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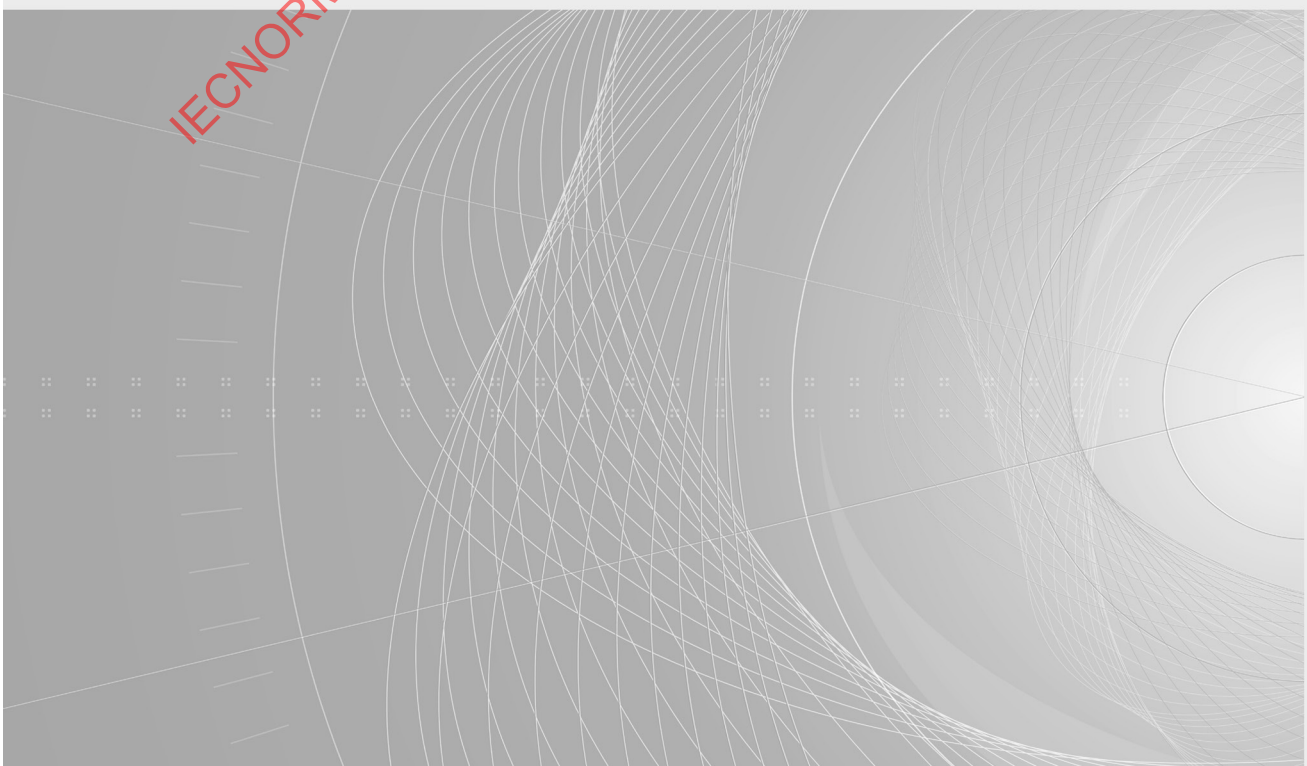
INTERNATIONAL STANDARD

Maritime navigation and radiocommunication equipment and systems – Global navigation satellite systems (GNSS) –
Part 6: Navigation with Indian constellation (NavIC)/Indian regional navigation satellite system (IRNSS) – Receiver equipment – Performance requirements, methods of testing and required test results



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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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CONTENTS

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MARITIME NAVIGATION AND RADIOCOMMUNICATION EQUIPMENT AND SYSTEMS – GLOBAL NAVIGATION SATELLITE SYSTEMS (GNSS) –

Part 6: Navigation with Indian constellation (NavIC)/Indian regional navigation satellite system (IRNSS) – Receiver equipment – Performance requirements, methods of testing and required test results

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The text of this International Standard is based on the following documents:

Draft	Report on voting
80/1055/FDIS	80/1058/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

A list of all parts in the IEC 61108 series, published under the general title *Maritime navigation and radiocommunication equipment and systems – Global navigation satellite systems (GNSS)*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

MARITIME NAVIGATION AND RADIOCOMMUNICATION EQUIPMENT AND SYSTEMS – GLOBAL NAVIGATION SATELLITE SYSTEMS (GNSS) –

Part 6: Navigation with Indian constellation (NavIC)/Indian regional navigation satellite system (IRNSS) – Receiver equipment – Performance requirements, methods of testing and required test results

1 Scope

This part of IEC 61108 specifies the minimum performance requirements, methods of testing and required test results for the Indian regional navigation satellite system (IRNSS), also known as Navigation with Indian Constellation (NavIC), shipborne receiver equipment, based on IMO resolution MSC.449(99), which uses the signals from NavIC/IRNSS in order to determine position.

This document takes account of the general requirements given in IMO resolution A.694(17) and is associated with IEC 60945. When a requirement in this document is different from IEC 60945, the requirement in this document takes precedence. This document also takes into account, as appropriate, requirements for the presentation of navigation-related information on shipborne navigational displays given in IMO resolution MSC.191(79) and is associated with IEC 62288. This document further takes into account, as appropriate, requirements for bridge alert management given in IMO resolution MSC.302(87) and is associated with IEC 62923-1.

This document applies to navigation in ocean waters for the standard positioning service and harbour entrances, harbour approaches and coastal waters, as defined in IMO resolution A.1046(27) within IRNSS/NavIC coverage area as given in IMO resolution MSC 449(99).

All text of this document whose meaning is identical to that in IMO resolution MSC. 449(99) is printed in italics and the resolution and paragraph number indicated between brackets, i.e. "(M.449(99)/A1.2)".

The requirements in Clause 4 are cross-referenced to the tests in Clause 5 and vice versa.

NOTE 1 A description of the IRNSS standard positioning service can be found in the interface control documents which were officially released in 2017 in the public domain (see ISRO-IRNSS-ICD-SPS-1.1).

NOTE 2 The IRNSS constellation was renamed as "NavIC" (navigation with Indian constellation) in 2016.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. 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 61108-4, *Maritime navigation and radiocommunication equipment and systems – Global navigation satellite systems (GNSS) – Part 4: Shipborne DGPS and DGLONASS maritime radio beacon receiver equipment – Performance requirements, methods of testing and required test results*

IEC 61108-5:2020, *Maritime navigation and radiocommunication equipment and systems – Global navigation satellite systems (GNSS) – Part 5: BeiDou navigation satellite system (BDS) – Receiver equipment – Performance requirements, methods of testing and required test results*

IEC 61162-1, *Maritime navigation and radiocommunication equipment and systems – Digital interfaces – Part 1: Single talker and multiple listeners*

IEC 61162-2, *Maritime navigation and radiocommunication equipment and systems – Digital interfaces – Part 2: Single talker and multiple listeners, high-speed transmission*

IEC 61162-450, *Maritime navigation and radiocommunication equipment and systems – Digital interfaces – Part 450: Multiple talkers and multiple listeners – Ethernet interconnection*

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*

IEC 62923-1, *Maritime navigation and radiocommunication equipment and systems – Bridge alert management – Part 1: Operational and performance requirements, methods of testing and required test results*

IEC 62923-2, *Maritime navigation and radiocommunication equipment and systems – Bridge alert management – Part 2: Alert and cluster identifiers and other additional features*

IMO resolution A.694(17):1991, *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.915(22), *Revised maritime policy and requirements for a future Global Navigation Satellite System (GNSS)*

