to IHO S-52 and radar background;

m) confirm by observation that if Non-Official-Data is used, a clear indication is given to the user according to IHO S-52;

n) confirm by observation that the displayed chart area is not greater than the area available for presenting the radar image.

12.1.10 Chart display size

12.1.10.1 Requirements

(MSC.192/6.2.3) *The display sizes* shall *conform to those defined in* Table 1*,* according to the equipment category.

12.1.10.2 Methods of test and required results

Confirm by measurement using a flexible transparent ruler that the operational radar and chart area within the bearing scale is compatible with Table 1.

12.1.11 Chart alerts and indications

12.1.11.1 Requirements

If an operational alarm for crossing a safety contour is provided, it shall conform to the ECDIS standard as defined in IEC 61174.

12.1.11.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by observation that an alarm is generated when the vessel is crossing the safety contour within the time specified by the user and according to IEC 61174;

b) confirm by observation that at all times, the safety contour is the one specified by the user or the next deeper contour if the specified one is not available. At a minimum, the user shall be informed by emphasizing the new safety contour. If the mariner does not specify a safety contour, the contour shall default to 30 m. If the safety contour specified by the user is not in the ENC, verify that the safety contour shown defaults to the next deeper contour.

12.1.12 Chart malfunction

12.1.12.1 Requirements

(MSC.192/5.33.6) *A malfunction of the source of chart data* shall *not affect the operation of the radar / AIS system.*

12.1.12.2 Methods of test and required results

Confirm by analytical evaluation and documentation that as far as practical, the design meets the objective and where practical, check that a simulated malfunction of the source of chart data does not adversely affect the operation of the radar/AIS system or restrict the use of unrelated functionality.

12.1.13 Chart radar malfunction

12.1.13.1 Requirements

If the radar fails while ENC information is selected, a warning alert shall be given. The ENC information may be retained.

12.1.13.2 Methods of test and required results

a) Confirm by observation that when the radar signals are removed, a warning alert is provided;

12.2 Additional requirements for standalone radar with chart facilities

12.2.1 General

The following requirements for provision and updating of chart information are relevant for a standalone radar with chart facilities (i.e. if the radar does not get pre-processed SENC information from an associated ECDIS)

Where additional facilities are provided, then the appropriate requirements and tests from IEC 61174 shall apply.

12.2.2 Provision and updating of chart information

12.2.2.1 Requirements

If the chart radar has its own database, it shall comply with the requirements of IEC 61174 for chart maintenance. For encrypted data, it shall fulfil the functional requirements and procedures of IHO S-63.

12.2.2.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm that the updated procedures in accordance with IEC 61174 are fulfilled;

b) confirm that the requirements for encrypted data noted within IHO S-63 are fulfilled.

12.2.3 Content and structure of chart data

12.2.3.1 Requirements

The chart radar shall comply with the relevant requirements of IEC 61174.

12.2.3.2 Methods of test and required results

Verify that the EUT includes a chart library, which lists the ENC in the EUT by edition and date in accordance with IEC 61174.

12.3 Additional requirements for ECDIS back-up (optional)

12.3.1 General

(MSC.232/Appendix 6) Adequate back-up arrangements include:

1 Facilities enabling a safe take-over of the ECDIS functions in order to ensure that an ECDIS failure does not result in a critical situation.

2 means to provide for safe navigation for the remaining part of the voyage in the case of ECDIS failure.

12.3.2 Requirements

If ECDIS Backup capability is provided then, in addition to other requirements for chart radar, the radar equipment shall satisfy the requirements for ECDIS Backup specified in MSC.232(82) Appendix 6 and further detailed in IEC 61174.

NOTE For ECDIS Backup, it is not required to provide means to remove the radar information, AIS information and other navigational information by single operator action.

12.3.3 Test Methods and required results

Verify in accordance with IEC 61174 that the radar equipment complies with ECDIS Backup requirements.

13 Ergonomic criteria (control functions and display)

13.1 General

The general requirements for operational controls are addressed in IEC 60945. Radar-specific control information is listed in Annex I of this standard.

13.2 Operational controls

13.2.1 Requirements

(MSC.192/6.1.1) *The design* shall *ensure that the radar system is simple to operate. Operational controls* shall *have a harmonised user interface and* shall *be easy to identify and simple to use.*

(MSC.192/6.1.2) *The radar system* shall *be capable of being switched on or off at the main system radar display or at a related control position.*

(MSC.192/6.1.3) *The control functions may be dedicated hardware, screen accessed* soft-keys*, or a combination of these. The primary control functions* shall *be* identified and shall be provided *with an associated status indication,* located *in a consistent and intuitive position.*

(MSC.192/6.1.5) *The primary functions may also be operated from a remote operating position in addition to the main controls.*

National Authorities and specific equipment categories (for example HSC) may require the provision of hardware controls for primary functions (see 13.3). The manufacturer shall submit any optional primary hardware controls for approval alongside the soft key functions. Dual operation, by soft key or hardware controls is permitted.

As far as practical, the information within each control-related information group shall be collocated on the radar screen.

13.2.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by document inspection, the category of equipment submitted for testing and the related requirements for that category;

b) confirm by document inspection that any optional hardware controls, including remote control modules, have been submitted and tested with the main equipment;

c) confirm by observation that primary control functions are instantly available. In the case of a soft key function, the use of a cursor and a single soft key is permitted. Check that hardware controls, where provided, have a dedicated or a related function;

d) confirm by observation that the control functions are provided with an associated status indication or description, as appropriate. Any soft keys provided shall be located adjacent to the function status indication;

e) confirm by observation that the location of the on/off control for an individual radar position and its associated radar sensor (transceiver and antenna) is conspicuous and easily accessible under all operational and ambient light conditions. Check that the radar on/off control is normally mounted at the radar display or at a related and logical position;

f) confirm by document inspection of submitted documentation, that the manufacturer has conducted a user performance evaluation with a representative user. The report shall demonstrate that the operation of the radar system can satisfy the safety of navigation requirements of the current version of the IMO STCW code (Standards of Training, Certification and Watch-keeping for Seafarers) radar training course;

g) confirm by observation and document inspection that the radar control display information is presented in logical functional groups according to the ergonomic requirements of IEC 60945. As far as practical, the information within each control-related information group shall be collocated on the radar screen.

13.3 Primary controls

13.3.1 Requirements

(MSC.192/6.1.4) *The following are defined as primary radar control functions and* shall *be easily and immediately accessible:*

Radar standby / run (transmit)*, range scale selection, gain, tuning function (if applicable), anti-clutter rain, anti-clutter sea, AIS function on/off, alert acknowledge, cursor, a means to set EBL/VRM, display brightness and acquisition of radar targets.*

13.3.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by observation that the specified primary control functions are available. For the purposes of this standard, the listed functions shall be directly accessible and immediately effected by dedicated controls or by primary access on the display within the user

dialogue area. Alternative solutions which meet the functional requirements may be provided;

b) confirm by observation that if these functions are provided as soft keys, that any optional hardware-based control panels provided shall be tested with the EUT;

c) confirm by observation that where discrete controls are available for the EBL and VRM, they are ergonomically positioned for simultaneous operation, on the left and right hand side respectively;

d) confirm by observation that the control functions are logically grouped in conformance to the requirements of IEC 60945 and that the grouping, as far as practical, conforms to Annex I of this standard.

13.4 Control properties

13.4.1 Requirements

It shall be possible to locate and control the panel illumination (where applicable), monitor brightness/contrast (as applicable) and on/off by tactile and/or visual means. If panel illumination is provided, the illumination shall be even and supportive of night vision. The following functions shall be continuously variable or in small, quasi-analogue steps:

– monitor brightness/contrast;

– VRM, EBL;

– cursor;

– tuning (if manual);

– rain, gain, sea.

The illumination of controls shall be in accordance with IEC 60945.

13.4.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by observation that listed controls can be located in a dark environment by tactile and/or visual means;

b) confirm by observation in a darkened environment, ranging from zero light to dusk conditions, that the illumination (where provided) meets the requirements;

c) confirm by observation that the illumination complies with IEC 60945.

13.5 Default control setting and saved user control settings

13.5.1 Requirements

A default setting speeds familiarisation by quickly putting operator controls in a known state, a uniform starting-point for all radars from which further adjustments can be made to suit the conditions at hand. The configuration specified in Table 35 shall be selectable by a simple operator action followed by an action to confirm the selection.

A facility shall be provided to store and recall user-specific settings that result after adjustments to suit the conditions at hand. At least two such configurations shall be stored for recall. Selection for recalling a stored configuration shall be followed by an action to confirm the selection.

Table 35 – Control settings configured in response to 'Default' selection

Function	Setting
Band	*X-band, if selectable*
Gain and anti-clutter functions (Sea, Rain)	*Automatically optimized* where provided or leave manual controls set 'as is'
Tuning	*Automatically optimized* where provided or leave manual tuning set 'as is'
Range	*6 NM*
Fixed range rings	*Off*
VRMs	*One VRM on*, 0,25 NM
EBLs	*One EBL on*
Parallel index lines	*Off or last setting, if applied*
Display mode of the radar picture	*True motion, north-up*
Stabilization Sea/Ground	Ground (SOG, COG)
Off-centring	*Appropriate look-ahead*
Target trails	*On,* 6 min (same as vector)
Past positions	*Off*
Radar target tracking	*Continued*
Vector mode	*Relative*
Vector time	*6 min*
Automatic radar target acquisition	*Off*
Graphical AIS reported target display	*On*
Radar and AIS Target fusion	Association *On*
Operational alarms (except collision warnings)	*Off*
Collision warnings	*On (limits CPA 2 nm; TCPA 12 min)*
Display of maps, navigation lines and routes	*Last setting*
Display of charts	*Off*
NOTE The text in italics derives from the INS default settings given in MSC.252(83).	

13.5.2 Test methods and required results

Confirm by observation that a default setting selection, clearly labelled for example "Default Setting", is provided by a simple operator action followed by an action to confirm the selection.

Confirm by observation that the result of the default settings selection matches Table 35.

Confirm by observation that means are provided to store and recall at least two different user-specific control setting configurations.

Confirm by observation that a selection to recall one of these configurations is followed by a confirming action.

Confirm by inspection of the user manual that the default setting capability and user-specific store/recall of control settings is fully described.

14 Interfacing

14.1 General

The equipment shall provide inputs for interfacing sensors and related navigation systems, and output interfacing to provide information for other navigation displays.

14.2 Input interfacing

14.2.1 Input data

14.2.1.1 Requirements

(MSC.192/8.1) *The radar system* shall *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);* and
– *an automatic identification system (AIS); or*
– *other sensors or networks providing equivalent information acceptable to the* IMO for example an INS.

(MSC.192/8.1) *The radar* shall *be interfaced to relevant sensors required by these performance standards in accordance with recognised international standards.*

Interfaces for inputs compliant to IEC 61162 shall be provided and shall support the sentences specified in Annex H.

14.2.1.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by document inspection that there is provision for receiving the required input information from the sensors listed;
b) confirm by document inspection and by observation, that there is a means to configure the input data to provide compatibility with the source. The interface configuration shall not be accessible in an operational mode and shall be protected (for example by a password or hardware device) from inadvertent adjustment;
c) confirm by document inspection and by observation that the parameters are retained either in hardware (for example by links) or in non-volatile memory and that the user manual describes how the parameters can be transferred when relevant hardware is replaced in the equipment;
d) confirm by document inspection that there is provision for IEC 61162 interfaces and that these are described in the manufacturer's documentation;
e) confirm by measurement that inputs comply with IEC 61162 by testing with a simulated signal a sample of each type of serial interface provided and each of the mandatory sentences listed in Annex H, including a test at the maximum data loads or rates specified;
f) if no suitable IEC 61162 interface is available, an alternative appropriate interface may be used and shall be tested to the manufacturer's information; for example an analogue interface to a heading sensor or pulsed/contact signals for SDME. Where alternative interfaces are provided, check that the application, basic protocol and connectivity are explained in the user and installation manuals.

14.2.2 Input quality, integrity and latency

14.2.2.1 Requirements

(MSC.192/8.2.1) *The radar system* shall *not use data indicated as invalid. If input data is known to be of poor quality, this* shall *be clearly indicated.*

(MSC.192/8.2.2) *As far as is practical, the integrity of data* shall *be checked prior to its use by comparison with other connected sensors or by testing to valid and plausible data limits.*

(MSC.192/8.2.3) *The latency of processing input data* shall *be minimised.*

14.2.2.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by observation of the EUT that when a serial message with invalid data is provided, the radar system does not use the data for any calculation and that the information is indicated as invalid;

b) confirm by observation where appropriate and as far as is practical, that the radar system compares input data against implausible limits. Verify where possible, that the design checks the integrity of data by comparison with related data from other sensors. For example, if two position inputs are available, these can be compared.

c) confirm by observation that the design of the radar system, where practical, ensures that the latency of processing an input serial message is less than 1 scan or 1 s, whichever is the lesser.

14.3 Output interfacing

14.3.1 Output format

14.3.1.1 Requirements

(MSC.192/8.3.1) Where practical*, information provided by any radar output interface to other systems* shall *be in accordance with international standards (publication IEC 61162).*

To provide use activity information to BNWAS, an EVE sentence as specified in IEC 61162-1 shall be output in response to user-interaction with the radar under conditions described in the user manual.

OSD and RSD sentences shall also be output. Output data values shall be referenced to the CCRP.

14.3.1.2 Methods of test and required results

Confirm by measurement that appropriate output interfaces conform to the IEC 61162 series, in terms of message content and hardware compatibility. In this case, “appropriate” means where practical and available. Monitor sample output messages to confirm conformity

Confirm by observation that the radar outputs an EVE sentence under the conditions described in the user manual and the OSD and RSD sentences.

NOTE Test of CCRP use is specified in 8.1.3.2.

14.3.2 Output target data

14.3.2.1 Requirements

The radar system shall provide target data via a serial interface for transfer to other navigational equipment using the TTD sentence. New associated targets shall be reported

using the TLB sentence. If MMSI information is available it shall be included in the TLB sentence. The recommended TLB field “Label assigned to target ‘n’” for MMSI 123456789 is “MMSI=123456789”.

14.3.2.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by measurement that outputs comply with IEC 61162 by testing samples of each type of interface provided and each of the target data sentences, including a test at the maximum data loads or rates specified;

b) confirm by observation that the tracked target data conforms to IEC 61162 and that all data is correctly identified within the output message;

c) confirm by observation using the target simulator, that each tracked target has a unique track identification number and MMSI if available;

d) confirm by observation and using the target simulator, that the EUT is capable of providing a tracked target data message for the maximum number of tracked targets and activated AIS targets for that category of equipment.

14.3.3 VDR interface

14.3.3.1 Requirements

(MSC.192/8.3.2) *The radar system* shall *provide an output of the display data for the voyage data recorder (VDR).*

The radar system shall provide at least one of the following interfaces for connection to a VDR:

- analogue RGB, buffered output dedicated to VDR
- digital visual interface (DVI), buffered output dedicated to VDR
- Ethernet UDP in accordance with IEC 61162-450
- Ethernet TCP in accordance with Annex H.2.

NOTE For Ethernet interface, IEC 61162-450 supersedes use of Annex H.2 and Annex H.2 is no longer recommended for use in new equipment.

Where an analogue RGB output are provided, the interface shall meet the timing specifications of VESA DMT, where that standard refers to screen of 1 280 × 1 024 and refresh rates between 60 Hz and 85 Hz or a refresh rate of 60 Hz for other aspect ratios and higher resolutions. The RGB output shall be buffered to prevent a failure of the output cabling from affecting the radar display. The output resolution shall match the resolution of the video output to the radar display.

Where a DVI output is provided, the interface shall meet the specifications of the DDWG DVI standard, where that standard refers to screen of 1 280 × 1 024 and refresh rates between 60 Hz and 85 Hz or a refresh rate of 60 Hz for other aspect ratios and higher resolutions. The DVI output shall be buffered to prevent a failure of the output cabling from affecting the radar display. The output resolution shall match the resolution of the video output to the radar display.

Where Ethernet interface is provided, a subjectively lossless graphic algorithm shall be used as defined in IEC 61996-1 (VDR). The video image data should be in one of the following formats:

- ".bmp" – (Microsoft GDI – bitmap reference),

NOTE The “.bmp” format image file is efficiently reduced by “.zip” compression.

- ".png" – (ISO/IEC 15948), or

- ".jpg" – (ISO/IEC 10918) or
- ".jp2" – (JPEG 2000 – ISO/IEC 15444 in a lossless format).

Where Ethernet interface is provided, the header data shall include the following information:

- Identify the source workstation and location
- Identify the image type
- Identify the radar antenna/transceiver(s) being displayed

in the “Status and information text field” as described in IEC 61996-1:2012, Annex E.

The Ethernet interface shall provide digital file transfers of one screen capture each 15 s. Means may be provided to configure use of higher update rates. Means shall be provided to change the header values and move the synchronization of the image message to the clock (i.e. Xband, send at :00, :15, :30, :45, Sband send at :04, :19, :34, :49).

14.3.3.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by observation that the analogue RGB output to VDR, if provided, complies with the requirements of this standard for resolution, refresh rates and buffered output;

b) confirm by document inspection that where the radar display resolution is not compatible with use of the RGB format, the radar processor provides either a dedicated DVI output or an Ethernet interface to VDR;

c) verify in accordance with IEC 61162-450 or Annex H.2 in this standard, if an Ethernet output to VDR is provided, that the data format and content complies with the requirements for transfer of radar image data and provides the required header information;

d) verify in accordance with IEC 61996-1, if an Ethernet interface to VDR is provided, that the radar digital output complies with the image fidelity test defined in the VDR standards;

e) confirm by observation, if an Ethernet interface to VDR is provided, that it can provide an output of one screen capture each 15 s and the synchronisation is configurable;

f) confirm by observation or by document inspection of the design, that a fault condition on the output to the VDR (for example a short circuit on the output) does not degrade the performance of the radar display;

g) confirm by observation and inspection of manufacturer documentation that the VDR output cannot be deactivated by the user;

h) confirm by document inspection that the instructions for connecting a VDR to the radar system are included in the installation manual.

