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IALA

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On

Virtual Aids to Navigation

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VIRTUAL AIDS TO NAVIGATION

1 INTRODUCTION

IALA recognises that there are various tools available for use by aids to navigation authorities to improve and enhance services to mariners. Among these are visual aids, radio aids and now, virtual aids to navigation.

This document offers national members and other authorities guidance on the provision of virtual aids to navigation.

2 SCOPE

This document provides guidance on the use of virtual aids to navigation (Virtual AtoN), risks and benefits, criteria for application, notification process, display, application and delivery methods, applicable standards and guidelines, availability and integrity, legal and liability issues.

This document is a general guide only and is not intended to specify in detail when or how to deploy Virtual AtoN. Appropriate sources should be consulted for additional relevant information.

The concept of Virtual AtoN has its roots in AIS but in the future other means of transmission and presentation will evolve. References to AIS in this document should not be construed as limiting Virtual AtoN to that system.

3 PURPOSE

The purpose of this Guideline is to inform aids to navigation authorities, mariners and equipment manufacturers of the value and uses of Virtual AtoN. It will assist administrations and authorities in determining the appropriate uses for and the means to establish and operate virtual aids to navigation. This Guideline will assist shipmasters, pilots and other mariners in realizing the benefits and the inherent risks involved when using virtual aids to navigation as a means to verify their position, determine a safe course to steer or to avoid dangers. Finally, this Guideline will assist marine electronics equipment manufacturers in designing and marketing the next generation of shipboard navigation display systems. Maritime training institutes may also wish to avail themselves of the information contained herein in order to develop curricula that will prepare seafarers to take advantage of this emerging technology.

4 DEFINING A VIRTUAL AID TO NAVIGATION

4.1 Definition

A virtual aid to navigation (Virtual AtoN) does not physically exist but is a digital information object[1] promulgated by an authorised service provider that can be presented on navigational systems.

4.2 Amplification

Virtual AtoN can be used to inform the mariner about dangers to navigation as well as safe waterways, areas in which extra caution may be necessary and areas to be avoided.

They may be used to represent a line, area, position or other form that may be displayed graphically.

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[1] An item or group of items, regardless of type or format that a computer can address or manipulate as a single object that will inform the user as to the characteristic of a Virtual AtoN.

The information, including geographic position, carried by virtual aids to navigation may be fixed or may be changed over time (dynamic), depending on the intended purpose.

Virtual AtoN are used primarily where there is a time critical consideration. They may also be used in places where permanent physical aids to navigation cannot be sited. However, they are not intended to replace physical aids to navigation.

Virtual AtoN should be reflected in Maritime Safety Information (MSI) or, if appropriate, be shown on the relevant nautical chart in due course.

5 USE OF VIRTUAL AtoN

Virtual AtoN can provide early notification to the mariner of urgent, temporary or dynamic information. Virtual AtoN should not be considered as a replacement for other forms of MSI but can provide a valuable supplementary delivery mechanism, enabling an automated graphical display of MSI otherwise only available in textual form.

5.1 User needs

Users will include mariners and shore side authorities.

User needs may include presentation of information on:

- New hazards (fixed or dynamic);
- Temporary channels or routes;
- Temporary areas to be avoided (e.g. survey / dredging/ fishing / yacht racing);
- Changed hydrography;
- Temporary replacement of off station physical AtoN;
- Dynamic areas (e.g. reduced visibility, presence of protected species);
- Polar navigation;
- Ice conditions and navigation;
- Incident response (e.g. environmental, SAR);
- Port specific applications (e.g. passage planning, amended pilot boarding location, etc.);
- Measures for the protection of the marine environment;
- Security.

5.1.1 Advice to Mariners

In using Virtual AtoN the following are among the issues that need to be considered:

- Avoidance of reliance on single sources of information;
- Refer to MSI;
- Be aware of the possibility of different symbols on different systems;
- Be aware of limitations of Virtual AtoN provision and presentation;
- Difference between Virtual, Synthetic, Real AIS AtoN (A-126);
- The need to maintain situational awareness by comparing electronic and non-electronic means;
- The need to avoid target fixation;
- Many systems, including AIS, are GNSS dependent for position and timing and subject to the same vulnerabilities.