IMO resolution A.1046(27), *Worldwide radio navigation system*

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

IMO resolution MSC.449(99), *Performance Standards for Shipborne IRNSS Receiver Equipment*

ITU-R Recommendation M.823-3, *Technical characteristics of differential transmissions for global navigation satellite systems from maritime radio beacons in the frequency band 283.5-315 kHz in Region 1 and 285-325 kHz in Regions 2 and 3*

ISRO-IRNSS-ICD-SPS-1.1, *Navigation with Indian Constellation System – Signal in Space Interface Control Document for Standard Positioning Service V 1.1*, Aug 2017 [viewed 2022-11-11]. Available at https://www.isro.gov.in/media_isro/pdf/Publications/Vispdf/Pdf2017/irnss_sps_icd_version1.1-2017.pdf

RTCM 10402, *RTCM Recommended Standards for Differential GNSS (Global Navigation Satellite Systems) Service*

3 Terms, definitions and abbreviated terms

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

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- IEC Electropedia: available at https://www.electropedia.org/
- ISO Online browsing platform: available at https://www.iso.org/obp

NOTE All definitions and abbreviations used are the same as those used in ISRO-IRNSS-ICD-SPS-1.1.

3.1 Terms and definitions

3.1.1
integrity
ability of the system to provide users with warnings within a specified time when the system should not be used for navigation

3.1.2
Indian regional navigation satellite system
IRNSS
independent satellite navigation system developed and operated by India

Note 1 to entry: IRNSS can provide 3D position, velocity and time information for users within 1 500 km from the Indian geopolitical boundary.

Note 2 to entry: IRNSS is known as NavIC and the words are used interchangeably in this document.

3.1.3
IRNSS/NavIC time
time reference built and kept by IRNSS

Note 1 to entry: The IRNSS system time start epoch is 00:00 UT on Sunday August 22nd 1999 (midnight between August 21st and 22nd). At the start epoch, IRNSS system time is ahead of UTC by 13 leap seconds (i.e. IRNSS time, August 22nd 1999, 00:00:00 corresponds to UTC time August 21st 1999, 23:59:47).

3.2 Abbreviated terms

BAM bridge alert management
CAM central alert management
COG course over ground
CW continuous wave
DNavIC differential navigation with Indian constellation
EUT equipment under test
GNSS global navigation satellite system
GPS global positioning system
HAL horizontal alert limit
HDOP horizontal dilution of precision
HPL horizontal protection limit
ICD interface control document
MKD minimum keyboard and display
NavIC navigation with Indian constellation
NB narrow band
NPLI national physical laboratory of India

PDOP position dilution of precision
PNT position navigation and timing
RAIM receiver autonomous integrity monitor
RF radio frequency
RFCS radio frequency constellation simulator
RFI radio frequency interference
SOG speed over ground
SPS standard positioning service
UTC universal time coordinated
WB wide band

4 Minimum performance requirements

4.1 Object

(M.449(99)/A1.2) The IRNSS Standard Positioning Service (SPS) provides positioning, navigation and timing services, free of direct user charges. The IRNSS SPS receiver equipment should be capable of receiving and processing the IRNSS SPS signal. It should be capable of tracking all IRNSS satellites.

(M.449(99)/A1.3) Receiver equipment for the Indian Regional Satellite System (IRNSS) intended for navigational purposes on ships with maximum speeds not exceeding 70 knots shall, in addition to the general requirements contained in resolution A.694(17), comply with the following minimum performance requirements.

(M.449(99)/A1.4) This standard covers the basic requirements of position fixing, determination of course over ground (COG), speed over ground (SOG) and timing either for navigation purposes or as input to other functions. The standards do not cover other computational facilities which may be in the equipment nor cover the requirements for other systems that may take input from the IRNSS receiver.

This document contains the basic minimum performance requirements for use of IRNSS/NavIC standard positioning service (SPS) signals for navigational position fixing, including differential corrections, and, in addition, for the determination of speed and direction of the movement of the antenna over the ground.

Other computational activity, input/output activity or extra display functions which may be provided shall not degrade the performance of the equipment below the minimum performance requirements set out in this document.

The IRNSS/NavIC receiver equipment shall comply with:

– the provisions of IMO resolutions A.1046(27), MSC. 449(99), MSC.302(87) and A.694(17);
– the accuracy requirements of the SPS interface control document;
– tests in accordance with IEC 60945.

4.2 IRNSS/NavIC receiver equipment

4.2.1 Minimum facilities

(M.449(99)/A2.1) The term "IRNSS receiver equipment" as used in these performance standards includes all the components and units necessary for the system to properly perform its intended functions. The equipment shall include the following minimum facilities:

a) *antenna capable of receiving IRNSS signals;*

b) *IRNSS receiver and processor;*

c) *means of accessing the computed latitude/longitude position;*

d) *data control and interface; and*

e) *position display and, if required, other forms of output.*

If the IRNSS/NavIC receiver forms part of an approved integrated navigation system (INS), requirements of c), d) and e) may be provided within the INS.

If the IRNSS/NavIC receiver forms part of an approved multi-system PNT, requirements of c), d) and e) may be provided within the multi-system PNT.

4.2.2 Configuration

The IRNSS/NavIC receiver equipment may be supplied in one of several configurations to provide the necessary position information. Examples are as follows:

– stand-alone receiver with means of accessing computed position via a keyboard with the positional information suitably displayed and with means to display alerts and acknowledge alerts via the keyboard;

– IRNSS/NavIC black box receiver fed with operational parameters from external devices/remote locations and feeding an integrated system with means of access to the computed position via an appropriate interface, and the positional information and alert management information available to at least one remote location. With this option, a separate user interface called as MKD shall be provided as a backup;

– as one of the position velocity and time (PVT) methods included in a multi-system PNT equipment based on IMO resolution MSC.401(95).

The above examples should not be implied as limiting the scope of future development.

4.2.3 Quality assurance

The equipment shall be designed, produced and documented by manufacturers complying with approved quality systems as applicable.

4.3 Performance of IRNSS/NavIC receiver equipment

4.3.1 General

(See 5.6.2)

(M.449(99)/A3.1) The IRNSS receiver equipment shall be capable of receiving and processing the IRNSS SPS positioning and velocity, and timing signals, and shall use the ionospheric model broadcast to the receiver by the constellation to generate ionospheric corrections.

A detailed description of the IRNSS/NavIC navigation signal characteristics is given in ISRO-IRNSS-ICD-SPS-1.1, Aug 2017.

(M.449(99)/A3.2) The IRNSS receiver equipment shall provide position information based upon WGS-84 and should be in accordance with international standards.

Means may be provided to transform the computed position based upon WGS-84 into data compatible with the datum of the navigational chart in use. Where this facility exists, the display shall indicate that co-ordinate conversion is being performed and shall identify the co-ordinate system in which the position is expressed.

(M.449(99)/A3.3) The IRNSS receiver equipment shall provide time referenced to universal time coordinated UTC (NPLI).

4.3.2 Equipment interfaces

(See 5.6.3)

(M.449(99)/A3.4) The IRNSS receiver equipment shall be provided with at least two outputs from which position information, UTC, course over ground (COG), speed over ground (SOG) and alarms can be supplied to other equipment. The output of position information shall be based on the WGS 84 datum and shall be in accordance with international standards. The output of UTC, course over ground (COG), speed over ground (SOG) and alarms shall be consistent with the requirements of M.449(99)/A3.16 and M.449(99)/A3.18.

(M.449(99)/A3.17) The IRNSS receiver equipment shall provide at least one normally closed contact, which shall indicate failure of the IRNSS receiver equipment.