15 Design, servicing and installation

15.1 General

The following design and servicing information provides guidelines to support maximum equipment availability and serviceability.

15.2 Fault diagnosis and servicing

15.2.1 Requirements

(MSC.192/7.1.1) *As far as is practical, the radar system* shall *facilitate simple fault diagnosis and maximum availability.*

(MSC.192/7.1.2) *The radar system* shall *include a means to record the total operational hours for any* critical *components with a limited life.*

(MSC.192/7.1.3) *The documentation* shall *describe any routine servicing requirements and* shall *include details of any restricted life components* and their advised replacement.

15.2.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by document inspection that the user manual provides a top level guide for simple fault diagnosis and guidance to maintain maximum equipment availability;

b) confirm by document inspection that the user manual includes a list of components that have a limited (short) operational life for example, magnetrons and other thermionic devices, mechanical components for example, belts, brushes, motors, fans, lubrication for gearboxes, and instructions to service these items;

c) confirm by document inspection that the equipment provides details of total operational hours for those components with a limited life, such as the magnetron, and that information for their recommended replacement or maintenance is included in the user manual. The operational hours of a limited life component shall be capable of being displayed at a related display or with an alternative indication;

d) confirm by observation and by document inspection that an indication is provided, or as a minimum included in the user manual, that there is a recommendation that specific components having a declared limited operational life shall be replaced.

15.3 Display design

15.3.1 Requirements

(MSC.192/7.2) *The physical requirements for the display device* shall *meet those specified in the performance standards for the Presentation of Navigation-related Information on Shipborne Navigational Displays adopted by the* IMO *(MSC.191(79)),* and those specified in Table 1 and Clause 6 of this standard.

All critical equipment, system and installation related parameters shall be retained in a non-volatile and transferable memory, or the equivalent.

15.3.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by document inspection and by measurement using a ruler that the display size conforms to Table 1 in this standard for the category of equipment submitted;

b) verify that the display is according to Clause 6 for all physical requirements;

c) confirm by document inspection of the relevant equipment manuals, that there is provision for the retaining of critical parameters (for example installation parameters). Retained parameters shall be listed within the manufacturer's manual. The documentation shall describe that when a relevant replacement module is fitted, the parameters are transferable from the replaced module. (Some of these requirements are verified elsewhere in this standard.) Retained information may include, for example installation parameters, sensor parameters, interface parameters, blank sector limits, maps, and default display configurations.

15.4 Transceiver design

15.4.1 General

The transceiver includes the generation of microwave energy and the transmission of that energy via an appropriate transmission line. The receiver system typically shares that transmission line and provides a signal representing the radar image. The transceiver may be down-mast or combined with an up-mast unit. The transceiver system may be non-coherent or coherent.

15.4.2 Sector blanking

15.4.2.1 Requirements

(MSC.192/7.3) *The equipment* shall *provide a* sector blanking *(mute) facility to inhibit the transmission of radar energy over a preset sector. The* blanked *(muted) sector* shall *be set up on installation* and the values retained in transferable non-volatile memory. *An indication of sector mute status* shall *be available* and provided on the display.

15.4.2.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by observation that a transmission sector blanking (mute) facility is provided and that there is an indication to identify the sector and the status of the function;

b) confirm by observation that the sector blanking (mute) function can be set up in a non-operational equipment menu;

c) confirm by document inspection that the method of adjustment is described in the manufacturer's documentation, and ensure that access is via a protected menu;

d) confirm by observation that the sector blanking (mute) can be set and automatically applied for each selected radar sensor and that these parameters are retained in a transferable non-volatile memory.

15.5 Antenna design

15.5.1 Requirements

(MSC.192/7.4.1) *The antenna* shall *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.*

(MSC.192/7.4.2) *The combined radar system* shall *be capable of providing an appropriate information update rate for the class of ship on which it is installed.* Equivalent tests for new technology shall be conducted in agreement with the test authority.

15.5.2 Methods of test and required results

The methods of test and the required results are as follows:

a) the antenna/pedestal combination shall be placed in a wind tunnel capable of producing an air stream of up to 100 kn. The largest antenna for the frequency band submitted shall be used. The antenna motor shall be provided with a power source at its nominal voltage and frequency. Where appropriate, only the antenna/pedestal combination shall be used in this test;

b) confirm by observation, that in the case of a rotating antenna, the scan is continuous and in a clockwise direction when viewed from above and automatic through 360° in azimuth, and with a rotation rate adequate for the category of equipment;

c) confirm by observation that the antenna starts and operates satisfactorily in continuous relative speeds of 100 kn;

d) check by document inspection and by measurement that the radar system provides an update rate adequate for the class of ship and category against which it is submitted. The update rate shall be sufficient to ensure that all tracking and signal processing functions operate correctly, and the user is provided with adequate situation awareness. In the case of a conventional antenna and radar system, the recommended minimum rate of rotation is 20 rpm for standard ships and 40 rpm for HSC.

   Slower antenna rotation rates may be provided for higher range scales or to provide compatibility with novel processing techniques, provided that update-dependent requirements are met. For example a system with a back-to-back antenna assembly could be submitted and could provide equivalent performance at a lower rotation rate.

Equivalence to these rotation rates may be submitted, demonstrated and tested by the test authority.

NOTE Alternative technologies could provide other solutions to meet the relevant requirements of this standard.

15.6 Inter-switched and multiple radars

15.6.1 General

The radar system shall be designed and configured to maximise radar availability.

15.6.2 System safeguards

15.6.2.1 Requirements

(MSC.192/5.35.1) *The system* design shall *safeguard against single point system failure. A fail-safe condition* shall *be applied in the event of an integration failure.*

In the event of a single point failure, it shall be possible to configure the multiple radar system to enable each of the radars to operate as a standalone system.

Where two radars are required to be carried, they shall be so designed, configured and installed that each radar can be operated individually and both be operated simultaneously, without being dependent upon one another. Where provided, the flexibility and availability shall be improved by the inter-switching facility and the failure of either radar shall not cause the other radar to be adversely affected.

15.6.2.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by document inspection that the user manual describes how the system safeguards against single point failure and, how a fail-safe condition is automatically, or can be manually, applied in the event of a failure, to permit standalone operation;

b) confirm by document inspection, that two radars may be configured and installed so that they can operate individually and simultaneously without any critical interdependence. Configuration guidelines and non-dependency shall be described in the user manual;

c) confirm by observation that when simulating a single point failure within the inter-switch system, each of the radars is able to operate as a standalone system.

15.6.3 Combining radar

15.6.3.1 Requirements

(MSC.192/5.35.2) Where the combining of radar signals from multiple sensors is provided, *the source and any processing or combination of radar signals* from two or more radar sensors shall *be indicated.*

It is permitted to present radar signals from more than one radar sensor on a single display. The combining of radar signals from multiple sensors shall not degrade performance and the failure of one sensor shall not disable signals from other sensors from being displayed.

15.6.3.2 Methods of test and required results

Where the radar system submitted is capable of processing or combining the signals from two separate sources, these additional tests shall apply:

a) confirm by document inspection, if the manufacturer has submitted a radar system which is capable of processing and/or combining the radar signals from two or more sensors, that the manufacturer’s manual describes operation, advantages and limitations of this

system and the intended purpose, for example to provide radar coverage over two sectors, improve performance by dual radar coverage of a common sector, or both;

b) confirm by observation that combining controls such as anti-clutter rain, anti-clutter sea, gain and tuning, if provided, does not preclude independent control of each radar sensor and that their status is indicated on the display;

c) confirm by observation that each radar sensor has position compensation with respect to the CCRP;

d) confirm by document inspection that the interfacing, commissioning and setting-up procedure are clearly described in the installation and/or user documentation;

e) where radar coverage overlaps, confirm that signals from the two sensors share a common position on the display position. The two signals shall as a minimum partially overlap;

f) where radar sensors cover different sectors, confirm that the presentation is seamless or that the limits of sectors are indicated, for example by the absence of system noise;

g) confirm by observation, that where a combined or pre-processed system is submitted, the performance of the resulting radar system is not inferior to that required in these radar test standards;

h) confirm by analytical evaluation, that the failure of one radar sensor does not degrade the operation of other radar sensors and is clearly indicated to the operator.

15.6.4 Multiple radar system status

15.6.4.1 Requirements

(MSC.192/5.35.3) *The system status for each display* position and for each radar sensor shall *be available.*

15.6.4.2 Methods of test and required results

Confirm by observation that the status for the radar system, as applicable for each display position, is indicated. The indications shall be permanent and shall inform the user if the display or system is:

- a master display, for example to a radar sensor;
- a slave display to another display. This should be identified as for example “Radar 1” or “Display A”;

The display reference may be identified either on, or adjacent to the presentation.

15.7 Multiple operational displays

15.7.1 Additional information and conformity

The displays may be configured to present radar, chart and other navigation information.

15.7.2 Requirements

(MSC.191/7.1.1) *If the display equipment is capable of supporting the presentation of multiple functions, then there* shall *be a clear indication of the primary function supported by the presentation (for example, radar, ECDIS). It* shall *be possible to select the radar presentation or the ECDIS presentation by a simple* operator *action.*

(MSC.191/7.4.1) *The user may configure a presentation for a specific task at hand. The presentation may include radar and/or* electronic *chart information, in combination with other navigation or ship related data. When not fully compliant with the radar or ECDIS, Performance Standards, such a presentation* shall *be identified as an auxiliary presentation.*

(MSC.191/7.4.2) *As far as practical, the presentation of any radar and/or ECDIS related functions* shall *be compliant with the requirements of the relevant Performance Standards and* the Presentation Standard, MSC.191(79), *with the exception of size requirements for the operational area. Chartlets or windows of radar information may be presented along with other information associated with the task at hand.*

15.7.3 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by observation that if the display equipment is capable of supporting the presentation of multiple functions, then there shall be a clear indication of the primary function supported by the presentation. If a display is not compliant with this standard it shall be identified as an auxiliary display;

b) confirm by observation that the presentation associated with the primary function can be selected by a simple operator action;

c) confirm by observation that, as far as practical, the display presentation is in accordance with the relevant performance standards.

15.8 Safety – antenna and radiation

15.8.1 General

Basic safety requirements relating to radiation and antenna rotation are defined.

15.8.2 Antenna radiation and rotation

15.8.2.1 Requirements

Radio frequency radiation from the antenna shall be possible only when the beam is scanning, except that override facilities may be provided for maintenance purposes. A means shall be provided to prevent antenna rotation during servicing.

15.8.2.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by observation that, as appropriate to the technology, transmission is only enabled when the antenna is scanning. An override may be provided for maintenance purposes. The means of isolation may be either located on the turning unit, may be available as a separate switch, or by the removal of clearly identified equipment fuses;

b) confirm by inspection of the documentation that the means to prevent the antenna from rotating and the override function are described in the user manual.

15.8.3 Microwave radiation levels

15.8.3.1 Requirements

The maximum distances from the antenna at which radio frequency radiation levels of 100 W/m^2, 50 W/m^2 and 10 W/m^2 can be expected shall be included in the equipment manual.

15.8.3.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by document inspection that the radiation levels at specified distances are available in the user and installation manuals;

b) confirm by measurement the radiation levels at the quoted distances are correct or are within the manufacturer’s quoted measurements.

16 Alerts and failures

16.1 General

16.1.1 Priority of alerts

The radar shall provide alerts and indications to signify total or partial failure. The priority and classification of alerts is described in IMO resolution MSC.302(87) – Bridge Alert Management (BAM).

16.1.2 Alerts and indications

16.1.2.1 Requirements

(MSC.192/5.34) Alerts *and indications* shall *comply with the performance standards for the Presentation of Navigation-related Information on Shipborne Navigational Displays, adopted by the* IMO, MSC.191(82) and *Performance Standards for Bridge Alert Management – Module A,* MSC.302(87), as further specified in IEC 62288*.*

16.1.2.2 Methods of test and required results

Verify in accordance with IEC 62288 that the presentation of alerts and indications complies with the requirements.

16.1.3 Alarm contact outputs

16.1.3.1 Requirements

(MSC.192/8.3.3) *At least one normally closed isolated contact* shall *be provided* with the radar system *for indicating failure of the radar* system*.*

16.1.3.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by document inspection that an isolated pair of normally closed contacts is available to indicate the failure of the radar and that the contacts are rated to switch at least 100 mA into a resistive load;

b) confirm by observation that the relay contacts open by simulating failures, for example of a transceiver, antenna rotation (as applicable), power supply or processor.

16.1.4 Alert management interface

16.1.4.1 Requirements

(MSC.192/8.3.4) *The radar* shall *have a bi-directional interface to facilitate communication so that alarms from the radar can be transferred to external systems and audible alarms from the radar can be muted* or acknowledged *from external systems. The interface* shall *comply with relevant international standards.*

The performance standards for Bridge Alert Management (BAM) tailor the IMO Code on Alerts and Indicators to harmonize the priority, classification, handling, distribution and presentation of alerts on bridge equipment.

Radar equipment shall provide an alert management interface compliant with the requirements of BAM Module C further specified for radar in the Annex H list of IEC 61162 sentences, the state diagram of IEC 61924-2:2012 Annex J and the detailed sentence definitions of IEC 61924-2:2012 Annex K.

Alert management requires:

a) classification of all alerts available in the EUT, see 16.1.4.2

b) presentation of the alerts, see 16.1.4.2

c) reporting of alerts, see 16.1.4.2 and 14.3.3.2

d) handling of unacknowledged warnings, see 16.1.5

e) handling of unacknowledged alarms, see 16.1.6

f) functionality of remote acknowledge and remote silencing, see 16.1.7.

16.1.4.2 Methods of test and required results

Confirm by inspection of manufacturer's documentation that manufacturer defined alerts are in compliance with the criteria for classification and categories of alerts defined in MSC.302(87) and the alerts for Radar/AIS listed in IEC 61924-2:2012 Annex C.

For test of alert communication and presentation, refer to the manufacturer's documentation to identify at least 2 of the available alarm conditions which may be chosen at random, 2 of the available warnings which may be chosen at random and 2 of the available cautions which may be chosen at random. Then:

a) verify the compliance of alert presentation in accordance with IEC 62288;

b) confirm by analytical evaluation that the alert communication complies with the IEC 61162 sentences listed in Annex H, the detailed sentence definitions IEC 61924-2:2012 Annex K and the state diagram of IEC 61924-2:2012 Annex J;

c) confirm by analytical evaluation that, if means are provided for interface to a centralised alert management system, a caution alert is provided when the periodic reception of the HBT sentence is interrupted.

16.1.5 Unacknowledged warnings

16.1.5.1 Requirements

(MSC.302/7.62) *An unacknowledged warning* shall *be:*

1) repeated as a warning after a limited time period not exceeding 5 min; or

2) changed to alarm priority after a limited time period not exceeding 5 min; or

3) changed to alarm priority after a user selectable time not more than 5 min.

The default time for the user selected period shall be 60 s.

16.1.5.2 Methods of test and required results

Confirm by inspection of manufacturer's documentation that the default value for alert escalation is 60 s.

Confirm by observation that the user selectable time period for alert escalation is less than 5 min.

Confirm by inspection of manufacturer's documentation that the manufacturer provides information about:

- which warnings are repeated as warning;
- which warnings are changed to alarms after the user selectable time period;
- which warnings are changed to alarms after manufacturer fixed time period.

Refer to the manufacturer's documentation to identify at least 2 cases which may be chosen at random, if available, in which a warning is repeated as warning. Confirm by observation that the time between repetitions is as selected by the user.

Refer to the manufacturer's documentation to identify at least 2 cases which may be chosen at random, if available, in which a warning is changed to alarm. Confirm by observation that the time before change of priority is as selected by the user.

16.1.6 Unacknowledged alarms

16.1.6.1 Requirements

The radar may provide the capability to transfer unacknowledged alarms from the radar to BNWAS after a time defined by the user, in accordance with IEC 62616 as defined by the applicable requirements of IEC 61924-2:2012 Clause 8. Interface sentences of IEC 61162 shall be as defined in Annex H.

16.1.6.2 Methods of test and required results

When provided, confirm by observation that functionality is in accordance with IEC 61924-2 and that the interface is as defined in Annex H.

16.1.7 Remote acknowledgement and silencing of alerts

16.1.7.1 Requirements

Remote temporary silencing and remote acknowledgement shall be provided via alert related communication according to sentence definitions IEC 61924-2:2012 Annex K and the state diagram in Annex J.

Remote acknowledgement shall only be possible for category B alerts, as defined in MSC.252(83) and IEC 61924-2.

Remote silencing of the relevant audible alarms of the radar shall be possible at any time.

16.1.7.2 Methods of test and required results

Perform the following tests using a simulator for BAM:

a) Test of alert reporting and silencing:
   1) create 2 alerts, at least one of Category B;
   2) confirm by observation that ALF, ALC and HBT sentences are transmitted from the EUT to the BAM interface;
   3) use simulator to send ACN sentence to the EUT to silence one of the alerts;
   4) confirm by observation that ALF, ALC and HBT sentences report correctly the new state of the alerts;
   5) use simulator to send ACN sentence to the EUT to acknowledge the Cat B alert;
   6) confirm by observation that ALF, ALC and HBT sentences report correctly the new state of the alerts.
b) Test of attempt to acknowledge Category A alert:
   1) create an alert of Cat A;
   2) confirm by observation that ALF, ALC and HBT sentences are transmitted from the EUT to the BAM interface;
   3) use simulator to send ACN sentence to the EUT to acknowledge the Cat A alert;
   4) confirm by observation that the EUT refuses to acknowledge and that the ARC sentence reports correctly this refusal.

16.1.8 Picture freeze

16.1.8.1 Requirements

(MSC.192/5.34.1) *A means* shall *be provided to alert the user of "picture freeze".*

16.1.8.2 Methods of test and required results

The methods of test and the required results are as follows:

a) verify in accordance with IEC 62288 that means are provided to indicate a *"picture freeze"* presentation failure*;*

b) confirm by document inspection that the user manual describes a picture freeze failure condition and any associated indications for that condition.