5.2 Benefits

Some of the potential benefits of Virtual AtoN in enhancing safety, environment and security are:

- Timely notification;
- Ease and accuracy of presentation, where displayed graphically;
- Ease and speed of deployment;
- Direct delivery to navigational systems; limited to relevant area;
- Information readily apparent to the user;
- Avoidance of misinterpretation through use of standardised symbology and IMO phraseology;
- Easily changed / amended;
- Low cost to install and maintain.

6 APPLICATION OF VIRTUAL AtoN

6.1 Technical deployment

Information from the Virtual AtoN services should be broadcast to shipboard receivers by more than one means. The navigation information provided for virtual AIS AtoN must be repeated in MSI broadcasts to assure that all mariners receive safety information. Virtual AIS AtoN messages should include a reference to identify the associated MSI message. Reference could be provided in the Message 21 field 'Name of AtoN Extension'. (see Reference [18]) 'The 'Name of AtoN Extension' needs to be considered on a wider scale when developing new message definitions for Virtual AtoN delivery. (See section 8.1)

The navigation information needs to be displayed on ECDIS, ECS and on radar equipment. These displays should indicate the information graphically as well as provide text display of detailed information when available in addition to the graphic.

There may be a limit to the number of Virtual AtoN and / or their reporting interval (update rate), that can be in the same area due to limitations in the capacity of the communication link. There may also be a limitation on the shipboard processing capability.

To mark areas, AIS binary application specific messages may be used, rather than multiple Virtual AIS AtoN (Message 21). There is a limit to the number of Virtual AIS AtoN that can be in the same area due to available timeslots in the AIS system. Multiple virtual AIS AtoN (Message 21) could increase clutter on the display. The authority needs to be aware that the number of Maritime Mobile Service Identities (MMSI) available for use by AIS AtoN is a finite resource (1000 per designated area code) and for this reason another means of unique identification, linking Virtual AtoN to relevant MSI or chart objects may need to be considered in the future.

MMSI numbers are normally assigned to a transmitting device. For virtual AIS AtoN using Message 21, the MMSI number represents the unique identity of the AtoN itself, rather than the transmitting source. The repeat indicator is used to identify whether the signal is transmitted from another station.

7 REGULATORY ISSUES

7.1 Authority to deploy

SOLAS Chapter V Regulation 13 (Establishment and operation of aids to navigation) states, in part, that "each Contracting Government undertakes to provide, as it deems practical and

necessary, either individually or in co-operation with other Contracting Governments, such aids to navigation as the volume of traffic justifies and the degree of risk requires."

Under SOLAS, Contracting Governments are obliged to provide aids to navigation, subject to IALA Recommendations and Guidelines and based on the navigational requirements for waters under their jurisdiction. However, SOLAS allows administrations significant discretion in determining what would be an appropriate mix of visual, radio and now virtual aids to navigation to meet the needs of mariners.

Section 10 of this document is intended to assist administration to assess the risk associated with Virtual AtoN for this purpose.

7.2 Capability

A Contracting Government has an obligation under SOLAS to provide aids to navigation. This obligation is exercised by the appropriate entity (usually a national administration). This entity should also be responsible for determining who may be permitted to deploy virtual aids to navigation. Typically, a VTS, Harbour Master, Rescue Co-ordination Centre (RCC) or some other entity may have the capability to deploy virtual aids to navigation.

The lines of authority between the Contracting Government and the entity deploying virtual aids to navigation should be clearly delineated. Roles and responsibilities at all levels should be clearly defined.

7.3 Liability

Virtual aids are simply another type of aid to navigation. Having elected to deploy a virtual aid, an administration should be able to establish that the virtual aid is being provided as promulgated and is operating correctly.

It is likely that an administration's exposure to liability from deploying a virtual aid will be similar to that for any other aid to navigation. Therefore, noting the unique nature of virtual aids to navigation, robust processes and procedures for promulgating information about them, together with integrity monitoring and record keeping, should be established.

8 DELIVERY METHODS

8.1 Technical aspects

This guideline addresses near term and long term alternatives for delivery of a Virtual AtoN service.