(M.449(99)/A3.18). The IRNSS receiver equipment shall have a bidirectional interface to facilitate communication so that alarms can be transferred to external systems and so that audible alarms from the IRNSS receiver can be acknowledged from external systems; the interface shall comply with relevant international standards.

NOTE Alarms are read as alerts in M.449(99)/A3.4 and A3.18 for BAM compliance.

The physical interface shall be based on IEC 61162-1 or IEC 61162-2 or IEC 61162-450. Logical interfaces are shown in Figure 1, where required interfaces are indicated with solid lines and optional interfaces are indicated in dashed lines.

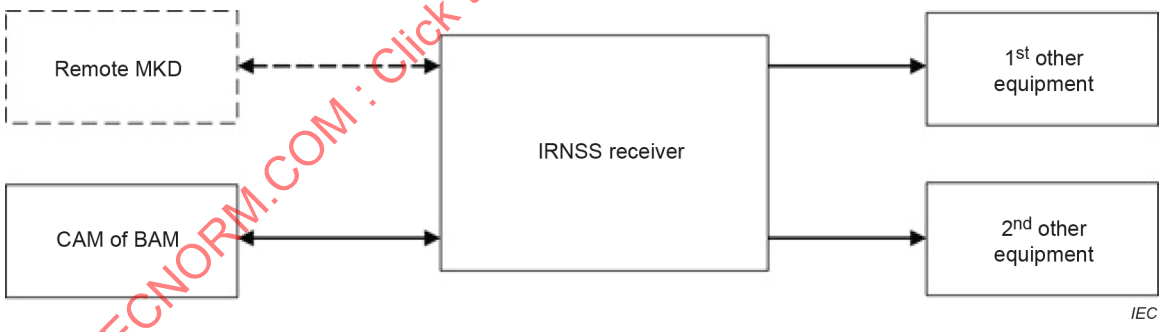

Figure 1 – Logical interfaces of IRNSS/NavIC receiver

IRNSS/NavIC receiver shall use talker ID "GI".

For reporting purposes, the following sentences shall be available in any combination:

- DTM – Datum reference (see IEC 61108-5);
- GBS – GNSS satellite fault detection (see IEC 61108-5);
- GFA – GNSS fix accuracy and integrity (see IEC 61108-5);
- GNS – GNSS fix data (see IEC 61108-5);
- RMC – Recommended minimum specific GNSS data;
- VTG – Course over ground and ground speed;
- ZDA – Time and date.

If a sentence uses a datum other than WGS 84, then the DTM sentence shall be used in compliance with IEC 61162-1 or IEC 61108-5, whichever is newer.

For reporting GNSS differential correction data, the following sentence shall be available:

- GDC – GNSS differential correction (see IEC 61108-5).

For alert reporting and alert command purposes, the following sentences shall be available:

- ACN – Alert command;
- ALC – Cyclic alert list;
- ALF – Alert sentence;
- ARC – Alert command refused;
- HBT – Heartbeat supervision sentence.

Alert requirements shall comply with IEC 62923-1 and IEC 62923-2.

In addition, for integrating with other navigational aids, the following sentences may be available for output in any combination:

- GRS – GNSS range residuals (see IEC 61108-5);
- GSA – GNSS DOP and active satellites (see IEC 61108-5);
- GST – GNSS pseudorange error statistics (see IEC 61108-5);
- GSV – GNSS satellites in view (see IEC 61108-5).

GBS, GRS, GSA, GST and GSV are required to support external integrity checking. They are synchronized with the corresponding fix data (GNS).

4.3.3 Accuracy

(See 5.6.4)

4.3.3.1 Static position accuracy

(M.449(99)/A3.5) The IRNSS receiver equipment shall have static accuracy such that the horizontal position of the antenna is determined to within 25 m horizontally (95 %) and 30 m vertically (95 %).

NOTE The position accuracy with the specified user conditions has been determined to be within 10 m (95 %) as specified by the IRNSS SPS ICD document. According to ICD, IRNSS provides L5 and S band dual-frequency services. The IRNSS/NavIC receiver equipment has higher static accuracy for dual frequency operations on L5 and S frequencies.

4.3.3.2 Dynamic position accuracy

(M.449(99)/A3.6) The IRNSS receiver equipment shall have dynamic accuracy equivalent to the static accuracy specified in 4.3.3.1 above under the normal sea states and motion experienced in ships.

4.3.4 Acquisition

(See 5.6.5)

(M.449(99)/A3.9) The IRNSS receiver equipment shall be capable of selecting automatically the appropriate satellite transmitted signals to determine the ship's position, velocity and time with the required accuracy and update rate.

(M.449(99)/A3.12) The IRNSS receiver equipment shall be capable of acquiring position, velocity and time to the required accuracy within 3 min when there is no valid almanac data.

(M.449(99)/A3.13) The IRNSS receiver equipment shall be capable of acquiring position, velocity and time to the required accuracy within 2 min when there is valid almanac data.

(M.449(99)/A3.14) The IRNSS receiver equipment shall be capable of reacquiring position, velocity and time to the required accuracy within 1 min when there has been a service interruption of 60 s or less.

Acquisition is defined as the processing of IRNSS/NavIC satellite signals to obtain a position fix within the required accuracies.

Three conditions of the IRNSS/NavIC receiver equipment are set out under which the minimum performance requirements shall be met.

- Condition A

  Initialization (cold start) – the equipment has no valid almanac because it has:

  – been transported over large distances (> 1 000 km to < 10 000 km) without power or IRNSS/NavIC signals or by the deletion of the current almanac;

  – not been powered for > 7 days;

  – not received IRNSS/NavIC signals for > 7 days.

- Condition B

  Warm start – the equipment has a valid almanac but there is:

  – power outage – the equipment under normal operation loses power for at least 24 h; or

  – interruption of IRNSS/NavIC signals – under normal operation, the IRNSS/NavIC signals receptions are interrupted for at least 24 h, but there is no loss of power.

- Condition C

  Brief interruption of power or IRNSS/NavIC signals – under normal operation, the power or the signals are interrupted for 60 s.

  No user action other than applying power and providing a clear view from the antenna for the IRNSS/NavIC signals shall be necessary, from any of the initial conditions above, in order to achieve the required acquisition time limits in Table 1.

Table 1 – Acquisition time limits

Equipment condition	A	B	C
Acquisition time limits (min)	3	2	1

4.3.5 Protection

(See 5.6.6)

(M.449(99)/A4) Precautions shall be taken to ensure that no permanent damage can result from an accidental short circuit or grounding of the antenna or any of its input or output connections or any of the IRNSS receiver equipment inputs or outputs for a duration of 5 min.

4.3.6 Antenna design

(See 5.6.7)

(M.449(99)/A2.2) The antenna design shall be suitable for fitting at a position on the ship which ensures a clear view of the satellite constellation, taking into consideration any obstructions that might exist on the ship.

4.3.7 Sensitivity and dynamic range

(See 5.6.8)

(M.449(99)/A3.10) The IRNSS receiver equipment shall be capable of acquiring satellite signals with input signals having carrier levels in the range of –137 dBm to –127 dBm as measured at the antenna input. Once the satellite signals have been acquired the equipment shall continue to operate satisfactorily with satellite signals having carrier levels down to –140 dBm as measured at the antenna input.

4.3.8 Effects of specific interfering signals

(See 5.6.9)

The IRNSS/NavIC receiver equipment shall meet the following requirements.

a) In a normal operating mode, i.e. switched on and with antenna attached, it is subject to radiation consisting of a burst of 10 pulses, each 1,0 µs to 1,5 µs long on a duty cycle of 1 600:1 at a frequency lying between 2,9 GHz and 3,1 GHz at power density of about 7,5 kW/m^2. The condition shall be maintained for 10 min with the bursts of pulses repeated every 3 s. When the unwanted signal is removed and the IRNSS/NavIC receiver antenna is exposed to the normal IRNSS/NavIC satellite signals, the receiver shall calculate valid position fixes within 5 min without further operator intervention.