16.1.9 Sensor failure alert

16.1.9.1 Requirements

(MSC.192/5.34.2) *Failure of any signal or sensor in use, including; gyro, log, azimuth, video, sync and heading marker,* shall *be* indicated by an alert; a warning if the sensor is in use or otherwise a caution indication. *System functionality* shall *be limited to a fall back mode or in some cases, the display presentation* shall *be inhibited.*

16.1.9.2 Methods of test and required results

Confirm by inspection that the principal signal and sensor failure modes are described in the user manual. Fallback modes are tested in 16.2.

16.2 Backup and fallback arrangements

16.2.1 Requirements

(MSC.192/9) *In the event of partial failures and to maintain minimum basic operation, the fallback arrangements listed below* shall *be provided. There* shall *be a permanent indication of the failed input* status *information.*

16.2.2 Failure of heading information (azimuth stabilisation)

16.2.2.1 Requirements

(MSC.192/9.1.1) *The equipment* shall *operate satisfactorily in an unstabilised head-up mode;* refer to 3.32 head-up*.*

(MSC.192/9.1.2) *The equipment* shall *switch automatically to the unstabilised head up mode within 1 min after the azimuth stabilisation has become ineffective.*

(MSC.192/9.1.3) *If automatic anti-clutter processing could prevent the detection of targets in the absence of appropriate stabilisation, the processing* shall *switch off automatically within 1 min after the azimuth stabilisation has become ineffective.*

(MSC.192/9.1.4) *An indication* shall *be given that only relative bearing measurements can be used.*

16.2.2.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by observation that the sequence of requirements is met;

b) confirm by observation that all functions reliant on azimuth stabilisation are disabled, for example target tracking, and that there is an indication that only relative bearings can be used.

16.2.3 Failure of speed through the water information

16.2.3.1 Requirements

(MSC.192/9.2) *A means of manual speed input* shall *be provided and its use clearly indicated.*

16.2.3.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by observation that a means for manual entry of speed (STW) is provided and its use clearly indicated;

b) confirm by observation that the speed is adjustable over the range of at least 1 kn to 70 kn;

c) verify in accordance with the test methods of 10.5.3.2 b), c), d) and f) that sea stabilisation requirements are met using manual speed entry.

16.2.4 Failure of course and speed over ground information

16.2.4.1 Requirements

(MSC.192/9.3) *The equipment may be operated with course and speed through the water information.*

16.2.4.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by observation that any function reliant on own ship COG and SOG is inhibited;

b) confirm by observation that if the facility is provided, the radar system identifies the failure of COG and SOG and that the system automatically reverts to speed through water;

c) confirm by observation that the user is alerted to the change in speed vector stabilisation reference by simulating a failure of velocity over ground.

16.2.5 Failure of position input information

16.2.5.1 Requirements

(MSC.192/9.4) *The overlay of chart data and geographically referenced maps* shall *be disabled if only a single reference target is defined and used, or the position is manually entered.*

16.2.5.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by observation that when chart data or geographically referenced maps are in use, they are disabled if only a single reference target is defined or if the position is manually entered;

b) confirm by observation that when own ship position data becomes invalid or unavailable, a warning alert is provided and that the display of geographically referenced information such as AIS, maps and charts is disabled;

c) confirm by observation that when own ship position is manually entered and SOG/SOG update is done by a single tracked reference target, the display of geographically referenced information is disabled;

d) confirm that when manually entered position is in use that this status is clearly indicated and that information reliant on it are marked as doubtful integrity.

16.2.6 Failure of radar video input information

16.2.6.1 Requirements

(MSC.192/9.5) *In the absence of radar signals, the equipment* shall *display target information based on AIS data. A frozen radar picture* shall *not be displayed.*

16.2.6.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by observation that it is not possible to display a frozen radar picture when the radar video signal is disconnected or disabled;

b) confirm by observation that in the absence of radar video, it is possible to display target information based on AIS data;

c) confirm by observation that a user message is provided to alert the user of the failure status and any resulting limitations that apply for collision avoidance assessment.

16.2.7 Failure of AIS input information

16.2.7.1 Requirements

(MSC.192/9.6) *In the absence of AIS signals, the equipment* shall *display the radar video and target database.*

16.2.7.2 Methods of test and required results

Confirm by observation that, in the absence of AIS signals, the radar continues to provide radar video and target information and that functionality is not impaired.

16.2.8 Failure of an integrated or networked system

16.2.8.1 Requirements

(MSC.192/9.7) *The equipment* shall *be capable of operating equivalent to a stand-alone system.*

16.2.8.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by observation and/or by inspection of the documentation that, if appropriate with the submitted equipment, means are provided to permit the radar to operate as a standalone system;

b) confirm by document inspection that the documentation describes changing the configuration to a stand-alone system.

17 Environmental testing

17.1 General

(MSC.192/2) *The radar* shall *meet the general requirements as set out in resolution A.694(17)* as further specified in IEC 60945. The equipment shall comply with the general requirements of IEC 60945 including temperature, vibration, corrosion (by inspection of materials used), EMC, ergonomics, software, maintenance of hardware and maintenance of software.

The environmental category of each individual module of the radar system shall be identified as being exposed (above deck) or protected (below deck). Refer to general test conditions described in Clause 4.

17.2 Testing to IEC 60945

17.2.1 Requirements

The equipment under test shall be set to work and confirmed to be operational by the application of basic performance checks and a performance test. Testing to IEC 60945 general requirements shall then commence.

The “performance check” shall as a minimum be conducted on a system with the antenna replaced by a dummy load and using simulated ship sensors for log, gyro and AIS connected so that the gain and tuning response can be checked and the following can be conducted with own ship in simulated motion. The magnetron current (or transmission equivalent) shall be monitored and the receiver noise, as presented shall be set to an operational level at room temperature.

17.2.2 Methods of test and required results

Verify that the EUT conforms to the standard general requirements in accordance with IEC 60945. Where a performance check is required confirm that there is no external indication of damage and there is no detectable degradation in functional performance as follows:

a) confirm by observation that the cursor control responds and operates smoothly in each axis;

b) confirm by observation that each of the hardware controls and a sample of the software control functions (as provided confirm that they continue to be functional during the environmental condition);

c) confirm by measurement and observation that when exercising the target simulation facility described in 18.1 or the tracking scenario in 11.3.13, the solution is correct;

d) confirm by observation that when switching through the range scales during the tracking scenario, the trails are retained as required;

e) confirm by measurement that the radar transmission (for example magnetron current) does not vary by more than 20 % over the operating temperature range;

NOTE Allow a settling time of at least 30 min.

f) confirm by observation that the system noise level, as presented does not appreciably change over the operating temperature range.

NOTE The appropriate use of ‘performance check’ or ‘performance test’ (as specified in 17.2) during testing is as required in IEC 60945 for the specific environmental tests.

17.3 Additional environmental tests

17.3.1 General

In addition to the standard IEC 60945 requirements, and for HSC radar only, the antenna and its mounting requires an additional shock/vibration test. The shock test provides a simulation in which the resonant responses, comparable with those likely to be experienced in practice in the operational environment, can be reproduced in the test laboratory. The antenna and its mounting shall be designed to withstand the test without external indications of damage or subsequent degradation in performance. A performance check is to be carried out before and after the test.

17.3.2 Antenna shock test

17.3.2.1 Requirements

The largest available antenna and mount provided with the EUT shall be so mounted that the shock can be applied to the antenna mounting base to simulate an upward vertical impulsive force. The antenna shall be mechanically connected to the shock machine by its normal means of attachment.

The procedure shall be carried out in normal laboratory environmental conditions.

The severity of the test is specified by the peak acceleration, pulse shape and duration given in Table 36.

Table 36 – Antenna shock test severity (half sine pulse)

Peak acceleration m/s^2	**Duration of pulse** Ms
100	25

The shock pulse shall be measured by an accelerometer placed at the antenna fixing point nearest to the centre of the table surface.

17.3.2.2 Methods of test and required results

Confirm by observation that after three successive upward shocks of the required test severity and pulse shape have been applied and the power supply is switched off, there is no external indication of physical damage.

18 Equipment familiarisation and documentation

18.1 Familiarisation simulator

18.1.1 General

The equipment shall include a familiarisation simulator and shall be simple to operate.

18.1.2 Requirements

(MSC.192/7.6.2) *A target simulation facility* and other material shall *be provided for training* (familiarisation) *purposes* for the specific type of radar.

(MSC.192/7.6.1) *The design* shall *ensure that the radar system is simple to operate by trained users.*

18.1.3 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by document or media inspection that the familiarisation training material (for example a DVD, a concise user guide, a brief operator instruction or other portable media) is available;

b) confirm by document or media inspection that the basic specific knowledge applicable to the radar equipment is considered to be adequate to familiarise a trained person. The familiarisation medium which is an additional requirement, shall be submitted for approval with the equipment, and does not replace an official user STCW (Standards of Training, Certification and Watch-keeping for Seafarers) radar training course;

c) confirm by document inspection of the submitted material that the evaluation report required by 13.2.1 included a statement that the equipment was simple and intuitive to operate;

d) confirm by observation that a target simulator function has been provided for familiarisation training purposes;

e) confirm by document inspection that the user manual includes a description of the training simulator, including a known solution to any scenario that is provided.

18.2 Instructions and documentation

18.2.1 General

User documentation shall be clear and unambiguous, and without unnecessary technical terminology. It shall provide guidance for operating the equipment and support for basic fault diagnosis. Installation-specific information shall be provided as a separate document and may also be included within the user manual.

18.2.2 Documentation

18.2.2.1 Requirements

(MSC.192/6.3.1) *The operating instructions and manufacturer's documentation* shall *be written in a clear and comprehensible manner and* shall *be available at least in the English language.*

(MSC.192/6.3.3.1) *The manufacturer's documentation* shall *contain a description of the radar system and factors that may affect detection performance, including any latency in signal* or data *processing.*

(MSC.192/6.3.3.2) *Documentation* shall *describe the basis of AIS filter criteria and AIS /radar target association* / disassociation *criteria.*

18.2.2.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by document inspection that the user manual meets the requirements. Confirm that information is easily located via a contents page and/or an index;

b) confirm by document inspection that the requirements for a description of the system, factors affecting detection performance, signal latency and data processing are included in the user manual;

c) verify that the user manual includes operational information relating to the AIS filter criteria and to the target association and disassociation criteria, as required by 11.5.3 and 11.8;

d) confirm by inspection of the installation documentation that there is adequate guidance for the location and interconnection of the radar system. The factors that may degrade performance or reliability shall be included within the installation instructions.

18.2.3 Operating instructions

18.2.3.1 Requirements

(MSC.192/6.3.2) *The operating instructions* shall *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* to achieve optimum target detection (see also 6.9.3);

– *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;*
– processing *applied to* process, filter and *display AIS targets and any limitations;*
– *principles underlying the trial manoeuvre technology, including simulation of own ship's manoeuvring characteristics, if provided;*
– *alerts and indications;*
– radar system *installation requirements as listed under* 18.3;
– *radar range and bearing accuracies;*
– *any special operation, for example tuning for the detection of SARTs;*
– *the role of the CCRP for radar measurements and its specific value.*

18.2.3.2 Methods of test and required results

Confirm by document inspection that the user documentation includes the information listed in the requirements and that the description is suitable for a non-technical user to comprehend.

18.3 Radar system installation

18.3.1 Requirements

(MSC.192/6.3.3.3) *The equipment documentation* shall *include full details of installation information, including additional recommendations on unit location and factors that may degrade performance or reliability.* Manufacturer's documentation shall reference all mandated IMO guidelines for radar installation.

(MSC.192/7.5) *Requirements and guidelines for the radar system installation* shall *be included in the manufacturers' documentation which* shall be separate and additional to the user manual. As a minimum*, the following subjects* concerning the antenna and display shall *be covered.*

18.3.2 Methods of test and required results

18.3.2.1 General

Confirm by document inspection that any IMO guidelines as mandated by IMO are referenced in the installation information.

18.3.2.2 The antenna

18.3.2.2.1 Requirements

(MSC.192/7.5.1) *Blind sectors* shall *be kept to a minimum, and* shall *not be placed in an arc of the horizon from the right ahead direction to 22,5° abaft the beam and especially* shall *avoid the right ahead direction (relative bearing 000°). The installation of the antenna* shall *be in such a manner that the performance of the radar system is not substantially degraded. The antenna* shall *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* shall *take account of target detection performance relating to range of first detection and target visibility in sea clutter.*

18.3.2.2.2 Methods of test and required results

The methods of test and the required results are as follows:

a) confirm by document inspection that adequate guidance is included within the installation documentation;

b) confirm by document inspection that there is provision to enter blind sector and antenna height information for each available sensor and confirm that the information is accessed in a protected (for example by password, switch or link) and non-operational mode.

18.3.2.3 The display

18.3.2.3.1 Requirements

(MSC.192/7.5.2) *The orientation of the display unit* shall *be such that the user is looking ahead, the lookout view is not obscured and there is minimum ambient light on the display* viewing surface.

18.3.2.3.2 Methods of test and required results

Confirm by document inspection that the appropriate advice is included within the installation documentation.

18.4 Maintenance information for equipment update

18.4.1 Requirements

Adequate software and hardware maintenance arrangements shall be supported by the manufacturer in accordance with MSC.1/Circ.1389 and SN.1/Circ.266.

Manufacturers shall provide customers with timely access, for example via a website, to a list showing the relevant regulatory approvals and compliance status for applicable IMO, ITU and, if chart radar capability is provided, IHO standards currently in effect for the software versions.

18.4.2 Methods of test and required results

The methods of test and the required results are as follows:

a) verify compliance in accordance with IEC 60945 for maintenance, including hardware and software, and marking;

b) verify by inspection of manufacturer documentation that a list can be accessed, following information provided in the operator's manual or on the equipment, showing the relevant regulatory approvals and compliance status for applicable IMO, ITU and, if chart radar capability is provided, IHO standards currently in effect for the software versions.

Annex A
(informative)

Guidelines for radar functionality on navigation displays

A.1 General

Navigational displays providing partial radar functionality, including radar overlay, target functions and AIS should fully comply with the appropriate clauses in this standard. Only full compliance with this standard will meet the performance requirements for a radar system as defined by IMO. Partial radar functionality may be permitted as defined in the relevant equipment standard for the navigation display, for example ECDIS and ECS. Primary radar functions and associated clauses in this standard are referenced as appropriate.

A.2 Guidelines for navigation displays

A.2.1 General

The following clauses are provided as guidelines for navigation displays which provide radar detection, radar overlay, collision avoidance and AIS functionality and presentation.

A.2.2 Radar overlay and target detection

Clause 6 of this standard defines the requirements for target detection. A radar overlay should meet the requirements of Clause 6 as follows:

a) if a navigational system or equipment provides the capability to detect targets and to present a radar overlay, the presentation should be in accordance with IEC 62288;

b) a navigational system or equipment slaved to a radar system tested according to this standard, may provide a radar overlay when complying with Clause 6 of this standard except for the following subclauses: 6.2, 6.3, 6.4.4, 6.5.5, 6.6.2, 6.10, 6.11;

c) a navigational system or equipment controlling a radar system and providing a radar overlay without a collision avoidance task, should comply fully with Clause 6.

A.2.3 Collision avoidance

Clause 11 of this standard defines the requirements for collision avoidance. The following guidelines apply:

a) if a navigational system or equipment provides the capability to present both radar and AIS targets, then it should also provide the capability to associate reported AIS targets to tracked radar targets in accordance with 11.8;

b) if a navigational system or equipment provides the capability to associate reported AIS targets to tracked radar targets, then it should also provide the capability to track radar targets in accordance with 11.3;

c) if a navigational system or equipment provides the capability to present reported radar targets (for example in accordance with the IEC 61162 series), then it should obtain CPA and TCPA from the reported radar message and should not calculate CPA and TCPA. If the radar target tracking system does not calculate the CPA and TCPA, then the navigational system or equipment may calculate the CPA and TCPA in accordance with 11.3.

A.2.4 As part of a radar system

A navigational system or equipment should be approved as part of a radar system when tested in accordance with this test standard.

Annex B
(normative)

Unwanted emissions of radar systems

B.1 General

ITU-R has developed a recommendation for out-of-band (OOB) emission limits (SM.1541). This OOB recommendation is associated with the following recommendations:

a) OOB emissions falling into an adjacent allocated band (SM.1540);

b) boundary between OOB and spurious emissions (SM.1539);

c) spurious emissions (SM.329).

Spurious emission limits are given in Clause II of Appendix 3 of the Radio Regulations together with the definition of the boundary between the OOB domain and the spurious domain. For radars the Radio Regulations refer to the OOB recommendation for the definition of the boundary.

This annex defines how the requirements of Appendix 3 of the Radio Regulations and the ITU Recommendations concerned with unwanted emissions are implemented with regard to marine radars. This includes the requirements, method of measurement, the results to be obtained and the interpretation of the measurement results.

B.2 Requirements

The requirements are defined in Appendix 3 of the Radio Regulations and the recommendations are listed above in Clause B.1.

The boundary between the OOB and spurious domains and the OOB mask are defined in Annex 8 of the OOB recommendation, in the following manner:

a) (boundary and mask) – “the mask rolls off at 30 dB per decade from the 40 dB bandwidth to the spurious level specified in Appendix 3 of the Radio Regulations. The B_{-40} dB bandwidth can be offset from the frequency of maximum emission level, but the necessary bandwidth (1.152 of the Radio Regulations) should be completely contained within the allocated band”;

b) (exclusions) – “the OOB limits are not applicable inside exclusive radio-determination and or Earth Exploration Satellite (EES) and Space research service bands, but do apply at the band edges.”

These requirements are illustrated in Figures B.1 and B.2. The OOB masks shown in Figures B.1 and B.2 are calculated using the transmitted pulse width and rise (or fall) time.

The necessary bandwidth and the –40 dB bandwidth are generally centred about the operating frequency but may be offset to take account of spectrum asymmetry.

The OOB mask commences at a level of –40 dB and falls off at the rate of –30 dB per decade until it meets the spurious emission limit at the OOB boundary.

When the calculated –40 dB bandwidth falls within the allocated band the OOB mask commences at the edge of the allocated band.

When the –40 dB bandwidth falls outside the allocated band the OOB mask commences at that point in the adjacent band.

The OOB mask can be offset further into the adjacent band to allow for spectrum asymmetries, but the necessary bandwidth associated with this mask shall be contained completely within the allocated band.

The OOB mask emission limits only apply outside the adjacent bands, i.e. below 2,7 GHz and above 3,3 GHz in the case of radars operating in the 2,9 GHz to 3,1 GHz band, and below 8,5 GHz and above 9,8 GHz in the case of radars operating in the 9,3 GHz to 9,5 GHz band.

Emissions in the spurious domain (Figures B.1 and B.2) shall be at least 43 10 log PEP or 60 dB, whichever is the least stringent, below the carrier power, as measured in the far field of the radar. For most current marine radars the limit will be 60 dB and this means that the spurious domain starts at $5 \times B_{-40}$ from the operating frequency of the radar.

B.3 Methods of measurement

The basic methods of measurement for unwanted emissions are contained in ITU-R Recommendation M.1177. This describes two methods, referred to as the “direct” and “indirect” methods. Either method is admissible.

Measurements are to be made for all frequencies in the measurement frequency bands specified in Table B.1 below.

Table B.1 – Measurement frequency ranges

Allocated band	Measurement band	
	Lower limit	Upper limit
2,9 GHz – 3,1 GHz	2 GHz	5^{th} harmonic
9,3 GHz – 9,5 GHz	0,7 of the waveguide cut-off	26 GHz

B.4 Guidelines for the use and interpretation of ITU-R Recommendation M.1177

B.4.1 General

The recommendation provides some specific techniques for the measurement of the unwanted emissions of radar systems that in principle can be used for any type of radar system. In practice, the recommendation makes no attempt to provide detailed test methods for each type of system.

This standard provides the additional detail required for the minimum test requirements for the measurement of marine radars as a basis for demonstrating that the particular marine radar system under test, meets the requirements of the Radio Regulations and ITU-R Recommendations as appropriate.

B.4.2 Selection of pulse widths

The ITU-R Recommendation on OOB (SM.1541) applies to complex and simple radars with user-selectable pulse waveforms. For any given radar, the pulse length, rise time and fall time for a number of representative pulses (including the shortest and longest pulses) shall be measured and the corresponding B_{-40} bandwidths calculated. The widest calculated B_{-40} bandwidth shall then be used to create the OOB mask to be applied to that radar. Emission measurements only need to be carried out for the pulse length setting producing the widest calculated B_{-40} bandwidth.

B.4.3 Measurement in azimuth and elevation – antennas

For marine radars that are essentially surface search radars, there is no requirement to make measurements in the vertical plane.

For measurements in the azimuth plane, the antenna may be either rotating or the measurement system may be aligned to the antenna bore sight and measurements in azimuth taken at appropriate antenna angles where the directions of unwanted emissions are known. Both techniques are admissible and the particular choice shall be made by agreement between the manufacturer and the test authority. In both cases, the maximum value of the emission occurring in the azimuth plane shall be recorded over the frequency range defined in Table B.1.

Provided that all of the antennas to be used with the equipment under test are of the same type in general structure for the design and construction of the radiation mechanism, then only the smallest antenna with the worst case unwanted emission profile needs to be tested to verify compliance with the unwanted emission requirements.

B.5 Required results

B.5.1 Necessary bandwidth

The necessary bandwidth as calculated from the measured pulse width, rise time and fall time shall be within the allocated frequency band.

B.5.2 B_{-40} bandwidth

The B_{-40} bandwidth shall be calculated using the methods defined in B.4.2 and in Annex 8 of reference ITU-R Recommendation SM.1541. This bandwidth together with the declared frequency of the pulse transmission, are used to determine which of the masks illustrated in Figure B.1 or Figure B.2 shall be used for the purposes of conformity.

B.5.3 Emission spectrum

The emission spectrum shall be below the calculated mask, as determined by B.5.2 above, in both the OOB and spurious domains, for all appropriate frequencies over the ranges specified in Table B.1. As previously indicated in Clause B.2, the OOB emission masks limits do not apply within the allocated band or the adjacent RD/ESS-bands. The spurious emission limit applies in the spurious domain, regardless of frequency band.

Systems shall be compliant if the OOB mask of Figure B.2 is offset further into the adjacent band to allow for spectrum asymmetries, provided that the necessary bandwidth associated with this mask is completely contained within the allocated band.

NOTE 1 References:

a) ITU-R Recommendation M.1177: Techniques for measurement of unwanted emissions for radar systems.

b) ITU-R Recommendation M.1460: Technical and operational characteristics and protection criteria of radiodetermination radars in the 2 900 MHz to 3 100 MHz band.

c) ITU-R Recommendation M.1796: Characteristics of and protection criteria for terrestrial radars operating in the radiodetermination service in the frequency band 8 500 MHz to 10 680 MHz.

d) ITU-R Recommendation SM.329: Spurious emissions.

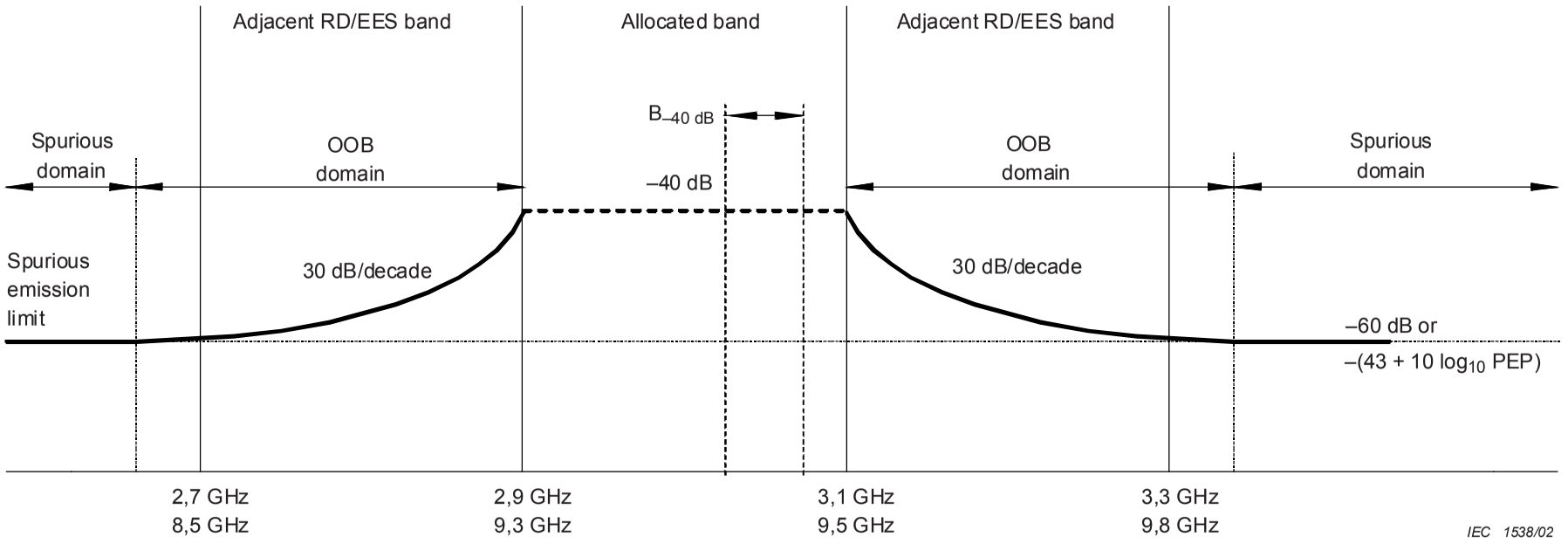
e) ITU-R Recommendation SM.1541: Unwanted emissions in the out-of-band domain.

f) ITU-R Recommendation SM.1539: Variation of the boundary between the out-of-band and spurious domains required for the application of Recommendations ITU-R SM.1541 and ITU-R SM.329.

g) ITU-R Recommendation SM.1540: Unwanted emissions in the out-of-band domain falling into adjacent allocated bands.

h) ITU-R – Radio Regulations – Appendix 3: Spurious emissions.

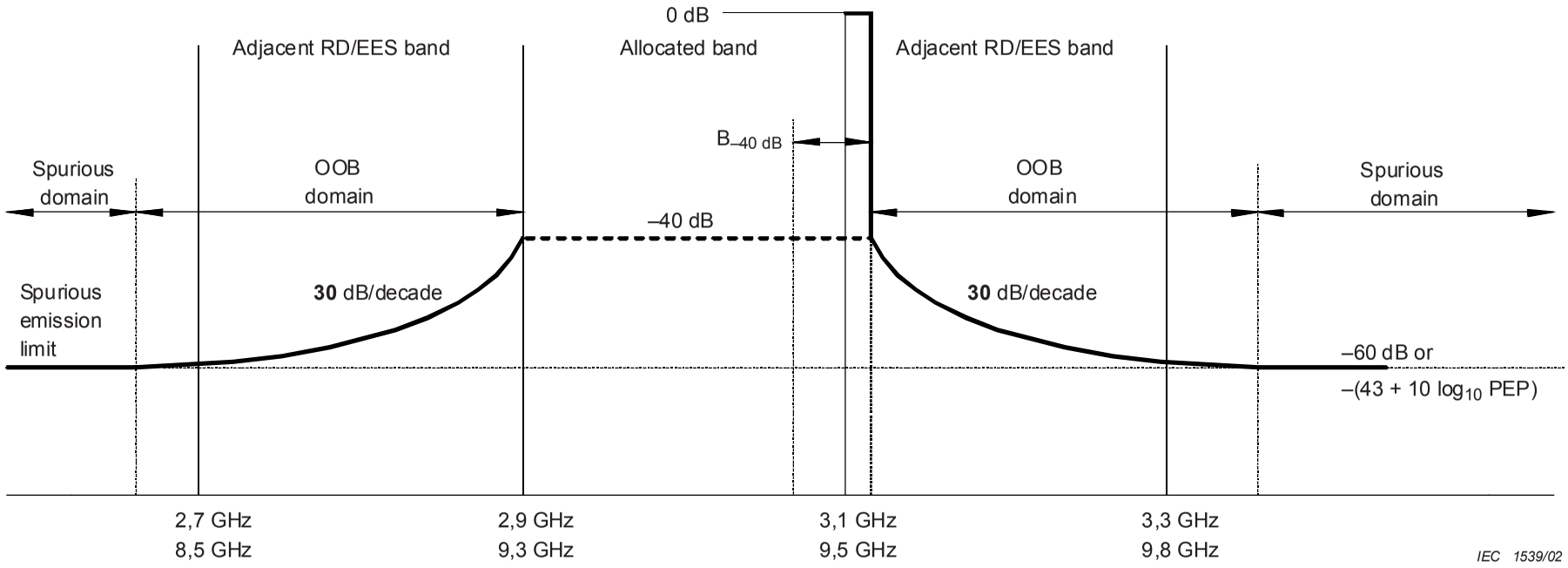
NOTE 2 Refer to the latest version of the ITU-R Recommendation.



NOTE 1 RD/EES – Radio-determination/Earth Exploration Satellite.

NOTE 2 OOB emission mask limits do not apply within the allocated or adjacent RD/EES bands.

Figure B.1 – B_{-40} falls within the allocated band



NOTE 1 RD/EES – Radio-determination/Earth Exploration Satellite.

NOTE 2 OOB emission mask limits do not apply within the allocated or adjacent RD/EES bands.

Figure B.2 – B_{-40} falls outside the allocated band

Annex C
(informative)

Radar target size (RCS) and detection range calculations

C.1 Radar range

The power density at range R from a radar antenna is:

$$G\ P_t/4\pi\ R^2 \qquad [W/m^2]$$

The maximum range of a radar target R_{max}, is the distance beyond which the target cannot be detected. The received signal power P_r (W) is:

$$P_r = P_t G A_e \sigma /(4\ \pi)^2 R^4$$

When the received signal power P_r just equals the minimum detectable signal S_{min}, the radar equation becomes:

$$R_{max} = (P_t G A_e \sigma /(4\pi)^2 S_{min})^{1/4}$$

where

G is the antenna gain;

σ is the radar cross-section;

P_t is the transmitted power;

A_e is the antenna effective aperture = G (wavelength)$^2/4\pi$

C.2 Effect of a change of target size

Where a target of radar cross-section or "echoing area" s_1 is substituted for s_2 in the same circumstances, the corresponding change in power from p_2 to p_1 received back at the radar is given by

$$\frac{p_2}{p_1} \quad \frac{s_1}{s_2}$$

hence

$$10\ \log \frac{p_2}{p_1} \quad 10\ \log \frac{s_1}{s_2} \qquad [dB]$$

EXAMPLE 1

When a 30 m^2 radar reflector is substituted for 10 m^2, the change in power received back at the radar will be:

10 log (30/10) = 4,8 [dB]

C.3 Effect of a change of target range

Apart from other possible effects described in the following the relationship between power p_1 reflected back from a target at distance d_1, and power p_2 reflected back from the same target at distance d_2, is given by the inverse fourth power law as:

$$\frac{p_2}{p_1} \quad \frac{{d_2}^4}{{d_1}^4}$$

In decibels, this equation becomes:

$$10 \log \frac{p_2}{p_1} \quad -40 \log \frac{d_2}{d_1} \quad [\text{dB}]$$

EXAMPLE 2

A change of distance from 2 NM to 3 NM will give, apart from other possible changes described below, a power change of:

$$-40 \log (3/2) = -7{,}0 \text{ dB}$$

C.4 Effect of target and radar height on discrete (non-distributed) targets

In calm to moderate sea states, a radar wave train that is reflected from the sea surface (with the angle of incidence equal to the angle of reflection) before striking the target will vectorially add to the wave train that travels directly to the target. This vectorial addition gives rise to a power enhancement Y seen at the radar. When Y is expressed in decibels it can vary between the limits 12 dB and $-\infty$ dB. This is of considerable importance when "discrete" or "point source" targets are used.

For the 3 cm band (9 410 MHz) and the 10 cm band (3 050 MHz), values for the enhancement Y (in decibels) can be read from Figures C.1 and C.2. The formulae on which the values in Figures C.1 and C.2 are based are given in Clause C.7.

EXAMPLE 3

Question: Referring to an X-band radar whose antenna height above the sea is 15 m, at what height above the sea shall a physically small 10 m^2 target be mounted, at a distance of 2 NM, in order to give a net effect of 10 m^2 at this distance?

Answer: This will be the condition where enhancement $Y = 1 = 0$ dB.

By inspection of the curve for 9 410 MHz in Figure C.1, the minimum such height is 0,7 m.

C.5 Effects of frequency sensitivity

Certain types of target are frequency sensitive, as will be indicated in the formula relating the physical dimensions of the particular device to its radar cross-section. For a trihedral corner reflector the radar cross-section varies as the square of frequency. For example the performance of a trihedral corner reflector will be reduced by 9,9 dB at S-band compared with X-band. It shall be borne in mind also that a change of operating frequency will affect in addition the considerations described in Clause C.4 above.

C.6 Conclusion

Factors that affect the performance of given radar targets under normal propagation conditions are described above. This gives a theoretical method whereby one target may be compared with another, by simple addition of the various factors expressed in decibels.

EXAMPLE 4

Question: It is calculated from the dimensions of a particular corner reflector that its radar cross-section (echoing area) is 30 m^2 (in free space) at a frequency of 9 410 MHz (X-band). This reflector is mounted at a height of 2,5 m above sea level, at a distance of 3 NM from a radar antenna mounted at a height of 15 m and operating at X-band.

How might the power returned to the radar from this reflector be expected to compare with that from a 10 m^2 target situated at 2 NM from the radar at a height of 0,7 m (as used in example 3)?

Answer: Considering the various relevant factors:

a) power change due to greater target size is 10 log (30/10) = 4,8 dB

b) power change due to greater distance is –40 log (3/2) = –7,0 dB

c) power change (enhancement) due to lobing at 3 NM is seen by inspection of Figure C.1 (9 410 MHz, target height 2,5 m) is = 10,7 dB

Adding the above three factors, the following answer is obtained: 8,5 dB

C.7 Formulae for Figures C.1 and C.2

The formula for Figures C.1 and C.2 is:

$$Y \quad 16\sin^4 \frac{4\pi h_1 h_2 f}{2c\ D}$$

where

h_1 is the radar height above the tangent plane to the earth at the reflection point ;

h_2 is the target height above the tangent plane to the earth at the reflection point;

f is the frequency of operation;

c is the velocity of microwave propagation;

D is the radar-to-target distance.

Power enhancement Y, expressed in decibels (dB), is given by Y = 10 log(Y).