   NOTE 1 This condition is approximately equivalent to exposing the antenna to radiation from a 60 kW S band marine radar operating at a nominal 1,2 µs pulse width at 600 pulses/s using a 4 m slot antenna rotating at 20 r/min with the IRNSS/NavIC antenna placed in the plane of the bore site of the radar antenna at a distance of 10 m from the centre of rotation.

b) In a normal operating mode, i.e. switched on and with antenna attached, it is subject to radiation of 0,16 W/m^2 at a frequency in the range of 1 626,5 MHz to 1 660,5 MHz for 10 min. During the period, the IRNSS/NavIC receiver equipment shall be able to calculate valid position fixes.

   NOTE 2 This is equivalent to exposing a IRNSS/NavIC antenna to radiation from an Inmarsat Fleet Broadband antenna at 10 m distance along the bore sight.

Advice shall be given in the manual for adequate installation of the antenna unit, to minimize interference with other radio equipment such as marine radars, Inmarsat ship earth stations, Iridium ship earth stations, etc.

4.3.9 Position update

(See 5.6.10)

(M.449(99)/A3.15) The IRNSS receiver equipment shall generate and output to a display and digital interface (conforming to IEC 61162) a new position solution at least once every 1 s for conventional craft and at least once every 0,5 s for high speed craft.

For high speed craft purposes, the equipment shall additionally provide an IEC 61162-2 or IEC 61162-450 interface with a position update rate of 2 Hz.

(M.449(99)/A3.7) The IRNSS receiver equipment shall have position resolution equal to or better than 0,001 min of latitude and longitude.

NOTE AIS receivers require 0,000 1 min of latitude and longitude.

4.3.10 Differential IRNSS/NavIC input

(See 5.6.11)

(M.449(99)/A3.19) The IRNSS receiver equipment shall have the facilities to process differential IRNSS (DNavIC) data fed to it in accordance with the standards of Recommendation ITU-R M.823 and an appropriate RTCM standard and provide indication of the reception of DNavIC signals and whether they are being applied to the ship's position. When a IRNSS receiver is equipped with a differential receiver, performance standards for static and dynamic accuracies (M.449(99)/A3.5 and A3.6) shall be 10 m (95 %).

An integrated DNavIC receiver shall have an ITU-R M.823 compliant asynchronous full duplex serial input/output port for testing in compliance with IEC 61108-4. The data input/output port shall be supplied for testing purposes only.

4.3.11 Navigation warnings and status indications

(See 5.6.12)

4.3.11.1 Position

(M.449(99)/A4.1) The IRNSS receiver equipment shall also indicate whether the performance of IRNSS is outside the bounds of requirements for general navigation in the ocean, coastal, port approach, restricted waters, and inland waterway phases of the voyage as specified in either IMO resolution A.1046(27) within IRNSS coverage area or appendix 2 to IMO resolution A.915(22) and any subsequent amendments, as appropriate.

The IRNSS/NavIC receiver equipment shall as a minimum:

a) *(M.449(99)/A4.2.1) provide a warning within 5 s of loss of position or if a new position based on the information provided by the IRNSS constellation has not been calculated for more than 1 s for conventional craft and 0,5 s for high-speed craft. Under such conditions the last known position and the time of last valid fix, with the explicit indication of the state allowing for no ambiguity, shall be output until normal operation is resumed;*

b) display DNavIC messages. The IRNSS receiver either shall have as a minimum the capability of displaying appropriate DNavIC messages or forwarding those messages in GDC sentences for display on a remote system;

c) provide an indication of the navigational status.

The navigational status for different position accuracy levels shall be expressed in three navigational states:

– "safe"

– "caution", and

– "unsafe"

The conditions for a "safe" navigational state are as follows:

d) the estimated error (95 % confidence) along the major axis of the error ellipse is less than the selected accuracy level corresponding to the actual navigation mode; and

e) integrity is available and within the requirements for the actual navigation mode; and

f) a new position has been calculated within 1 s for a conventional craft and 0,5 s for a high speed craft.

The conditions for a "caution" navigational state are as follows:

g) integrity has not been available for a period of at least 3 s; and/or

h) HDOP exceeded – HDOP exceeds the required threshold; and/or

i) loss of differential signal or differential corrections not applied – DNavIC signals are not received, or they are not being applied to the indicated ship's position.

The conditions for an "Unsafe" navigational state are as follows:

j) loss of position – the estimated error (95 % confidence) along the major axis of the error ellipse is greater than the selected accuracy level corresponding to the actual navigation mode; and/or

k) no calculation of position – a new valid position has not been calculated for more than 1 s for a conventional craft and 0,5 s for a high speed craft; and/or

l) integrity status – integrity is available but exceeds the requirements for the actual navigation mode for a period of at least 3 s.

The navigational status shall be continuously displayed along with an indication of the accuracy level selected. The navigational status and alert identifier and the accuracy level selected shall be provided to other equipment in accordance with the equipment output requirements in 4.3.2.

The classification, presentation, handling and interfacing of alerts, including transmitted alert identifiers shall be as required in Annex B for the purpose of bridge alert management.

In case the manufacturer uses colours for navigational status indication, the colours as specified in IEC 62288 shall be used:

– "safe" shall be green;
– "caution" shall be yellow; and
– "unsafe" shall be red.

The manufacturer may use icons for navigational status indication.

A change in the navigational status shall be indicated within 10 s.

For receiver equipment which does not provide information by a dedicated display, the provision of the navigational status indication and the selected accuracy level with an appropriate output interface is required.

4.3.11.2 Integrity monitoring using RAIM

(See 5.6.12.1.3)

4.3.11.2.1 General

(M.449(99)/A4.2.2) The IRNSS receiver equipment shall as a minimum use receiver autonomous integrity monitoring (RAIM) to provide integrity performance appropriate to the operation being undertaken.

The RAIM algorithm employed shall be capable of detecting and excluding a faulty range signal from the position solution.

The decision thresholds used to detect and exclude a faulty range signal shall be consistent with the IMO integrity and continuity requirements as stated in IMO resolutions A.1046 (27) and A.915 (22).

NOTE DNavIC integrity information can be used to assist RAIM calculations when available.

The maximum delay for reaction of the integrity calculation by means of RAIM due to negative changes affecting the integrity status is 10 s.

4.3.11.2.2 Conditions for the "safe" integrity state

The result of integrity calculation (see Table 2) shall be stated as "safe", if the calculated horizontal protection limit (HPL) is less than or equal to the horizontal alert limit (HAL).

This generally requires at least 5 "healthy" satellites available and in a robust geometry, i.e. the worst 4 satellite geometry is still suitable for navigation.

4.3.11.2.3 Conditions for the "caution" integrity state

The "caution" status indication shall be used when insufficient information is available to calculate HPL for more than 3 s.

Those conditions may occur if an insufficient number of satellites are available, for example 4 or 5 with 2 satellites "close" together in azimuth and elevation, causing the geometry to degrade to the point that the RAIM calculation becomes unreliable. The resulting accuracy based on 4 or 5 satellites in use may be within the selected accuracy level, but the RAIM algorithm cannot verify it.

4.3.11.2.4 Conditions for the "Unsafe" integrity state

The "Unsafe" status indication shall be used when the calculated HPL exceeds the HAL for more than 3 s.