NOTE For horizontal polarisation only:

In the case of the curved earth, the heights h_1 and h_2 above the tangent have to be determined from the corresponding heights h_r and h_t of the radar and target respectively above the surface, by use of the approximate relationships (obtained from geometrical considerations):

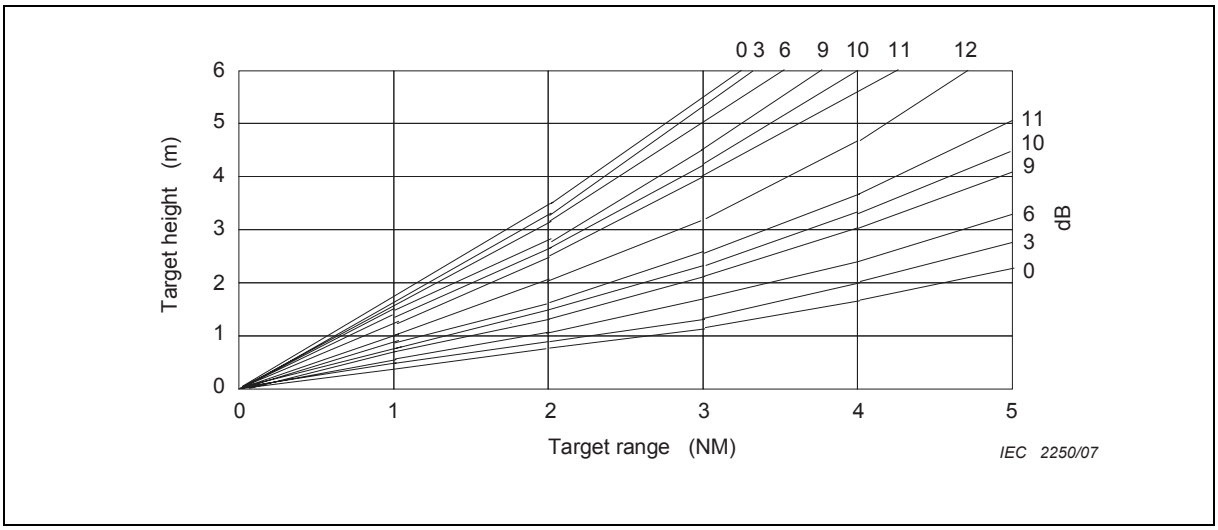
$$h_1 = h_r - \frac{(h_r\ D)^2}{d\,(h_r\quad h_t)^2}$$

and

$$h_2 = h_t - \frac{(h_t\ D)^2}{d\,(h_r\quad h_t)^2}$$

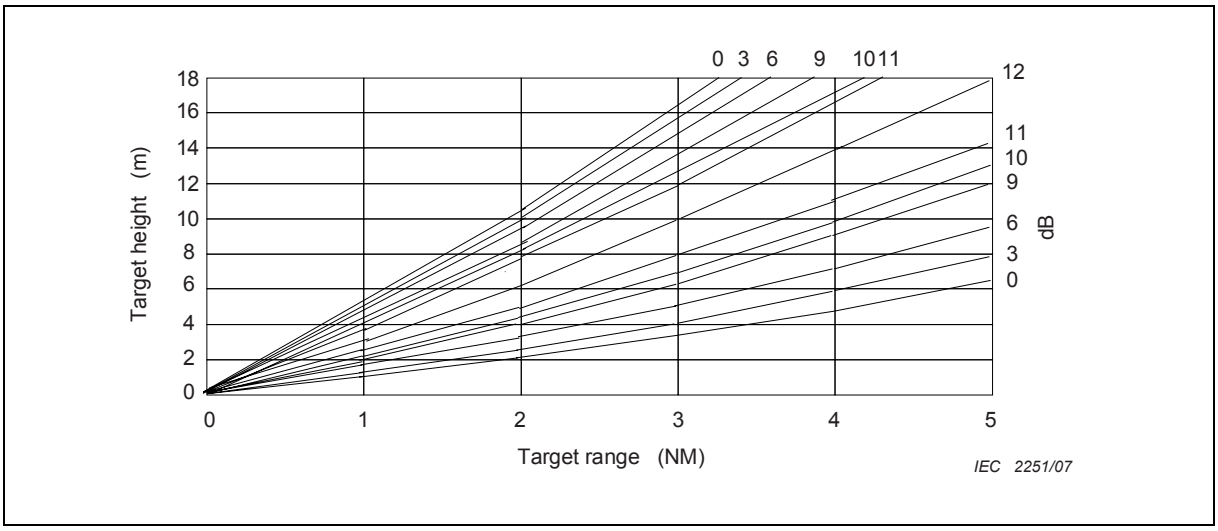
where d is the effective diameter of the "radio" earth (taken here as 6 371 × 4/3 × 2 = 16 990 km).

The formulae do not take the influence of "beam divergence" during reflection at the curved earth into account, which will reduce the maximum enhancement and "fill in" the nulls, thus increasing the minimum values of Y above $-\infty$.



NOTE Radar antenna height is 15 m and Y is expressed in decibels (dB), given by $Y\ dB = 10 \log(Y)$.

Figure C.1 – Enhancement by reflection (dB) over free-space (9,41 GHz)



NOTE Radar antenna height is 15 m and Y is expressed in decibels (dB), given by $Y\ dB = 10 \log(Y)$.

Figure C.2 – Enhancement by reflection (dB) over free-space (3,05 GHz)

Annex D
(informative)

Factors that influence target detection

D.1 Detection

The detection of targets, particularly small or marginal radar targets, is very susceptible to target composition, antenna height and horizontal beam width, target size and height, sea state, clutter characteristics, and atmospheric conditions. Even small changes in these parameters will impact target detection and for targets at closer ranges (typically within 1,5 NM), signal amplitude may be affected by multi-path (see Figure D.2 and Figure D.3). Caution should therefore be exercised when performance comparisons are made with other radar equipment for assessment purposes; in this case it is essential that the two pieces of equipment are physically installed very close to each other and have the same antenna installation height.

D.2 Target RCS values

The relationship between X-band and S-band RCS values for small point targets is assumed to be in the ratio of 10:1. Some targets may produce a smaller ratio or an even larger RCS value for S-band, depending on the target characteristics. Guidelines for calculations based on simplified formula relating to different target properties and detection ranges are located in Annex C. Simple, stable and established point targets will provide a more consistent reference than a distributed target. An example of a distributed target is a large yacht, comprising multiple reflective surfaces, each of differing radar cross-section and at various heights, and having multiple polarisation reflections.

The RCS of a shoreline is variable according to the reflectivity of the surface. As the range of a shoreline increases, the RCS may increase as a greater surface is illuminated by the antenna beam. The surface illuminated is partly offset by the curvature of the earth and increased scattering of reflected signals. Shoreline radar visibility should therefore rely on the experience of a test authority and the performance assessment related to their expectations within a known environment.

The RCS of a large SOLAS ship will vary primarily according to the structure, profile and aspect of the ship. Newer shipping, particularly HSC, will tend to have a much smoother profile and therefore have a correspondingly lower RCS. The aspect of the ship observed will also influence the RCS value.

Distributed targets generate a more complex multi-path and may produce different RCS values according to the antenna polarisation in use. A simple cylinder reflector such as a channel marker pole will provide a known RCS if the reflector is correctly installed to be stable and vertical. A small angular offset will greatly decrease the RCS values. For distributed targets including all ships, the target centroid height shall be assumed.

A Swerling 1 type target is chosen for the reference performance predictions. It is expected that if the targets are installed at sea then the effects of multi-path alone will cause significant signal variation. The Swerling 0 case may be applicable under calm very controlled conditions but in the case of floating targets the height and exact distance may vary, introducing differing multi-path effects. Further, as the sea roughens the multi-path signal is influenced by the roughness of the intervening ocean surface and specular reflection may no longer describe the indirect path.

D.3 Assessment of targets

It should be recognised that the undefined and varying nature of coasts and surface objects cannot provide an accurate performance assessment. While defined test targets provide an identifiable performance reference, atmospheric conditions and the sea surface may enhance or degrade the range of first detection listed in Table 2. The extent of ducting or other performance dependent phenomena will not be apparent in the empirical assessment and test described in 6.9.2.

Table D.1 provides an indication of the spread of RCS values for ships for an X-band radar system (RCS values are extracted from empirical measurements made by Dr P. Williams).

Table D.1 – Spread of RCS values for typical ships

Reference	Description	Length m	Total height m	Gross tonnage	RCS of ship (X band) m^2
1	Inshore fishing vessel	8,5	2,4	5	2-10
2	Small coaster	42	4,5	225	20-680
3	Coaster	54,5	6	500	50-2 300
4	Coaster	54,5	7,6	500	320-3 500
5	Coaster	55	7,4	500	1 000-1400
6	Large coaster	67	7,6	850-10 000	1 000-5 500
7	Collier	73	9	1 570	280-2 100
8	Naval frigate	102	9	2 000	4 800-100 000
9	Cargo liner	113	12	5 000	11 000-17 000
10	Cargo liner	136	17	8 000	4 300-14 000
11	Bulk carrier	165	12	8 200	530-11 000
12	Cargo vessel	152	12	9 400	1 400-11 000
13	Cargo vessel	165	15	10 500	600-14 000
14	Bulk carrier	197	17	15-20 000	1 000-27 000
15	Ore carrier	205	18	25 400	1 800-24 000
16	Container carrier	210	23	26 500	10 000-72 000
17	Medium tanker	220	15	30-35 000	50 000-890 000
18	Medium tanker	250	18	45 000	17 000-1 700 000

NOTE The wide variation in RCS values is due to the target ship aspect, the quantity and reflection characteristics of ship deck cargo and ship structure. Stern and bow aspects provide the least RCS value. The inshore vessel includes a small radar reflector.

D.4 Sea clutter (sea state, wind and wave height)

Sea clutter is generally defined in terms of a sea state. Establishing the sea state is important for assessing the visibility of radar targets in sea clutter. Sea state is a term used as a measure of wave height and can be defined for example by the Douglas scale, the Hydrographic Office scale and the Beaufort scale, which is a wind speed scale. Guidance for the sea state and wind speed is provided in Table 6.

The sea state describes the roughness of the sea, but is not a full indication of the strength of sea clutter. Wind speed is often a better indication of sea clutter, though this does depend on the duration (time blowing over sea) and the fetch (the maximum length of open water over which wind can blow). When wind begins to blow, the sea requires a finite time to reach a condition known as a fully developed sea. Sea states in Table 6 are approximately equated to wind speeds. During any assessment or measurement, it shall be noted that sea swell will

make accurate assessment of wave observations very difficult and the table is only applicable to waves formed by local wind conditions.

Crosswinds relative to the line of sight to the target produce less clutter than head winds and in terms of clutter returns, this represents 2 dB to 3 dB (approximately half a numerical sea state) less clutter signal return than detecting a target in head wind.

Many variables impact on actual radar performance and a controlled test cannot fully cover all of these, nor can conditions during type approval be rigidly specified. For example, in the Sea State 5 situation, a 5 m^2 RCS target may demonstrate low probability of detection in the near range with an acceptable or high probability of detection in the further ranges.

Figure D.1 illustrates this case for a probability of detection with a low false alarm rate. Sea clutter may vary so that lower detection is achieved due to the presence of wave spikes. Atmospheric conditions can enhance or degrade detection performance. The presence of rain will further degrade performance in the local area of the rain by causing additional clutter and target return loss.

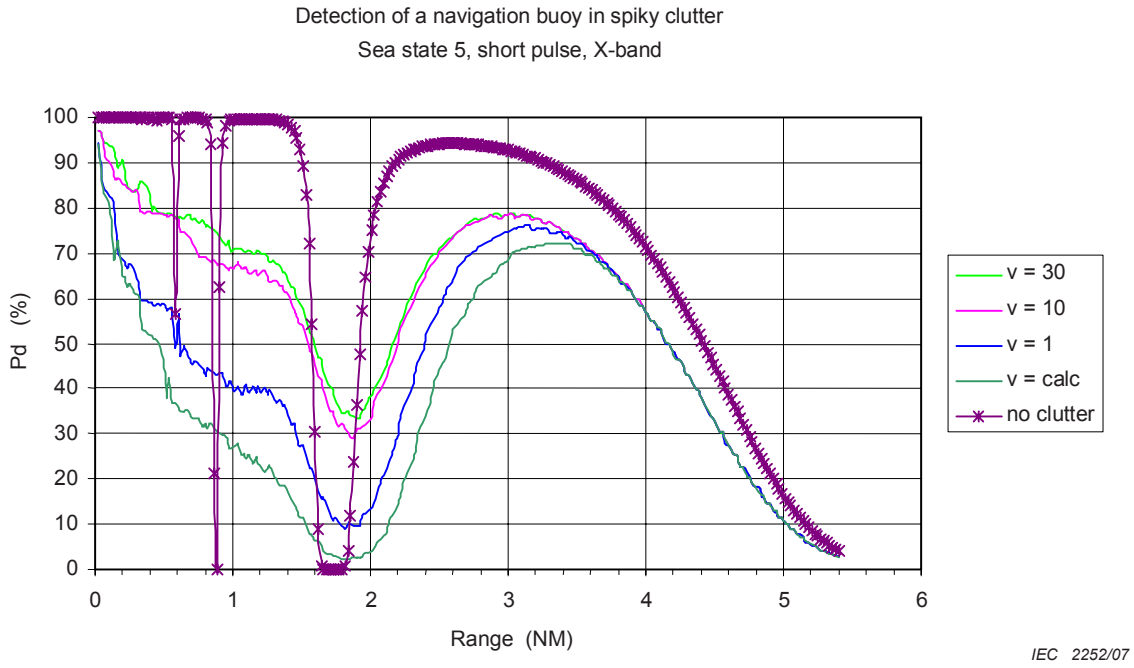


Figure D.1 – Effect of sea spikes on target detection

NOTE Factor "v" is the sea spike factor which depends on the sea conditions in the locality. The lower v gives a more spiky clutter. High sea spikes will require a user to increase the detection threshold, thereby degrading detection performance. The performance will also be adversely influenced by target obscuration (screening). Plot v = calc is the value used for the predictions.

In assessing the suitability of particular radar to the task at hand it is important to be able to model detection performance. This process includes the computation of the expected received signals from targets and clutter, and the system noise level. One of the more difficult problems in predicting radar target detection over the sea is accurately accounting for the effect of sea clutter. A number of models are available to provide the average normalised radar cross-section for the ocean as a function of sea state. The sea clutter statistical properties play a significant role in detection as a radar is required to operate with a relatively low false alarm rate, meaning the tail of the sea clutter distribution will have a major effect on the detection threshold. Models for the statistical properties of sea clutter vary from the Rayleigh distribution for low resolution radars and high grazing angles, to Weibull and Log-normal for high resolution radars or low grazing angles. The K-distribution has been proposed

in numerous papers and it offers a number of benefits for modelling the physical properties of sea clutter. The K-distribution shape parameter, "v", controls the tail of the distribution and for a small shape parameter the sea clutter becomes very spiky and for a large shape parameter the distribution provides Rayleigh clutter.

Tables D.2 and D.3 present performance predictions for target detection in sea clutter by an S-band and an X-band radar respectively (with parameters as defined in Clause D.7), using the K-distribution sea clutter model. Entries with an asterisk (*) are not computed as they are not needed to determine detectability. The predictions are generally more pessimistic than those provided using the CARPET tool. These differences are primarily due to the introduction of the K-distribution for the sea clutter. Comparative calculations using a large K-distribution shape parameter provide similar predictions to CARPET.

It should be noted that in operational conditions, the conditions selected for the modelled environment would never be achieved exactly. As a result the performance predictions are only indicative of the performance achieved in the real world and hence are only provided for guidance. Probability-of-detection (Pd) figures are expressed as a percentage and a probability of false alarm (Pfa) of 10^{-4} is assumed.

Table D.2 – S-band performance predictions for ranges of 0,2, 0,4, 0,7 NM

RCS (m^2)	**S-band Pd** (%)																	
	Sea state 1			**Sea state 2**			**Sea state 3**			**Sea state 4**			**Sea state 5**			**Sea state 6**		
	0,2	0,4	0,7	0,2	0,4	0,7	0,2	0,4	0,7	0,2	0,4	0,7	0,2	0,4	0,7	0,2	0,4	0,7
0,1	100	100	100	95	100	100	59	83	95	14	34	50	5	4	7	*	*	*
0,5	*	*	*	99	100	100	91	97	99	65	75	87	52	47	57	45	30	26
1	*	*	*	100	100	100	93	98	99	84	90	95	76	65	77	66	60	52
NOTE Entries with an asterisk (*) are not computed as they are not needed to determine detectability.																		

Table D.3 – X-band performance predictions for ranges of 0,2, 0,7 NM

RCS (m^2)	**X-band Pd** (%)											
	Sea state 1		**Sea state 2**		**Sea state 3**		**Sea state 4**		**Sea state 5**		**Sea state 6**	
	0,2	0,7	0,2	0,7	0,2	0,7	0,2	0,7	0,2	0,7	0,2	0,7
1	100	100	85	98	53	60	30	10	23	3	11	0
5	98	91	96	98	90	91	83	63	75	45	63	30
10	98	91	93	92	94	93	91	76	85	65	75	52

The predictions provided in Table D.2 and Table D.3 are made without any signal processing that may be available in the radar system. In fixed frequency radar, little benefit is gained from pulse to pulse processing in sea clutter limited detection due to the correlation time for the clutter. Scan to scan processing has the potential for reducing the effect of clutter spikes provided the scan processing can operate over a period of time that permits the clutter spikes to de-correlate.

D.5 Signal multi-path

Target detection, particularly in calm conditions and in lower sea states conditions, is greatly influenced by multi-path, a phenomenon created by multiple signal paths from a given target. Multi-path is influential at closer ranges and depends on many variables, including the antenna height, radar transmission frequency, target characteristics (height, reflective surfaces etc.), target range and sea state. Multi-path may enhance or reduce the target signal

amplitude due to the combined signal phase received by the radar antenna. Higher sea states tend to reduce the effect of multi-path, while at lower sea states the signal particularly from point targets will fluctuate in amplitude according to target range from the antenna. Figure D.2 and Figure D.3 illustrate the signal variation due to multi-path and from a point target. It should also be noted that the width of a multi-path null increases with range so that a target may be undetectable for some time.