Table 2 – RAIM integrity status

Nav status	No. of range signals	Protection level
Safe	≥ 5	And HPL ≤ HAL
Caution	< 5	--
Unsafe	≥ 5	And HPL > HAL
NOTE Table 2 represents the theoretical results of RAIM calculations, but with certain satellite geometries and RAIM algorithms, it is possible the receiver cannot calculate a RAIM status with certainty.		

4.3.11.3 Self test

(See 5.6.12.2)

(M.449(99)/A4.2.3) The IRNSS receiver equipment shall provide a self test function.

The IRNSS/NavIC receiver shall provide means to perform self test of major functions either automatically or manually. The major functions of self test are: antenna interface, BAM interface, MKD interface or other equipment interfaces.

4.3.12 Output of COG, SOG and UTC

(See 5.6.13, 5.6.14, 5.6.15)

4.3.12.1 Accuracy of COG

(M.449(99)/A3.16) The IRNSS receiver equipment shall provide the COG, SOG and UTC outputs, with a validity mark aligned with that on the position output. The accuracy requirements for COG and SOG shall not be inferior to the values in Table 3 *and the accuracy shall be obtained under the various dynamic conditions that could be experienced on board ships.*

The error in the COG (the path of the antenna position over ground) due to the actual ship's speed over ground shall not exceed the values in Table 3.

Table 3 – Accuracy of COG

Speed range (knots)	Accuracy of COG output to user
0 to ≤ 1 knot	Unreliable or not available
> 1 to ≤ 17 knots	±3°
> 17 knots	±1°

Due to the limitations of IRNSS/NavIC receivers of this document, it is not appropriate to include requirements for COG errors attributed to high dynamic movement. Such limitations shall be stated in the manufacturer's operational manual.

4.3.12.2 Accuracy of SOG information

Errors in the SOG (velocity of the antenna position over ground) shall not exceed 2 % of the actual speed or 0,2 knots, whichever is greater.

4.3.12.3 Availability and validity of time information

The IRNSS/NavIC receiver equipment shall provide UTC with resolution of 0,01 s on the digital interface. The validity mark of the digital interface for position contained in the mode indicator of GNS sentence shall be used for interpretation of validity of digital interface for UTC contained in ZDA sentence.

NOTE As a time reference for IRNSS/NavIC, the IRNSS/NavIC time is associated with international UTC by NPLI and synchronized with UTC in 100 ns (modulo one second).

4.3.13 Typical interference conditions

(See 5.7)

(M.449(99)/A3.11) The IRNSS receiver equipment shall be capable of operating satisfactorily under normal interference conditions consistent with the requirements of IMO resolution A.694(17).

Operational situations include static accuracy and reacquisition within 30 s after satellite signals have been masked for 60 s or less by an obstruction, for example a bridge.

The typical IRNSS/NavIC RF interference environment can be characterized as being continuous wave (CW) in-band and near-band RFI, in-band CW/NB/WB RFI and in-band and near-band pulse interference. For a clarification of this requirement, see Annex A.

5 Methods of testing and required test results

5.1 Test sites

The manufacturer shall, unless otherwise agreed, set up the IRNSS/NavIC receiver equipment to be tested and ensure that it is operating normally before testing commences.

During performance of all tests contained in the test section, the following information shall be recorded for later evaluation:

- position;
- course over ground (COG);
- speed over ground (SOG);
- time;
- indications and alerts.

Indications and alerts shall be appropriate to the conditions being experienced by the equipment under test (EUT) at the time of their display.

5.2 Test sequence

The sequence of tests is not specified. Before commencement of testing, the sequence shall be mutually agreed between the test laboratory and the supplier of the equipment.

Where appropriate, tests against different subclauses of this document may be carried out simultaneously. The manufacturer shall provide sufficient technical documentation to permit the IRNSS/NavIC receiver equipment to be operated correctly.

Additional data shall be provided by the manufacturer to cover specific tests which do not form part of the normal user operations, for example means to remove the almanac data, when applicable, for the purpose of testing according to 5.6.5.

5.3 Standard test signals

The static tests (5.6.4.1) shall be based upon using IRNSS/NavIC signals in compliance with the requirements of the standard positioning service signal specified in ISRO-IRNSS-ICD-SPS-1.1, Aug 2017, either the real IRNSS/NavIC signals or signals from a IRNSS/NavIC RF constellation simulator (RFCS).

The IRNSS/NavIC RFCS shall generate signals which have the same characteristics as the satellites, and produce signal delays due to normally occurring ionospheric and atmospheric conditions as well as multipath.

The IRNSS/NavIC RFCS shall operate in accordance with the IRNSS/NavIC standard positioning service signal specification, the IRNSS/NavIC signal in space (SIS) interface control document, as given for the IRNSS/NavIC signals.

The interference test generator shall be able to generate the broadband, CW and pulsed interference conditions typical for the marine environment as specified in 5.7.

The IRNSS/NavIC RFCS shall also be capable of generating differential corrections at a virtual reference station placed in any position using a geodetic class receiver and antenna.

The EUT shall have an ITU-R M.823 compliant asynchronous full duplex serial input/output port in compliance with IEC 61108-4 for input of differential correction signals. For integrated receivers, the data input/output port may be supplied for testing purposes only.

Test signal A shall be a sequence of applicable RTCM version 2 messages for IRNSS/NavIC (equivalent to ITU-R M.823 message 9 type 9-3 for GPS) and one message type 27 that form a continuous parity loop. The station ID of test signal A shall be an ID of a station that is stored in the almanac. The type 27 message shall give data for station B.

Test signal B shall contain applicable RTCM version 2 messages of IRNSS/NavIC for station B. The station ID of test signal B shall not be an ID of a station that is stored in the almanac.

5.4 Determination of accuracy

In the determination of the accuracy of position being calculated by the IRNSS/NavIC receiver equipment, note should be taken of the geometry of the satellites in use. The HDOP measurement is an indication of the suitability of the constellation in view for use in receiver equipment testing. If the HDOP is ≤ 4, the test conditions can be considered as suitable. If HDOP is > 4 but ≤ 6, then results may be unreliable. For HDOP > 6, testing shall be delayed until better geometry is established. The aim of the accuracy tests is to establish that the measurement of position calculated by the EUT under static and dynamic conditions is as good as or better than the performance levels set out in this document.

If a IRNSS/NavIC RFCS is used, the simulator scenario should be chosen such that HDOP ≤ 4 for the duration of the test.

5.5 General requirements and presentation requirements

5.5.1 Normal environmental conditions for tests

Normal environmental conditions shall be a convenient combination of +15 °C to +30 °C temperature and 20 % to 75 % relative humidity.

When it is impractical to carry out the test under the conditions stated above, a note to this effect, stating the actual temperature and relative humidity during the tests, shall be added to the test report.

5.5.2 General requirements

All the general requirements of IEC 60945 appropriate to the category of the EUT that is protected or exposed shall be carried out. The manufacturer shall declare any preconditioning required before environmental checks. For the purposes of this document, the following definitions for performance check and performance test, required by IEC 60945, shall apply.

- Performance check – a shortened version of the static accuracy test described in 5.6.4.1, that is a minimum of 100 position measurements shall be taken over a period of not < 5 min and not > 10 min, discarding any measurements with HDOP ≥ 4. The position of the antenna of the EUT shall not be in error compared with the known position > 25 m (95 %) using WGS-84 as the reference datum.
- Performance test – the static accuracy test described in 5.6.4.1.

5.5.3 Presentation requirements

All the presentation requirements of IEC 62288 shall be carried out as appropriate to the facilities provided with the EUT

5.6 Receiver performance tests

5.6.1 IRNSS/NavIC receiver equipment

(See 4.2.1)

The EUT shall be checked for composition by inspection of the equipment and the manufacturer's documentation.

5.6.2 Position output

(See 4.3.1)

The EUT shall be checked for the form of the position output by inspection of the manufacturer's documentation.

5.6.3 Equipment interfaces

(See 4.3.2)

The EUT shall be checked for conformity to IEC 61162-1, IEC 61162-2 or IEC 61162-450 by inspection of the manufacturer's documentation and protocol tests which shall be performed for input and output sentences as required in 4.3.2.

5.6.4 Accuracy

(See 4.3.3)

5.6.4.1 Static accuracy

(See 4.3.3.1)

5.6.4.1.1 Static test site

The antenna shall be mounted according to the manufacturer's instructions at a height of between 1 m and 1,5 m above the electrical ground in an area providing clear line of sight to the satellites from zenith through to an angle of +5° above horizontal. The position of the antenna shall be known, with reference to WGS 84 to an accuracy of better than 0,1 m in (x, y, z). Maximum cable lengths as specified by the manufacturer shall be used during testing.

If a IRNSS/NavIC RFCS is used, the simulator scenario shall be chosen such that clear line of sight views to all satellites above a +5° mask angle is ensured for the duration of the test.

5.6.4.1.2 IRNSS/NavIC

Position fix measurements shall be taken at the required sampling interval over a period of not < 24 h. The absolute horizontal position accuracy in WGS-84 co-ordinates shall be within 25 m (95 %), having discarded measurements taken in conditions of HDOP ≥ 4 and PDOP ≥6. The horizontal position of the antenna shall be known to be within 0,1 m in the datum used for position fixing.

5.6.4.1.3 Differential IRNSS/NavIC

Position fix measurements shall be taken at the required sampling interval over a period of not < 24 h. The distribution of the horizontal error shall be within 10 m (95 %), having discarded measurements taken in conditions of HDOP ≥ 4 and PDOP ≥ 6. The horizontal position of the antenna shall be known to be within 0,1 m in the datum used for position fixing and for the generation of the corrections.

If this test utilizes actual signals, the corrections shall be provided by an actual DNavIC broadcast in accordance with ITU-R M.823.

5.6.4.1.4 Angular movement of the antenna

The static tests specified in 5.6.4.1.2 and 5.6.4.1.3 shall be repeated with the antenna performing an angular displacement of ±22,5° (simulating roll) in a period of about 8 s during the duration of the tests.

The results shall be as in 5.6.4.1.2 and 5.6.4.1.3.

5.6.4.2 Dynamic accuracy

(See 4.3.3.2)

5.6.4.2.1 IRNSS/NavIC

The tests for dynamic accuracy are a practical interpretation of the conditions set out in IEC 60721-3-6:1987, Table V, item e), X-direction (surge) and Y-direction (sway). These are stated as surge 5 m/s^2 and sway 6 m/s^2 for all classes of environment.

The accuracy tests shall be performed using a IRNSS/NavIC RFCS, and the simulator characteristics shall accurately represent the signals required.

The IRNSS/NavIC RFCS shall generate the correct signal in space associated with the following dynamic situations:

- a fully locked and settled EUT travelling in a straight line at 48 knots ± 2 knots for a minimum of 1,2 min which is reduced to 0 knots in the same straight line in 5 s;
- a fully locked and settled EUT travelling at least 100 m at 24 knots ± 1 knot in a straight line then subjected, for at least 2 min, to smooth deviations either side of the straight line of approximately 2 m at a period of 11 s to 12 s.

For both dynamic situations, the receiver shall remain in lock and the deviation from the programmed simulator positions shall be within the accuracies stated in 5.6.4.1.3.

5.6.4.2.2 Differential IRNSS/NavIC

The tests for dynamic accuracy are a practical interpretation of the conditions set out in IEC 60721-3-6:1987, Table V, item e), X-direction (surge) and Y-direction (sway). These are stated as surge 5 m/s^2 and sway 6 m/s^2 for all classes of environment.

The accuracy tests shall be performed using a IRNSS RF signal simulator, and the RFCS characteristics shall accurately represent the DNavIC data signals broadcast in accordance with RTCM 10402 and ITU-R M.823.

The IRNSS/NavIC RFCS shall generate the correct signal in space associated with the following dynamic situations:

- a fully locked and settled EUT travelling in a straight line at 48 knots ± 2 knots for a minimum of 1,2 min which is reduced to 0 knots in the same straight line in 5 s;
- a fully locked and settled EUT travelling at least 100 m at 24 knots ± 1 knot in a straight line then subjected, for at least 2 min, to smooth deviations either side of the straight line of approximately 2 m at a period of 11 s to 12 s.

For both dynamic situations, the receiver shall remain in lock and the deviation from the programmed simulator positions shall be within the accuracies stated in 5.6.4.1.3.

5.6.5 Acquisition

(See 4.3.4)

5.6.5.1 Condition A – Initialization/no valid almanac (cold start)

The EUT shall be initialized by one of the following:

- initialized to a false position at least 1 000 km and not greater than 10 000 km from the test position, or alternatively, by deletion of the current almanac; or
- isolated from a power source for > 7 days.

When using a IRNSS/NavIC RFCS simulator scenario, date and position should be changed by a large amount; the date by more than 7 days and position by more than 1 000 km.

A performance check shall be carried out after the time limit contained in Table 1.

5.6.5.2 Condition B – With valid almanac (warm start)

Power outage – The EUT shall be isolated from the power source for a period within 24 h to 25 h. At the end of the period, a performance check shall be carried out after the time limit contained in Table 1.

Interruption of IRNSS/NavIC signals – During normal operation of the EUT, the antenna shall be completely masked for a period between 24 h and 25 h. At the end of the period, a performance check shall be carried out after the time limit contained in Table 1.

5.6.5.3 Condition C – Brief interruption of power or IRNSS/NavIC signals

The EUT shall be initialized by one of the following:

a) brief interruption of power – during normal operation of the EUT, the power shall be removed for a period of 60 s. At the end of this period, the power shall be restored; or

b) brief interruption of IRNSS/NavIC signals – during normal operation of the EUT, the antenna shall be completely masked for a period of 60 s. At the end of this period, the mask shall be removed.

A performance check shall be carried out after the time limit contained in Table 1.

5.6.6 Protection

(See 4.3.5)

The antenna input of the receiver and input/output connections, if provided, shall be connected to ground for 5 min. After completion of the test and reset of the EUT, if required, the antenna or input/output connections shall be connected normally, and a performance check shall be carried out to ensure that no permanent damage has resulted.

5.6.7 Antenna design

(See 4.3.6)

The antenna of the EUT shall be checked by inspection of the documentation provided by the manufacturer, to confirm that it is suitable for shipborne installation to ensure a clear view of the satellite constellation.

5.6.8 Sensitivity and dynamic range

(See 4.3.7)

5.6.8.1 Acquisition

The received satellite signals shall be monitored by a suitable test receiver. These signals shall be attenuated until they are in the range of –132 dBm ± 5 dB. A performance check shall be carried out. The EUT shall meet the requirements of this check, within this signal range.

This is tested by using a IRNSS/NavIC RFCS.

5.6.8.1.1 Methods of testing

Transmit the simulator signal over a suitable antenna.

Adjust the signal power by use of a calibrated test receiver to −132 dBm ± 5 dB.

Replace the antenna of the calibrated test receiver by the receiving unit of the EUT.

A performance check shall be carried out.

5.6.8.1.2 Required test results

The EUT shall meet the requirements of this check, within this signal range.

5.6.8.2 Tracking

5.6.8.2.1 General

The received satellite signals shall be monitored by a suitable test receiver. These signals shall be attenuated down to −140 dBm. Under these conditions, the performance requirements of the EUT shall be met.