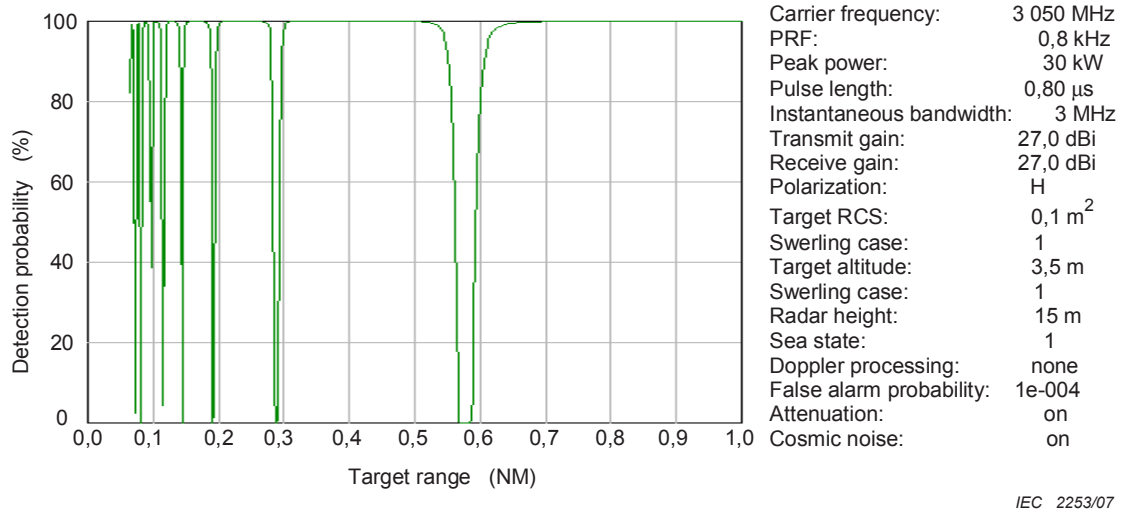


Figure D.2 – Multi-path plots for S-band

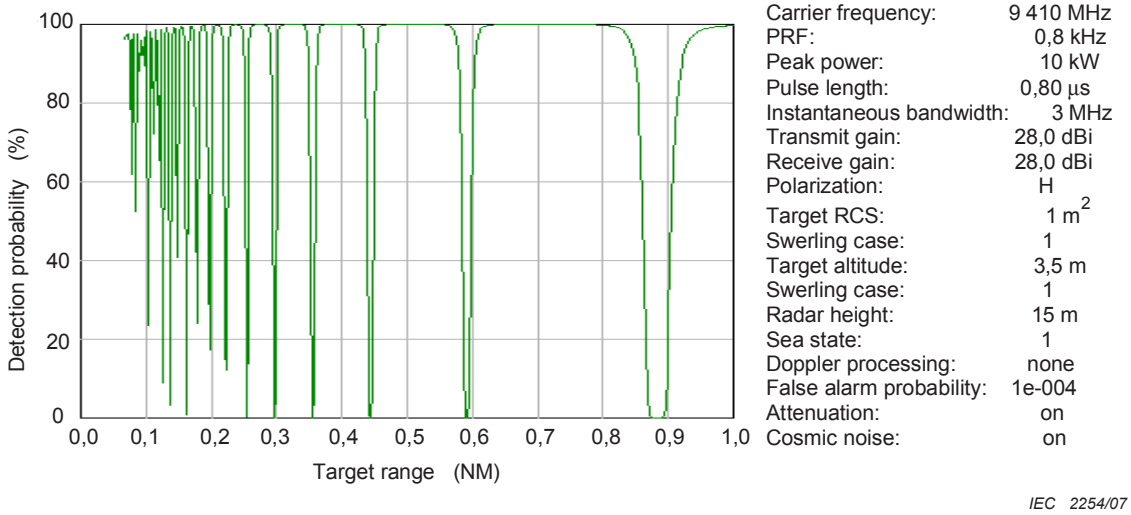


Figure D.3 – Multi-path plot for X-band

D.6 Rain

Rain clutter is described and addressed in 6.9.3.2. Detection performance in Table 2 is degraded as indicated in Figure 1 and Figure 2.

The attenuation coefficients due to uniform rain dB/km = kr^{α} (where k and α depend on frequency band and polarisation in use, r is the rainfall rate, mm/h) are given in Tables D.4 and D.5.

Table D.4 – Parameters for attenuation in uniform rain conditions

Frequency GHz	$K_{horizontal}$	$K_{vertical}$	$\alpha_{horizontal}$	$\alpha_{vertical}$
10 (X-band)	0,01	0,008 9	1,28	1,26
3 (S-band)	0,000 35	0,000 3	1,04	0,98

Table D.5 – Typical values for attenuation and backscatter in uniform rain conditions

Parameter	4 mm/h rain	16 mm/h rain
X-band attenuation (dB/km)	0,059	0,35
S-band attenuation (dB/km)	0,001 5	0,006 3
X-band backscatter dB (m^2/m^3)	–63	–53
S-band backscatter dB (m^2/m^3)	–83	–73

D.7 Radar system parameters

D.7.1 Radar parameters

Table 2 is based on representative radar systems with the parameters as listed in Table D.8 and Table D.9 and using appropriate target RCS and height parameters. Table D.6 provides information on pulse length, PRF and receiver bandwidth. The pulse length used has a significant impact on target detection in sea and rain clutter.

Table D.6 – Additional radar system parameters (X/S-band)

Parameter	SP	MP	LP
PRF kHz	1,8	1,8	0,785
Pulse width μs	0,05	0,25	0,8
Rx bandwidth MHz	20,0	20,0	3,0

The representative radar systems used for calculations were based on non-coherent systems, horizontal polarisation, a single frequency and used the smallest antenna. Performance predictions used CARPET software to provide the range of first detection in minimal clutter conditions for a defined target with a Pd of 0,8 and a false alarm rate of 10^{-4}. A down-mast installation was assumed with a transmission line of 20 m in length.

Calculations of the reduction of range to first detection due to rain used the parameters detailed in Tables D.8 and D.9 but with a K factor of 10 and a target height of 10 m at S-band and 3,5 m at X-band for all cases. In addition, the multi-path and sea clutter toggles were turned off.

D.7.2 Target parameters

The targets used in the calculations were assumed to fluctuate in accordance with Swerling 1.

D.8 Target RCS values

The values used for each target RCS in Table 2 are given in Table D.7.

Table D.7 – Target size, height and RCS values

Target description	Target parameters		
	Height above sea level m	RCS m^2	
		X-band	S-band
Shorelines rising to 60 m	50	50 000	50 000
Shorelines rising to 6 m	5	5 000	5 000
Shorelines rising to 3 m	2,5	2 500	2 500
SOLAS ships (5 000 gross tonnage)	10	50 000	30 000
SOLAS ships (500 gross tonnage)	5	1 800	1 000
Small vessel with radar reflector meeting IMO Performance Standards	4	7,5	0,5
Navigation buoy with corner reflector	3,5	10	1
Typical navigation buoy	3,5	5	0,5
Small vessel of length 10 m with no radar reflector	2	2,5	1,4
Channel markers	1	1	0,1
NOTE Additional notes in Table 2 apply.			

Table D.8 – S-band radar parameters (LP)

Propagation toggles	
Troposcatter	= F
Attenuation	= T
Free space	= F
Surface-based duct	= F
Evaporation duct	= F
Antenna noise	= T
Multipath	= T
Clutter toggles	
Sea clutter	= T
Land clutter	= F
Constant gamma	= F
Rain	= F
Chaff	= F
Jammer toggles	
Barrage	= F
Responsive	= F
Radar toggles	
Phase noise	= F
Doppler processing	= F
Pulse compression	= F
Timing jitter	= F
Rotating	= T
Propagation parameters	
Air temperature	= 15,0 °C
Atmospheric pressure	= 1 020 hPa
Relative humidity	= 70 %
Surface refractivity	= 328,0 N units
Wind direction	= 0°
K-factor	= 1,333
Galactic noise activity	= average
Sea state	= 0,0
Sea salinity	= 35 promille
Water temperature	= 10,0 °C
Evaporation duct height	= 10,0 m
Surface-based duct height	= 100,0 m
Wind force	= 3 Beaufort
Land temperature	= 10,0 °C
Water content soil	= 60 %
Surface roughness	= 0,1 m
Soil type	= average
Clutter parameters	
Land clutter reflectivity	= –38,0 dBm^2/m^2
Rainfall rate	= 16,0 mm/h
Chaff density	= 30 g/km^3
Minimum range rain/chaff	= 0,0 km
Maximum range rain/chaff	= 55,6 km
Maximum altitude rain/chaff	= 1 000 m
Jammer parameters	
Power	= 10,0 kW
Antenna gain	= 12,0 dBi
Bandwidth barrage mode	= 600 MHz
Bandwidth responsive mode	= 10,0 MHz
Range	= 200 km
Altitude	= 3,0 km
Transmitter parameters	
Mean carrier frequency	= 3 050 MHz
Peak power	= 30,0 kW
Pulse length	= 0,8 μs
Instantaneous bandwidth	= 3,0 MHz
Pulse repetition frequency	= 0,785 kHz
Transmitted pulses per burst	= 1
Pulse bursts	= 1
Transmitter losses	= 2,7 dB
White phase noise density	= –120,0 dBc/Hz
Coloured noise power	= –40,0 dBc
Cut-off frequency	= 1,0 Hz
Stdev timing jitter	= 0,1 ns
Antenna parameters	
Type	= rectangular
Vertical Illumination	= parabolic
Polarization	= horizontal
Tracking	= none
Transmit gain	= 27,0 dBi
Receive gain	= 27,0 dBi
Azimuth beamwidth	= 1,9°
Elevation beamwidth	= 30,0°
Azimuth sidelobe level	= –35,0 dB
Beamshape losses	= 1,6 dB
Dissipative losses	= 1,0 dB
Tilt	= 0,0°
Height	= 15,0 m
Frame time	= 1,5 s
Receiver parameters	
MTI	= none
Doppler filter bank	= F
Taper doppler filter	= Hanning
Noise figure	= 5,0 dB
Receiver losses	= 2,7 dB
Processing losses	= 1,8 dB
False alarm probability	= 4,0
Fill pulses	= 0
Stdev timing jitter	= 0,1 ns
Target parameters	
Radar cross-section	= 50 000 m^2
Range	= 10,0 km
Velocity	= 72,0 m/s
Altitude	= 50,0 m
Swerling case	= 1
Circ pol RCS reduction	= 5,0 dB
Layout parameters	
Performance parameter	= range
Minimum plot range	= 0,0 km
Maximum plot range	= 46,3 km
Minimum plot velocity	= 0,0 m/s
Maximum plot velocity	= 300,0 m/s
Minimum plot altitude	= 1,0 m
Maximum plot altitude	= 500,0 m
Range unit	= nmi
Velocity unit	= kn
Altitude unit	= m
Steps	= 400
Size graphics box	= 640 × 480
Logarithmic range axis	= F
Grid	= T
Contour	= F
Probability of detection	= 80,0 %
Follow closing scenario	= F
Write values to file	= F
Generate BMP	= F
Generate HPGL	= F

Table D.9 – X-band radar parameters (LP)

Propagation toggles	
Troposcatter	= F
Attenuation	= T
Free space	= F
Surface-based duct	= F
Evaporation duct	= F
Antenna noise	= T
Multipath	= T
Clutter toggles	
Sea clutter	= T
Land clutter	= F
Constant gamma	= F
Rain	= F
Chaff	= F
Jammer toggles	
Barrage	= F
Responsive	= F
Radar toggles	
Phase noise	= F
Doppler processing	= F
Pulse compression	= F
Timing jitter	= F
Rotating	= T
Propagation parameters	
Air temperature	= 15,0 °C
Atmospheric pressure	= 1 020 hPa
Relative humidity	= 70 %
Surface refractivity	= 328,0 Nunits
Wind direction	= 0°
K-factor	= 1,333
Galactic noise activity	= average
Sea state	= 0,0
Sea salinity	= 35 promille
Water temperature	= 10,0 °C
Evaporation duct height	= 10,0 m
Surface-based duct height	= 100,0 m
Wind force	= 3 Beaufort
Land temperature	= 10,0 °C
Water content soil	= 60 %
Surface roughness	= 0,1 m
Soil type	= average
Clutter parameters	
Land clutter reflectivity	= –38,0 dBm^2/m^2
Rainfall rate	= 16,0 mm/h
Chaff density	= 30 g/km^3
Minimum range rain/chaff	= 0,0 km
Maximum range rain/chaff	= 55,6 km
Maximum altitude rain/chaff	= 1 000 m
Jammer parameters	
Power	= 10,0 kW
Antenna gain	= 12,0 dBi
Bandwidth barrage mode	= 600 MHz
Bandwidth responsive mode	= 10,0 MHz
Range	= 200 km
Altitude	= 3,0 km
Transmitter parameters	
Mean carrier frequency	= 9 410 MHz
Peak power	= 10,0 kW
Pulse length	= 0,8 µs
Instantaneous bandwidth	= 3,0 MHz
Pulse repetition frequency	= 0,785 kHz
Transmitted pulses per burst	= 1
Pulse bursts	= 1
Transmitter losses	= 2,7 dB
White phase noise density	= –120,0 dBc/Hz
Coloured noise power	= –40,0 dBc
Cut-off frequency	= 1,0 Hz
StDev timing jitter	= 0,100 ns
Antenna parameters	
Type	= rectangular
Vertical illumination	= parabolic
Polarization	= horizontal
Tracking	= none
Transmit gain	= 28,0 dBi
Receive gain	= 28,0 dBi
Azimuth beamwidth	= 1,8°
Elevation beamwidth	= 24,0°
Azimuth sidelobe level	= –25,0 dB
Beamshape losses	= 1,6 dB
Dissipative losses	= 1,0 dB
Tilt	= 0,0°
Height	= 15,0 m
Frame time	= 1,5 s
Receiver parameters	
MTI	= none
Doppler filter bank	= F
Taper doppler filter	= Hanning
Noise figure	= 5,0 dB
Receiver losses	= 2,7 dB
Processing losses	= 1,8 dB
False alarm probability	= 4,0
Fill pulses	= 0
StDev timing jitter	= 0,1 ns
Target parameters	
Radar cross-section	= 50 000 m^2
Range	= 10,0 km
Velocity	= 72,0 m/s
Altitude	= 50,0 m
Swerling case	= 1
Circ pol RCS reduction	= 5,0 dB
Layout parameters	
Performance parameter	= range
Minimum plot range	= 0,0 km
Maximum plot range	= 46,3 km
Minimum plot velocity	= 0,0 m/s
Maximum plot velocity	= 300,0 m/s
Minimum plot altitude	= 1,0 m
Maximum plot altitude	= 500,0 m
Range unit	= nmi
Velocity unit	= kn
Altitude unit	= m
Steps	= 400
Size graphics box	= 640 × 480
Logarithmic range axis	= F
Grid	= T
Contour	= F
Probability of detection	= 80,0 %
Follow closing scenario	= F
Write values to file	= F
Generate BMP	= F
Generate HPGL	= F

Annex E
(normative)

Sensor errors

E.1 General

The accuracy figures quoted in 11.3.14 Table 11 and TT Scenario 1 are based upon the following sensor errors and are appropriate to equipment complying with the performance standards for shipborne navigational equipment.

E.2 Radar

E.2.1 Target glint (scintillation) (for 200 m length target)

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

NOTE σ means "standard deviation".

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

E.2.2 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.

E.2.3 Beam shape

Assumed normal distribution giving bearing error with σ = 0,05 .

E.2.4 Pulse shape

Assumed normal distribution giving a 3 sigma range error of 2 m (1 σ = 0,66 m).

E.2.5 Antenna backlash

Assumed rectangular distribution giving bearing error 0,05 maximum.

E.2.6 Quantization

Bearing – rectangular distribution 0,1 maximum.

Range – rectangular distribution 0,01 NM maximum.

Bearing encoder assumed to be running from a remote synchro giving bearing errors with a normal distribution σ = 0,03 .

E.3 Gyro-compass

Calibration error 0,0 . Normal distribution about this with σ = 0,08 .

E.4 Log

Calibration error 0,0 kn. Normal distribution about this, 3 σ = 0,2 kn.

E.5 Errors

The bearing error resulting from the combination of all sensor errors including target glint shall be limited to 0,6 . Calibration errors are regarded as having longer periods.

Annex F
(informative)

Target scenario simulator/reported target simulator

F.1 Target scenario simulator (TSS)

The TSS shall provide 5 target tracking scenarios as described in 11.3. The prime requirements are:

– provide a minimum of 100 radar targets with a controlled defined velocity and defined initial position;
– provide a fading target, a 50 % paint target and lost targets on demand;
– provide a minimum of five target tracking (TT) test scenarios to known solutions for assessing the tracking performance.

F.2 Reported target simulator (RTS)

The reported target simulator (RTS) provides the test scenarios for testing the AIS target functions and for target association for tests described in Clause 10. The simulator shall be PC based.

The RTS shall provide:

– sufficient AIS targets to simulate VDMs corresponding to 90 % of a fully loaded AIS VDL, comprising any combination of class A and class B messages, to test processing and indications/alerts required in 11.3 to 11.7. The AIS targets shall be arranged in a pattern to permit visual assessment of target numbers, and shall extend from 0,3 NM to 12 NM. There shall be a mixture of target velocities, varying from those moving at a high velocity with a high reporting rate with appropriate additional sentences, to those at zero velocity with a low reporting rate.
– four test scenarios for testing target association and disassociation. In these scenarios, two simulated targets, one tracked and the second reported, shall be provided. The scenarios are described in 11.7.

F.3 Combined simulator

The functions of the two target simulators (RTS and TSS) may be combined into a single unit.

F.4 Simulator output signals

The simulators (TSS and RTS) shall provide outputs for azimuth, heading, stabilisation (IEC 61162, gyro and EPFS), synchronisation and video. (An interface shall be provided by the test authority or by the equipment supplier if the EUT is not compatible):

– azimuth: incremental TTL pulses, 4 096 pulses per scan;
– heading: single TTL pulse, 5 ms to 10 ms duration, once per scan;
– video: (5 0,2) V peak into 75 Ω, referenced to 0 V; noise floor 0,5 V peak;
– synchronisation: 12 V nominal into 75 Ω, single pulse 100 ns to 200 ns at PRF.

Annex G
(informative)

Tracked and reported target states

This Annex gives the target tracking state diagram in Figure G.1 and the AIS target state diagram in Figure G.2.