This is tested by using a IRNSS/NavIC RFCS.

5.6.8.2.2 Methods of testing

Transmit the simulator signal over a suitable antenna.

Adjust the signal power by use of a calibrated test receiver to −132 dBm ± 5 dB.

Replace the antenna of the calibrated test receiver by the receiving unit of the EUT.

After the start of transmission and tracking with the nominal transmission level condition, gradually reduce transmission level down to −140 dBm.

5.6.8.2.3 Required test results

The EUT shall continue tracking at least four satellites and provide a valid position solution.

5.6.9 Protection from other shipborne transmitters

(See 4.3.8)

5.6.9.1 L band interference

(See 4.3.8)

In a normal operating mode, using an appropriate signal source, the EUT shall be subjected to radiation of 3 W/m^2 at a frequency of 1 636,5 MHz for 10 min.

The signal shall be removed and a successful performance check shall be carried out within 5 min.

5.6.9.2 S band interference

(See 4.3.8)

In a normal operating mode, using an appropriate signal source, the EUT shall be subjected to radiation consisting of a burst of 10 pulses, each 1,0 µs to 1,5 µs long on a duty cycle of 1 600:1 at a frequency in the range of 2,9 GHz to 3,1 GHz at power density of approximately 7,5 kW/m^2. This condition shall be maintained for 10 min with the bursts of pulses repeated every 3 s.

NOTE The peak power density is 7,5 kW/m^2 to be measured at the EUT; this is approximately 4,7 W/m^2 average power at a fixed transmitting antenna.

The signal shall be removed and a successful performance check shall be carried out within 5 min.

5.6.9.3 L band interference from Inmarsat Fleet BroadBand

In a normal operating mode, using an appropriate signal source, the EUT shall be subjected to radiation of 0,16 W/m^2 at a frequency in the range of 1 625,5 MHz to 1 660,5 MHz for 10 min.

During the period, the IRNSS/NavIC receiver equipment shall be able to calculate valid position fixes.

5.6.10 Position update

(See 4.3.9)

5.6.10.1 Slow speed update rate

The EUT shall be placed upon a platform, moving in approximately a straight line, at a speed of 5 knots ± 1 knot. The position output of the EUT shall be checked at intervals of 10 s, over a period of 10 min. The output position shall be observed to be updated on each occasion.

This test may be carried out by using a IRNSS/NavIC RFCS.

5.6.10.2 High speed update rate

The EUT shall be placed upon a platform, moving in approximately a straight line, at a speed of 50 knots ± 5 knots. The position output of the EUT shall be checked at intervals of 1 s, over a period of 10 min. The output position shall be observed to be updated on each occasion.

This test may be carried out by using a IRNSS/NavIC RFCS with a speed of 70 knots at intervals of 0,5 s.

Record the IEC 61162-2 or IEC 61162-450 output of the EUT during this test and confirm that received positions at the end of each interval are in compliance with the real or simulated reference position.

5.6.10.3 Minimum resolution

The minimum resolution of output position, i.e. latitude and longitude, shall be checked by observation during 5.6.10.1 and 5.6.10.2 above.

5.6.11 Differential IRNSS/NavIC input

(See 4.3.10)

The manufacturer's documentation shall be inspected to:

a) verify that the EUT will correctly process the message protocol of:
   1) the RTCM recommended standards for differential IRNSS/NavIC service; or
   2) in the case where maritime radio beacons are used as the means of communication of the differential corrections, the standards contained in ITU-R M.823; and

b) confirm that:
   1) receipt of DNavIC signals will be indicated;
   2) the application of DNavIC signals to the output ship's position is indicated.

5.6.12 Navigational warnings and status indications

(See 4.3.11)

5.6.12.1 General tests for alerts

5.6.12.1.1 Position/HDOP alert test

(See 4.3.11.1)

This is tested using a IRNSS/NavIC RFCS as follows:

a) set up the EUT in a simulation environment with HDOP < 4; select a specific EUT HDOP value as an indication threshold more than 4; modify the simulator output until its HDOP is greater than the EUT specified HDOP threshold; observe that an indication is given at the EUT within 5 s and that for the cause "HDOP exceeded" an alert is raised as defined in Annex B;

b) modify the simulator output until HDOP < 4 and observe that the indication is removed and that the related alert is rectified;

c) switch off transmission of simulated signals and observe that the EUT releases an appropriate indication and alert within 5 s;

d) verify that the navigational warning indicator is set to "unsafe" and an alert is raised for the cause "No calculation of position or loss of position" as defined in Annex B;

e) verify that the last known position and its time stamp are being displayed indicating the loss of position condition; an alert is raised for the cause "No calculation of position or loss of position" as defined in Annex B; verify that this mode is provided constantly on display and output interface with the associated alert until removal of the error condition at the simulation environment;

f) switch on transmission of simulated signals and observe that the EUT resumes normal operation.

5.6.12.1.2 Differential IRNSS/NavIC test

(See 4.3.11.1).

This is tested using a IRNSS/NavIC RFCS as follows:

a) set up the EUT in a simulation environment with an HDOP < 4. Observe that the status of EUT operation is IRNSS/NavIC without using DNavIC corrections;

b) set the EUT differential correction age mask to 30 s;

c) start transmission of test signal A (5.3). Observe that the indication for DNavIC status of EUT operation is given within 40 s;

d) check that the DNavIC message contains Satellite ID, Pseudorange correction, Issue of data, epoch time of GNSS, Modified Z-Count, and UDRE;

e) stop transmission of test signal A (5.3). Observe that the status of EUT operation resumes to IRNSS/NavIC without using DNavIC corrections within 40 s and an alert is raised for the cause "loss of differential signal" as defined in Annex B.

5.6.12.1.3 Test of integrity monitoring using RAIM

(See 4.3.11.2)

5.6.12.1.3.1 General

For the purpose of testing of the RAIM functionality, it is recommended that means are provided for real-time display of the actual position error with reference to the simulated position.

5.6.12.1.3.2 Testing of "safe" and "caution" status

The EUT shall be set up under simulated conditions using a IRNSS/NavIC RFCS, providing 6 "healthy" satellites available, acquired and tracked as follows.

a) Select an accuracy level of 100 m. Observe that:
   1) RAIM is indicated as "in operation"; and
   2) the "safe" status is indicated.
b) Consecutively reduce the number of "healthy" satellites until the "caution" state is raised. Observe that:
   1) RAIM is still indicated as "in operation"; and
   2) the status indication switches to "caution" within 10 s of the satellite change that caused it and consecutively that the associated alert described in Annex B is raised.
c) Increase the number of "healthy" satellites until the RAIM state returns to "safe" state. Observe that:
   1) RAIM is still indicated as "in operation"; and
   2) the status indication switches to "safe" within 10 s of the satellite change that prompted it and that the associated alert is rectified.

For each step of the above test sequence, observe if the appropriate interface output is provided.

Repeat the above test sequence for a selected accuracy level of 10 m and, if provided, for another accuracy level.