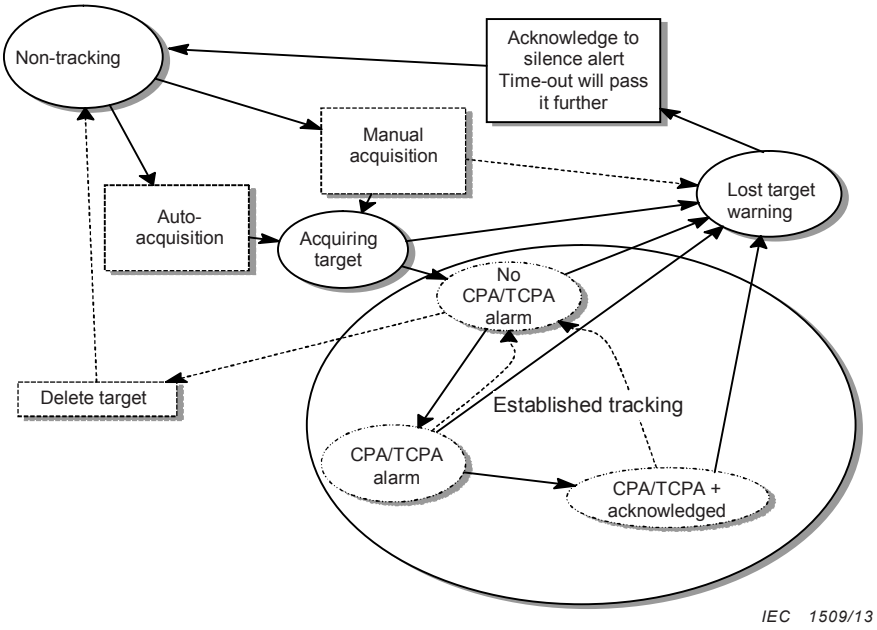


Figure G.1 – Tracked target states

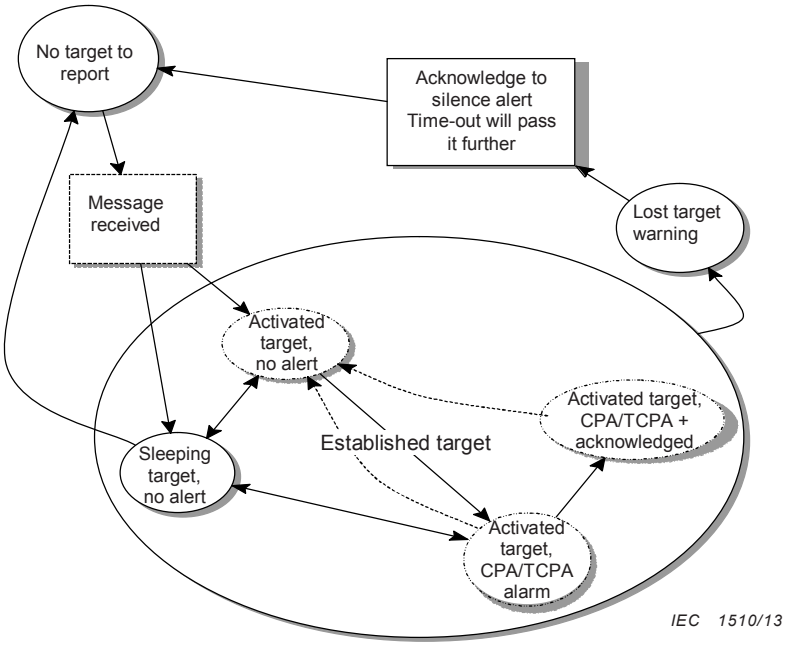


Figure G.2 – AIS target state

Annex H
(normative)

IEC 61162 sentence formats

H.1 General

This Annex H specifies the IEC 61162 sentences that shall be supported.

H.2 IEC 61162-1 Mandatory sentences

Mandatory sentences are listed in Table H.1 and defined in IEC 61162-1 and, for alert management, in IEC 61924-2. Suggested association of sentences with input and output ports are commented Table H.1.

Table H.1 – Mandatory IEC 61162-1 sentences

Parameter	Sentence format	Comments
Time and date	$--ZDA	Input Port 1
Geographic position	$--GLL $--GGA $--GNS	Input 1
AIS target and own ship information	!--VDM !--VDO	Input 2 (Load up to maximum bandwidth, IEC 61162-1 unsuitable)
Datum	$--DTM	Input 1
Heading	$--THS	Input 2 (Update rates to 50 Hz, IEC 61162-1 unsuitable)
Speed	$--VBW $--VTG	Input 1 from SDME (Up to required target capacity. IEC 61162-1 unsuitable)
Tracked target data	!--TTD $--TLB	Output 1 or 2 (up to maximum bandwidth)
Own ship data*	$--OSD	Output 1
Radar system data*	$--RSD	Output 1
Alarm handling	$--ALR $--ACK	Input 1 and Output 1
Alert handling	$--ALC $--ALF $--ARC $--HBT	Output 3
Alert handling	$--ACN $--HBT	Input 3
Heading*	$--HDT	Input 1 and 2 (Update rates to 50 Hz, IEC 61162-1 unsuitable)
Speed*	$--VHW	Input 1
Activity information	$--EVE	Output 1
NOTE Sentences included for backward compatibility are marked with an asterisk (*).		

H.3 Optional alternative IEC 61162-3 compliant messages

Optional messages for use with IEC 61162-3 are listed in Table H.2

Table H.2 – Optional IEC 61162-3 messages

Parameter	Parameter Group Number (PGN) and Description
Time and date	129033 - Time & date
Geographic position	129044 - Datum 129025 - Position, rapid update 129029 - GNSS position data
AIS target and own ship information	129038 - AIS Class A position report 129039 - AIS Class B position report 129040 - AIS Class B extended position report 129794 - AIS Class A static and voyage related data 129798 - AIS SAR aircraft position report 129809 - AIS Class B “CS” static data report, part A 129810 - AIS Class B “CS” static data report, part B 129041 - AIS AtoN
Heading	127250 - Vessel heading
Speed	128259 - Speed, water referenced 129026 - COG & SOG, rapid update
Tracked target data	128520 - Tracked target data
Own ship data	130577 - Direction data
Alarm handling	126983 - Alert 126984 - Alert response
Alert handling (Output)	126208 - Request group function 126983 - Alert 126985 - Alert text 127001 - Alert list
Alert handling (Input)	126984 - Alert response 127002 - Responsibility transfer function

H.4 Optional radar – VDR Ethernet interface using the TCP/IP protocol

NOTE This interface has been superseded by IEC 61162-450 and is not recommended for new equipment.

H.4.1 Definition

This optional interface is addressing the need to simplify interfacing high-resolution radars to Voyage Data Recorders (VDRs). The digital copying of the original radar presentation improves quality by removing digitising errors and reduces overall system complexity. It is also easily extended into a general method for data transfer via Ethernet.

NOTE 1 The TCP standard is RFC 793: 1981, Transmission Control Protocol (TCP), Internet Activities Board recommended standard. The IP standard is RFC 894: 1984, Internet Protocol on Ethernet Networks, Internet Activities Board elective standard. The Ethernet standard is IEEE 802.3.

NOTE 2 To reduce network load, it is advisable that the presentation data in the radar system are not only captured but also pre-processed and packed before they are sent to the VDR via TCP/IP. Experience has shown that the compression and transmission process of compressed data stresses a radar system far less than the transmission of uncompressed data.

The protocol specification is followed by a description of the principle of presentation acquisition and streaming. Table H.3 describes the terminology used.

Table H.3 – Description of terms

Term	Description
BYTE:	The lowest level data element consisting of 8 ordered bits (sometimes called an octet). Bit order is as determined by the computer implementation. Note that the implementation is required to make any necessary conversion between network bit order and computer bit order
Data packet:	A number of *bytes* that contains a *header*, an optional sequence of reserved bytes and the actual message content. The header specifies the length of header itself, of reserved bytes and data and will also contain information that allows a number of data packets to be re-assembled into a *presentation*
Data element:	One or more bytes that forms a stand-alone information carrier, i.e. a time stamp, an integer or a character
DWORD:	Double word. One unsigned 32-bit integer (in range 0 to 4 294 967 295). The DWORD is constructed from four consecutively transmitted BYTE, where the transmission order on the network is the most significant BYTE first followed by the next most significant BYTE till the least significant BYTE
Presentation:	One group of bytes that forms a stand-alone data set, for example one (compressed) radar presentation
Message data:	The data contents of a d*ata package*
Reserved bytes:	A number of bytes in the d*ata packet* that may be ignored by the receiver. The reserved bytes may be additional header information that only has meaning for newer versions of the protocol or they may also be used for manufacturer specific purposes
WORD:	One unsigned 16-bit integer (in the range 0 to 65 535). The WORD is constructed from two consecutively transmitted BYTES, where the transmission order on the network is the most significant BYTE followed by the least significant BYTE
STRING[N]:	A sequence of exactly N BYTES, interpreted as a string of characters. The transmission order on the network is the left-most character first. If the string is shorter than N, additional trailing bytes shall be set to zero. All strings in the header are encoded in ISO 18859-1 (ISO Latin 1)

H.4.2 Data field structure for transfer of presentations

H.4.2.1 General

The files or data streams are transmitted over the network in packets. The data field is defined as a sequential and unpadded stream of octets divided into two main groups – header and package data, as shown below. The header is needed for synchronisation and data integrity validation.

Header
Package data

H.4.2.2 Elements of the header structure

The header format is defined in the Table H.4. The first column specifies the name of the data item inside the header (starting from offset zero). The second column specifies the data type and size. The third column describes the data item and its purpose.

Table H.4 – Header format *(1 of 2)*

Header		
Data item	**TYPE**	**Description**
token	STRING[6]	It shall always contain the string “RaDaR” including a trailing NULL character. Identifier as ASCII string with a length of 5 bytes. This token defines the beginning of a new data block
crcHeader	WORD	Cyclic redundancy check for the header according to CRC-16-CCITT. The CRC is calculated from and including *headerversion* to and including any *reserved* bytes. The CRC is calculated from the sequence of bytes after formatting into transmission byte order. The CRC polynomial is: x^{16} x^{12} x^{5} 1
headerversion	WORD	Defines the header version. The headerversion with value 0 is defined in this standard. Extensions and/or modified versions will update this value
headerlength	DWORD	Defines the header content in octets. This is the length of the header as defined in this subclause including the reserved bytes. The headerlength shall be a minimum of 68 (no reserved bytes)
datalength	DWORD	Defines the data content of this data package in octets. This may be the full (oversized) data in one package or a typical size for network transfer (1280 octets). In the latter case, maxnum, actnum and streamlength will be used to synchronize data packets into a complete data transfer
timeSec	DWORD	Seconds part of time stamp. Timestamp is constructed both of time in seconds and nanoseconds at the grabbing instant. This timestamp shall be made at the source immediately at data recording, for example just before the screenshot. The nanoseconds are needed due to required time resolution of 0,05 s for VDR according to IEC 61996-1. The time representation is the number of seconds since January 1st 1970, not including leap seconds (i.e. in astronomic/GMT representation). This information is only needed with the first packet of each file or data stream. Time stamps in the following data packages belonging to the same data transfer shall be discarded by the receiver NOTE It is only practicable to use this value if the synchronization between the destination device (e.g. VDR) and the source device (e.g. Radar unit) is sufficiently precise (in the range of milliseconds). The *difftime* data item may be used as an alternative method for synchronisation. If difftime is non-zero, this field shall be ignored
TimeNsec	DWORD	Nanosecond part of time stamp. See timeSec for details

Table H.4 *(2 of 2)*

Header		
Data item	**TYPE**	**Description**
difftime	WORD	Time difference in milliseconds between data recording instant (e.g. grabbing instant) and transmission of the first packet of recorded data file or data stream. This element is evaluated only when the first field of the respective structure is zero (timeSec = 0). A timestamp with a resolution of at least in the millisecond range is made immediately before the source generation (e.g. screenshot) and the second timestamp is made immediately before the first packet is transmitted. The difference is entered as “difftime” and the packet is then sent. The destination device (e.g. VDR) uses this difftime value together with its system time to determine the timestamp for the transmitted data. Time tolerances between destination device (e.g. VDR) and source device (e.g. radar unit) may be neglected, because the time reference of the destination device (e.g. VDR) is always the system time of the destination device (e.g. VDR)
maxnum	DWORD	Number of packets needed for transmission of the corresponding file or data stream. The value can be 1 or more
actnum	DWORD	This packet number (range from 1 to maxnum)
streamlength	DWORD	Defines the length of the (full) stream/presentation content in octets
device	BYTE	Data source (device) as binary value, 1 ≥ equipment 1, 2 ≥ equipment 2, etc. The value can be between 1 and 255
channel	BYTE	Subdivision according to data source (device), values from 1 to 255, default = 1
deviceip	DWORD	IP of transmitting device; optionally used, if packet was broadcasted. The IP address is entered in Network Byte Order Format (DWORD)
deviceport	WORD	That port the transmitting device has used for message broadcasting. It may be used optionally
datatype	STRING[16]	This string defines the datablock encoding by assigning a file extension to the datablock for the server. Data Compression algorithms may be added into the data type (e.g. gzip compression of a BMP presentation is identified with file type "bmp.gz"). Archive formats may encapsulate filenames and file extension into the data (e.g. ZIP archive is identified with file type "ZIP"). Datatype for input to the VDR shall correspond to standardised presentation and audio formats that are possible to import into COTS (commercial off the shelf) picture, image and audio manipulation applications (e.g. "bmp", "png", "jpg", "avi"', "mp4", "ogg", "wav", "mp2", "mp3"). The image quality shall comply with the image test of IEC 61996-1
Status of acquisition	WORD	The status for the data return. A zero is returned for normal operation. Non-zero value is used to indicate an error condition. A descriptive text may be put in the status and information text field
Status and information text	STRING[n]	Status information (e.g. successful operation or error codes). This may be one or more strings terminated by a binary null

H.4.2.3 Elements of the package data structure

The package data format is defined in Table H.5. The first column specifies the name of the data item. The second column specifies the data type and size. The third column describes the data item and its purpose.

NOTE The package data structure size is set to zero if only status information is transmitted.

Table H.5 – Package data format

Package data		
Data item	**TYPE**	**Description**
datablock	BYTE[datalength]	This item is the data either split into pieces or in one block. Size is defined by datalength in the header

NOTE There is no CRC for the data contents as this is partly handled by the TCP/IP layer or by other mechanisms in the contents format. The header has a separate CRC as it is deemed more critical for the correct operation of the system.

H.4.3 Structure of the transfer stream

H.4.3.1 General

The transfer may be sent either as a single header and (oversize) datablock, or split into multiple headers and datablocks.

Multiple data blocks can be used for transmitting devices that have limited internal storage or to control the bandwidth utilization of the network. If very large files are transmitted, it may be useful to divide it into blocks that are transmitted with some time interval so that other traffic also can be interspersed.

H.4.3.2 Single header and package data

The complete file or data stream is transferred as one datablock. The data items actnum and maxnum shall be set to one.

H.4.3.3 Multiple headers and package data

The complete file or data stream is split into a number of datablocks. Each header and datablock is transmitted in increasing order, beginning with the first datablock and ending with the last datablock. Synchronisation is achieved with data items actnum and maxnum.

H.4.3.4 Unknown data types

A receiver that does not understand an incoming data type shall give one alert for the first message and then silently ignore all incoming data without closing the connection if the receiver is a server.

NOTE This provision is made so that one does not get an infinite number of connections and broken connections and corresponding alerts. The client will normally try to reconnect after 30 s in any case.

If the receiver is a client and does not understand incoming data, it shall give an alert and immediately close the connection.

NOTE If a radar receives unexpected data on the return link from the VDR server, this can be treated as an error as described here. Normally the VDR does not send any data to the radar.

H.4.4 TCP port and IP addresses

The IP address is freely selectable and is depending on the network configuration of the corresponding equipment manufacturer. The IP address of each presentation source and the VDR has to be coordinated and set manually beforehand.

Equipment unable to perform an address look-up service should be configured to the same IP sub-net. A router can be used if the equipment is connected on different IP sub-nets.

The default TCP port between radar and VDR for the transfer shall be 7096.

NOTE The radar supports configuration of the VDR port number and IP address.

H.4.5 Support for redundancy

Redundancy, if required, is established by utilising two independent networks (with independent power supplies and separate network components). Then each client and server will have two physical interfaces to the two independent networks.

The client and server shall be configured with the same network address, except for the subnet part. The client sends all messages on both networks with identical content. The server will receive and compare the two messages and use one of the copies.

H.4.6 Principle of operation

The principle of operation is described as implementation guidance.

H.4.7 VDR as server and radar as client

H.4.7.1 General

To satisfy performance standard requirements to the VDR, the VDR has to be configured as a passive listening device. Thus, the VDR is the passive server listening while the radar is the active client connecting and transferring the data.

Note that the VDR may be set up to accept multiple clients on the same input port. This is necessary if more than one radar is assumed to send its presentations to the VDR. For redundant networks, it is not necessary to support multiple clients on the listening port as the listening ports have to be configured for two different sub-nets.

H.4.7.2 Connection management from radar client

The client shall establish a connection to the server immediately after system initialisation. Once the connection is established, the client is responsible for the connection and streaming of data packet to the server.

If the connection attempt fails or connection is lost, the client shall try to establish the connection again. The interval between attempts shall not exceed 30 s. The maximum update interval for the radar presentations in the VDR is 15 s. This corresponds to two intervals.

H.4.7.3 Connection management from VDR server

The server shall make the listening port available for data transfers during initialisation.

The manufacturer shall specify the maximum number of client connections for the server. The server shall receive data individually from connected clients and detect any loss of connection from clients.

NOTE Some equipment test and performance standard require alerts to be raised for loss of connection.

The server may in some cases only detect a failed connection by timeout since data was received last time. The server data reception timeout shall not exceed 30 s. The server shall reinitialise the listening port and the receiver software module after timeout for the client.

H.4.7.4 Capturing the screen content

Initially a digital screen copy is used to generate a presentation bitmap. The capturing process shall be independent of the radar application creating the presentation.

H.4.7.5 Conversion into standardised presentation format

The captured presentation bitmap in the system memory (up to this point still a pure bitmap, i.e. as a pixel stream) is then converted into a standardised presentation format. The presentation format may be lossless or lossy. All algorithms shall comply with the receiving equipment requirement, i.e. VDR presentation tests as specified in IEC 61996-1.

NOTE Standardised presentation formats are possible to import into COTS (commercial off the shelf) picture and presentation manipulation applications.

H.4.7.6 Error handling

The server shall ensure data integrity at reception by verification of the header including token, version, consistency of data fields and the header CRC. Erroneous data reception shall be processed and indicated according to individual equipment standards (for VDR according to IEC 61996-1).

NOTE Consistency of data fields depends on application. However, strings can be checked against containing illegal characters, message sequence numbers can be checked, etc.

H.4.7.7 Transmission of a presentation

The client transmission of a presentation may occur at any time when the connection is open. The message header information is sufficient for the server to decode the data stream and reassemble the presentation and its associated header information data.

A presentation shall be encoded and transferred as one single (oversized) data packet with defined header, or as a set of packets with individually specified sizes.

H.4.7.8 Device identification

All clients shall be configured with a unique device identification (1–255) to allow the server to unambiguously identify the source of the received packets.

H.4.8 Interface test and test results

H.4.8.1 General

The radar is tested as a client and the VDR as a server.

H.4.8.2 Test of client

H.4.8.2.1 Description

The test set-up is a controllable server and the equipment under test. The following tests shall be performed and passed.

H.4.8.2.2 Connection establishment test

Remove server from network and power up client. Verify that client performs reconnection attempts as specified.

Connect server and verify that connection is established.

Test that the presentation transfer time is no more than 5 s.

H.4.8.2.3 Lost connection test

Power down or physically remove server from network and verify that client detects connection failure. This will normally require the transmission of some data from client.

Reconnect server and verify that client really is able to send data as specified. Inspect headers and verify that they are according to the data format specification. Verify that time stamp is increased.

Break connection in the middle of a transfer. Verify that the client equipment continues to operate and tries to reconnect. The client may also raise an alert.

H.4.8.2.4 Presentation quality test

Apply the test presentations defined in the presentation test of IEC 61996-1 on the display. Verify that the presentations transfer without degradation for lossless transfers, or within presentation test limits for lossy transfers.

H.4.8.3 Test of server

H.4.8.3.1 General

The test set-up is a controllable client server and the equipment under test. The client shall be able to generate the following and tests shall be made that check the correct functioning of the server in these cases.

H.4.8.3.2 Connection establishment test

Remove clients from network and power up server. Verify that server starts up as specified. Verify that configured clients without connection raise alert.

Connect client(s) and verify that server enters normal operation.

H.4.8.3.3 Lost connection test

Break connection in the middle of a transfer. Verify that the server raises an alert and continues to operate.

H.4.8.3.4 Single message transfer test

Test transfer of at least one presentation streamed as one packet.

H.4.8.3.5 Multiple message transfer test

Test transfer of at least one presentation streamed into a minimum of 5 packets.

H.4.8.3.6 Multiple client test

Test simultaneous transfers from the maximum allowed number of clients according to the manufacturer.

H.4.8.3.7 Erroneous input test

Test incorrect length set in the header.

H.4.8.3.8 Undefined header test

Test header version set to undefined value in the header.

Annex I
(normative)

Radar control function/indication grouping

I.1 General

Operational controls for navigational systems and equipment shall be easy to identify and simple to use. Controls may be implemented through dedicated hardware, screen-accessed soft keys, or a combination of both. The primary controls for each navigational system or equipment shall be identified and provided with an associated status indication in accordance with the function it is serving.

I.2 Logical grouping of data and control functions

Data and control functions for radar applications shall be divided into logical groups.

Table I.1 provides examples of top-level logical groupings of data and controls for radar.

Table I.1 – Top-level grouping of data and control functions for radar applications

Own ship information	**Navigation tools**
Position Heading/speed (or course/speed)	Cursor readout VRM/EBL/ERBL readout Parallel index lines readout
Range and mode information	**Radar system information**
Range scale Azimuth Orientation mode Sea/Ground Stabilisation mode Motion mode	Standby/run Pulse length Frequency band Master/slave designation Tune
Target information	**Radar signal information**
Target association Target vector properties Target trails Collision avoidance parameters AIS status AIS filter	Gain Rain Sea Processing (for example target enhancement or correlation)
Chart	**General**
Scale Database information	Alerts

Compliance with the logical grouping is tested in Clause 12.

I.3 Symbols for controls

When any of the following controls are used, they shall be identified in English by the relevant name or abbreviation as listed in IEC 62288. In addition, they may be identified by standard icons as shown in Table I.2.

Table I.2 – Icons for common function controls *(1 of 2)*

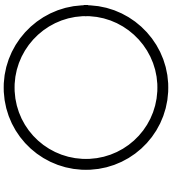
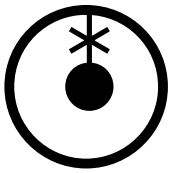
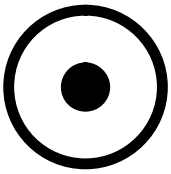
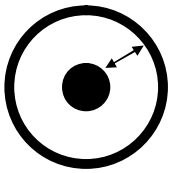
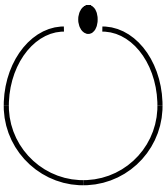
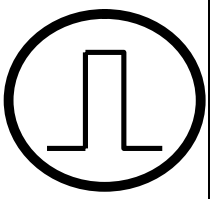
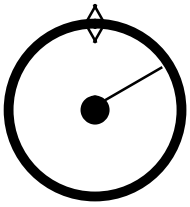
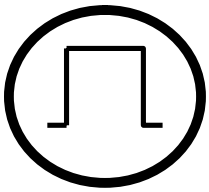
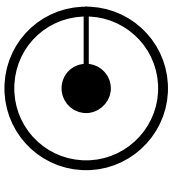
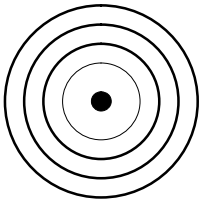
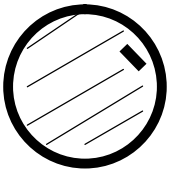
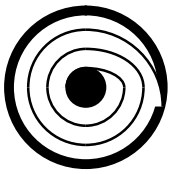
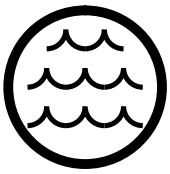
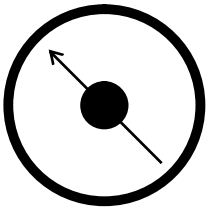
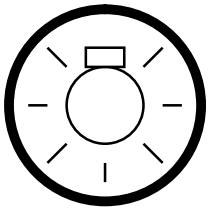
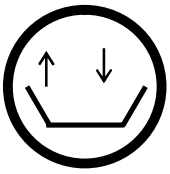
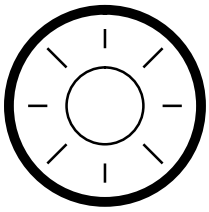
	Symbol	Name	Explanation		Symbol	Name	Explanation
1		OFF	To identify the "off" position of the control or switch	6		HEADING LINE OFF	To identify the "heading line" off position
2		ON	To identify the "radar on" position of the switch	7		RANGE	To identify the "range" selection switch
3		STAND-BY	To identify the "radar stand-by" position of the switch	8		SHORT PULSE	To identify the "short" pulse position of the pulse length selection control
4		NORTH-UP	To identify the "north-up" position of the mode of presentation switch	9		LONG PULSE	To identify the "long" pulse position of the pulse length selection control
5		SHIP'S HEAD-UP	To identify the "ship's head-up" position of the mode of presentation switch	10		TUNE	To identify the "tuning control"

Table I.2 *(2 of 2)*

	Symbol	Name	Explanation		Symbol	Name	Explanation
11		GAIN	To identify the "gain" control	16		RANGE RINGS	To identify the maximum position of the "range rings brilliance" control
12		RAIN	To identify the position of the "rain" control or switch	17		VARIABLE RANGE MARKER	To identify the "variable range marker" control
13		SEA	To identify the minimum position of the "anti-clutter sea" control	18		ELECTRONIC BEARING LINE	To identify the "electronic bearing line" control
14		PANEL ILLUMINATION	To identify the maximum position of the "panel illumination" control or switch	19		TRANSMIT/ RECEIVE MONITOR	To identify the position of the performance monitor switch
15		DISPLAY BRILLIANCE	To identify the maximum position of the "display brilliance" control				

I.4 Icon codes of practice

The following code of practice should be used when marking equipment controls with optional icons:

a) the minimum dimension of a symbol should be not less than 9 mm;

b) the distance between the centres of two adjacent symbols should be not less than 1,4 times the size of the larger symbol;

c) switch function symbols should be linked by a line. A linked line infers controlled action;

d) variable control function symbols should be linked by a line, preferably an arc. The direction of increase of the controlled function should be indicated;

e) symbols should be presented with a high contrast against their background;

f) the various elements of a symbol should have a fixed ratio one to another;

g) multiple functions of controls and switch positions may be indicated by a combined symbol;

h) where concentric controls or switches are fitted, the outer of the symbols should refer to the larger diameter control.

Annex J
(informative)

Interference to shipborne radar from emissions in adjacent frequency bands

J.1 Overview

In a future edition of this Standard, consideration of new test requirements will be required to ensure that radars can operate in the presence of interfering systems, above and below the radar band, applicable to magnetron based and solid state radar systems.

IMO recognises radar as an important tool to aid collision avoidance. Its use is explicitly referenced in the International Regulations for Preventing Collisions at Sea and carriage is made mandatory by the Convention on Safety of Life at Sea (SOLAS).

The deployment of Broadband Radio Services (BRS) is now authorized in the bands above and below S Band radar (2 900 MHz to 3 100 MHz). This presents a threat to shipborne radar systems of degraded detection performance and reduced usability.

Beginning with WRC-03, the ITU agreed on new frequency allocations for the band 2 520 MHz to 2 690 MHz. This included fixed and mobile services in all regions. Preparations were made to use this band for Broadband Radio Services (BRS) such as WiMAX and LTE and by about 2010 such services were already being deployed. In addition, there are similar fixed and mobile allocations in the band 3 400 MHz to 3 600 MHz. Parts of that spectrum have already been allocated to BRS. Other spectrum reallocations even closer to S-band are possible given the increasing demand for BRS spectrum.

J.2 Adjacent Frequency Bands

Before the advent of these new services shipboard radars were able to operate in a relatively benign radio environment with regard to possible interference from the adjacent bands. This also included the bands, 2 700 MHz to 2 900 MHz and 3 100 MHz to 3 400 MHz, all of which were allocated entirely to radiodetermination services.

This fundamental change to the radio environment and possible levels of interference has brought about many studies and some practical trials to quantify the potential levels of interference on shipboard radars operating in the S Band from the use of BRS in both the 2 600 MHz and 3 400 MHz bands. The output of these studies is generally in the form of the geographic separation distances required between the radiodetermination and BRS services at transmitter power levels based on broadband industry guidance for levels of interference assumed to be acceptable on navigation radar.

As stated in 6.2.1 shipborne radar should operate in conformance with the ITU Radio Regulations and applicable ITU Recommendations. In particular, the ITU Radio Regulations include:

- Article 3.3. Transmitting and receiving equipment intended to be used in a given part of the frequency spectrum should be designed to take into account the technical characteristics of transmitting and receiving equipment likely to be employed in neighbouring and other parts of the spectrum, provided that all technically and economically justifiable measures have been taken to reduce the level of unwanted emissions from the latter transmitting equipment and to reduce the susceptibility to interference of the latter receiving equipment.

- Article 3.13. The performance characteristics of receivers should be adequate to ensure that they do not suffer from interference due to transmitters situated at a reasonable distance and which operate in accordance with these regulations.
- Article 4.3. Any new assignment or any change of frequency or other change of characteristic of an existing equipment shall be made in such a way such as to avoid causing interference to services rendered by stations using frequencies assigned in accordance with the table of RR frequency allocations and the other provisions of these Regulations.

J.3 Current situation

A shipboard radar system in an allocated band may be susceptible to performance degradation due to BRS equipment operating in adjacent bands. The resulting degradation will put the detection of small targets at risk. If the operation of automatic-tuning functions are affected, then detection of larger targets could also be at risk, although this concern is currently unproven. Field tests have shown that, due to the broadband and continuous nature of such interference, in some cases radar users may observe nothing to warn them of any loss of capability.

Shipboard radars are required to detect a variety of targets at specified distances with a 0,8 probability of detection given $1x10^{-4}$ probability of false alarm and to maintain tracking of targets with 0,5 probability of detection. Interference may cause degradation below these requirements, quantified by decreased detection range or detection probabilities. Interference protection criteria are needed to limit this degradation. These criteria include the allowable detection degradation, minimum separation distance, allowable outage, and limits on out-of-band and spurious emissions.

NOTE Outage is a measure of reliability and reflects the statistical consequences of variation over time in propagation conditions and anomalous propagation between locations of the radar, target and interfering sources. Initial studies have expressed outage as the percentage of time the radar is operating below the allowed degraded probability of detection in 50 % of the physical area covered by an analysis.

Initial studies are focused on two interference mechanisms. In the first case, interference may be caused by BRS out-of-band and spurious emissions entering the radar receiver bandwidth. This may be mitigated by filtering at the BRS transmitter. In the second case, interference may be caused by BRS emissions that overload the radar front end. This case may be mitigated by radar receiver filtering.

Either case may be alleviated with attenuation achieved by re-aiming the antenna of a BRS base station transmitter and by increasing the distance from the shoreline to the closest BRS base station. Neither approach is applicable to mobile user terminals, which might be operated in relatively close proximity from bridge wings, open decks and nearby vessels.

Initial studies show that BRS spurious emissions need to be attenuated to power levels below limits established by the ITU to maintain reliable radar performance commensurate with the needs of ships operating under SOLAS regulations. In one example, based on industry guidelines for WiMAX with a 20 W BRS base stations in a cellular network transmitting a single channel toward radars and allowed a minimum separation of 1 km from radars, it has been estimated that BRS transmitters would need 100 dB of spurious emission attenuation to limit degradation in probability of detection to 5,3 % or a reduction in range of first detection by 5 % with $1x10^{-4}$ probability of false alarm and 5 % outage. Further degradation occurs if the WiMAX network is operating with a larger number of channels. For 20 channels, the increased spurious emission levels are estimated to require an additional 13 dB attenuation of spurious emissions. These initial studies assumed a clutter free environment, normal propagation in a maritime temperate climate and did not include radar side lobe effects. The effect on Doppler-based velocity measurement was not examined.

J.4 Outlook

To maintain the performance of shipboard radar systems and thus navigation safety, further research is needed into the trade-off between parameters including:

- acceptable radar performance degradation;
- acceptable radar performance reliability;
- radar receiver overload and front-end filtering characteristics;
- BRS out-of-band and spurious emission levels;
- minimum shoreline setback distances for BRS transmitters.

The power levels, spurious emission levels, and shoreline setback of BRS transmitters are factors regulated by national administrations and are outside the scope of standards for radar equipment. However, interference caused by BRS out-of-band and spurious emission levels that fall within a radar receiver's bandwidth cannot be filtered out at the radar receiver and will to some degree degrade radar performance and usability by effectively raising or modulating the noise floor.

Standards for shipboard radar systems should recognise the necessity of radar receiver filtering and receiver overload characteristics that will reduce the impact of the BRS emissions on radar detection performance and presentation usability. These considerations will require additional test methods which may call for field testing in a benign EMI environment with a controlled BRS transmitter or allow the alternative of laboratory measurements requiring access to internal waveguide.

J.5 Reference documents

ITU-R Recommendation M.1464-1, *Characteristics of radiolocation radars, and characteristics for sharing studies of aeronautical radionavigation and meteorological radars in the radiodetermination service operating in the frequency band 2700-2900*

M. Ganley, *Assessment of Interference to Maritime Radars, Oban Trial report,* ERA Technology

M. Ganley, *Potential impact of Out of band Emissions from 2.6 GHz on S band maritime radar,* ERA Technology

Ofcom, *Co-existence of S Band radar Systems and adjacent future services*

M. Ganley, S. Unday, I. Parker, S. Antwi, *Proof of concept radar testing for Bandsharing maritime radar,* ERA Technology

FH. Sanders, RL. Sole, BL. Bedford, D. Franc, and T. Pawlowitz, *Effects of RF Interference on Radar Receivers,* NTIA

OFCOM, *Communications signals in the 2.6 GHz band and maritime radar – Technical assessment of interference*

R. Achatz, P. McKenna, R. Dalke, N. Deminco, and F. Sanders, *Effects of Spurious Emissions from Broadband Radio Service Transmitters on Marine Radars,* Presentation to IEC 62388 TC/80 MT1 meeting in London, UK at the British Standards Institute, January 17, 2012.

Wimax Forum August 2006, *Mobile WiMAX – Part 1: A technical overview and performance evaluation,* Mobius Consulting

Bibliography

IEC 62616, *Maritime navigation and radiocommunication equipment and systems – Bridge navigational watch alarm system (BNWAS)*

ISO/IEC 10918-1, *Information technology – Digital compression and coding of continuous tone still images. Requirements and guidelines*

ISO/IEC 15444, *Information technology – JPEG 2000 image coding system*

ISO/IEC 15948*, Portable Network Graphics (PNG) Specification (Second edition): Information technology – Computer graphics and image processing – Portable Network Graphics (PNG): Functional specification*

ISO 9000, *Quality management systems – Fundamentals and vocabulary*

ISO 9241-8, *Ergonomic requirements for office work with visual display terminals (VDTs) – Part 8: Requirements for displayed colours*

ISO 9241-12, *Ergonomic requirements for office work with visual display terminals (VDTs) – Part 12: Presentation of information*

ITU-R Recommendation M.1371, *Technical characteristics for an automatic identification system using time division multiple access in the VHF maritime mobile band*

IMO SOLAS:1974, *International Convention for the Safety of Life at Sea, as amended*

IMO STCW:1978, *International convention on standards of training, certification and watchkeeping*

IMO Resolution MSC.164(78):2004, *Revised performance standards for radar reflectors*

IMO Resolution MSC.252(83):2007, *Revised performance standards for integrated navigation systems*

IMO MSC.333(90):2012, *Performance standards for shipborne Voyage Data Recorders (VDRs)*

IMO SN/Circ.243:2004, *Guidelines for the presentation of navigation related symbols, terms and abbreviations*

IMO SN/Circ.243 Add.1:2008, *Amendment to guidelines for the presentation of navigation related symbols, terms and abbreviations*

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