5.6.12.1.3.3 Testing of "unsafe" status

The EUT shall be set up under simulated conditions, providing 6 "healthy" satellites available, acquired and tracked.

a) Select an accuracy level of 100 m. Observe that:
   1) RAIM is indicated as "in operation"; and
   2) the "safe" status is indicated.
b) Reduce the number of healthy satellites to 5 and apply an unsafe simulated test constellation. This can be accomplished in a controlled manner by adding a suitable ramp to the pseudorange signal and/or adding a satellite clock error. Observe that:
   1) RAIM is indicated as "in operation"; and
   2) the status indication switches to "unsafe" and an alert is raised for the cause "integrity status" as defined in Annex B within 10 s of the time of the unsafe simulated test constellation.
c) Restore the pseudorange signals and/or remove the satellite clock error until the RAIM state returns to "safe" state. Observe that:
   1) RAIM is still indicated as "in operation"; and
   2) the status indication switches to "safe" state within 10 s of the satellite change that prompted it and that the associated alert is rectified.
d) Reduce the number of healthy satellites to 5 and apply a safe simulated test constellation. Change the behaviour of at least 1 satellite by varying the satellite clocks with the result that a satellite is detected as failed. Observe that:
   1) RAIM is still indicated as "in operation"; and
   2) the status indication switches to "unsafe" state and an alert is raised for the cause "integrity status" as defined in Annex B within 10 s of the time of the satellite failure.

e) Change the behaviour of the satellites back to regular behaviour where no satellites are detected as failed. Observe that:

   1) RAIM is still indicated as "in operation"; and

   2) the status indication switches to "safe" state within 10 s and that the associated alert is rectified.

For each step of the above test sequence, observe if the appropriate interface output is provided.

Repeat the above test sequence for a selected accuracy level of 10 m and, if provided, for another accuracy level.

5.6.12.2 Self test

The EUT shall be checked for provision of a self-check function of antenna interface, BAM interface, MKD interface or other equipment interfaces by inspection of the manufacturer's documentation.

5.6.13 Accuracy of COG and SOG

(See 4.3.12)

5.6.13.1 Methods of testing

The EUT shall be set up on an appropriate mobile unit or use a IRNSS/NavIC RFCS, and all outputs indicating SOG or COG shall be monitored as specified by each test.

Test number 1 – Constant speed for forward direction

At a constant forward direction, the forward speed shall be within 0 knot to 1 knot. Ten seconds after being in the range, measurements of SOG and COG shall be made for duration of 2 min. This cycle shall be repeated for all speed ranges of the Table 3.

Test number 2 – Change of speed for forward direction

Apply a constant speed of 1 knot for a period of not less than 15 min. Increase the speed by increments of 1 knot up to speed of 5 knots and thereafter by increments of 5 knots up to the maximum speed for which the equipment is designed at 5 m/s^2 acceleration. Observe the output of SOG after each change speed.

Test number 3 – Change of course

Apply a constant speed of 1 knot for a period of not less than 15 min. Change course once per 6 s by increments of 1° or rate of turn of 10°/min up to a course change of 40°. Observe the output of COG after each change of 1° of the course. This cycle shall be repeated for all speed ranges of the Table 3.

5.6.13.2 Required test results

The test results shall be observed on the display and the approved interface.

For SOG tests, no reading of the speed indicator shall differ from the constant speed being applied at the time by more than 2 % of that speed or 0,2 knot, whichever is the greater.

For COG tests, the differences between the reference direction and measured course over ground of in each test cycle shall not exceed the limits of Table 3.

5.6.14 Validity of COG and SOG information

5.6.14.1 Method of testing

The mode indicators of the GNS sentence of IEC 61108-5 and VTG sentence of IEC 61162-1 are used for interpretation of validity of COG and SOG. With the EUT normally operating, preclude invalid position data by reducing the number of received satellites. Investigate the content of the resultant GNS and VTG sentences.

5.6.14.2 Required test results

Observe that the mode indicators of the GNS sentence of IEC 61108-5 and VTG sentence of IEC 61162-1 turn to invalid. Observe that the COG and SOG information contained in the VTG sentence is replaced by null fields.

5.6.15 Output of UTC

5.6.15.1 Methods of testing

While the EUT is navigating, provoke an invalid position by reducing the number of received satellites to two. Investigate the content of the GNS and ZDA sentences provided.

5.6.15.2 Required test results

Observe that the resolution of UTC information contained in the ZDA sentence of IEC 61162-1 is as specified in 4.3.12.3. Observe that the mode indicator of GNS sentence of IEC 61108-5 turns to "N" to indicate no fix. Observe that the ZDA sentence remains transmitted carrying complete UTC information.

5.7 Tests for typical RF interference conditions

(See 4.3.13)

5.7.1 Simulator conditions

The IRNSS/NavIC RFCS setup shall be as follows:

- five IRNSS/NavIC satellites;
- one satellite at a maximum level of –127 dBm plus antenna gain at 90° elevation;
- one satellite at a minimum level of –137 dBm plus antenna gain at 15° elevation;
- three satellites at a level of –130 dBm plus antenna gain at 45° elevation.

5.7.2 Navigation solution accuracy test

Interference conditions, including narrow band and wide band RF noise, CW interference, and pulsed interference, centred at IRNSS/NavIC L5 frequency for L5 receiver and centred at IRNSS/NavIC S frequency for S band receivers, shall be simulated using a RF noise generator. For the pulsed interference tests, a pulse-modulated carrier (CW) with peak carrier level of –20 dBm and duty factor of 10 % shall be used. The interference values are shown in Table 4.

Table 4 – RF interference value

Narrow band/wide band interference (NBI/WBI) values		
Frequency MHz	**Noise bandwidth** MHz	**Total RMS power** dBm
1 176,45	1	–108
2 492,028	1	–108

Pulsed interference values 10 % duty factor		
Frequency MHz	**Pulse width** ms	**Peak carrier level** dBm
1 176,45	1	–20
2 492,028	1	–20

Continuous wave interference (CWI)	
Frequency MHz	**Power** dBm
1 176,45	–108
2 492,028	–108

The method of testing is as follows:

a) the EUT is subjected to one of the interference sources;

b) the simulator scenario shall be engaged and the satellite signals turned on;

c) the EUT shall be powered and initialized;

d) while the EUT is providing position solutions, the interference shall be applied to the EUT, and the level of the interference shall be adjusted to the required value;

e) when steady-state accuracy is reached, record a minimum of 100 position and HDOP values as reported by the EUT at a rate of one sample every 2 min;

f) repeat this cycle for any remaining interference source and receiver frequency.

If the EUT reports a position outside the given boundaries (at the 95 % confidence level) for the positioning service mode (see 4.3.3.1) in use or fails to report a position in more than 5 % of the samples, a test failure is declared.

5.7.3 Re-acquisition test

The re-acquisition test is designed to simulate a temporary loss of signal, such as passing under a bridge. To determine the re-acquisition pass/fail criteria, consider a single trial where the EUT provides a valid position fix that is within required accuracy at 30 s from restoration of the satellite signals, and maintains a tracking status for at least the next 60 s. This unit is considered to have passed one trial.

The interference condition to be tested includes narrow band and wide band interference (NBI/WBI) as shown in Table 4.

The method of testing is as follows:

a) the EUT is subjected to NBI/WBI sources;

b) the simulator scenario shall be engaged and the satellite signals turned on;

c) the EUT shall be powered and initialized;

d) the EUT shall be allowed to reach steady-state accuracy before the satellites are to be switched off.

e) the simulator RF output shall be removed for 30 s;

f) the simulator RF output shall be restored to the EUT;

g) after 30 s, record a position and HDOP values as reported by the EUT. If, after 30 s, no position report has been sent from the receiver, record a trial failure and go to step i);

h) ensure that the receiver continues position reporting for the next 60 s;

i) go to step d) and repeat as required;

NOTE If the simulator scenario is reset, it is possible some receivers require purging of all previous data to enable proper operation. This is due to the persistence of time data in the receiver and the inability of the receiver's software to deal with a backward transition in time.

j) repeat this cycle for any remaining receiver frequency.

A failure by the EUT to provide a position output after 30 s, reporting a position outside the given boundaries (at the 95 % confidence level) for the positioning service mode (see 4.3.3.1), in use or failing to continue position reporting for 60 s after sampling indicates a failure mode will result in the trial being declared a failure.