In the near term, shore based AIS networks provide competent authorities with means to operate an information service for shore-based VTS, traffic management schemes, ship reporting systems and other shore-based safety-related services, including Virtual AtoN services. This service consists of information delivery between ships and shore and vice versa.

Technical details of the AIS technology and of the layout and local configuration of shore-based AIS are described in IALA Recommendation A-124.

In the longer term, authorities may expect that other mediums for information services will be become available. This would enable Virtual AtoN services to be transmitted via means other than AIS, for example: satcom/internet; WiMAX; LORAN; DGPS - IALA maritime beacon system; GPRS cell phone data transmission protocol.

In the near term, not all vessels can be expected to be able to effectively display Virtual AtoN information. As of July 2008 SOLAS Radars are required to interface to AIS and display AIS information, as in MSC Resolution 192(79). Although ECDIS is capable of displaying AIS information, it is not required to do so. Based on current rates of navigation system upgrades, it is expected to take at least ten years before 50% of the international commercial fleet will have

this capability. Changes in mandatory carriage requirements may accelerate this development for SOLAS vessels. Portable Pilot Navigation Systems may facilitate implementation. Economic benefit to the shipping industry could also provide an impetus to early adoption of this new technology.

The nominal report rate of Virtual AtoN AIS broadcasts is specified in ITU-R-M.1371. However, due to the limitations in data link capacity IALA Recommendation A-126 recommends a more flexible approach to be considered, taking data link capacity and power consumption at transmitting stations into account.

In the longer term, different report rates may be implemented on different communication media, as appropriate.

The IMO e-Navigation concept includes the need to harmonise the presentation of both shipboard and shore side safety related information. Consideration should be given in implementing Virtual AtoN to the harmonisation process within e-Navigation for future applications.

8.2 Display

8.2.1 General

The Virtual AtoN should clearly indicate by its name or other relevant attribute the related navigational warning, notice to mariners or other form of MSI relating to the provision of the object.

The display or representation of symbols for Virtual AtoN onboard should be standardised. The display of symbols ashore should align to the onboard standard as closely as possible, to facilitate a common interpretation of the maritime situation. (see Reference [23])

8.2.2 Limitations

In the short to medium term Virtual AtoN will not be visible on the displays of many ships and, if visible, the symbols may differ from one display to another (see section 10.2).

8.2.3 Symbols

IMO SN/Circ. 243 Annex 2 provides guidance on the use of navigation related symbols on all shipborne navigational systems and equipment. The symbol for AIS AtoN is a diamond with a cross at the position of the AtoN, as follows.

No distinction is made between real and Virtual AtoN. These navigation related symbols are not chart symbols[2].

In IEC 62288 (Navigation Displays) and IEC 62388 (Radars) that came into force in 2008, the diamond is specified for AIS AtoN. For Virtual AIS AtoN the diamond has a V inside. This symbol will be implemented as an overlay on navigation equipment (ECDIS, radar etc) compliant with these specifications. Currently (2010) the symbols do not indicate the type of AtoN, although display equipment may allow interrogation to obtain such information.

[2] Navigation related symbols are approved and adopted by IMO. Chart symbols are approved and adopted by IHO.

The ECDIS performance standard requires that overlay symbols should be readily distinguishable from chart symbols. Chart symbols for Virtual AtoN are under development by the IHO (2010) based on the existing chart symbology for AtoN.

It should be noted that colours for the use of Virtual AtoN symbols are not clearly stated for ECDIS overlay and radar display in current specifications.

8.2.4 Point and Area Representation

In addition to the use of the AtoN Report Message 21, emerging application specific messages could be used to provide a representation of a point position, line, area, or other form that may be displayed graphically. There is a need to develop appropriate methods of representation, clearly distinguishable from existing charted symbols.

8.2.5 Expiry and cancellation of Virtual AtoN objects

Some Virtual AtoN objects (like the AIS AtoN Message 21) rely on repeated transmission to remain valid – however current display standards (2010) are not clear on this issue, and implementation may therefore vary in the short to medium term. The timeout limit of a repeatedly transmitted Virtual AtoN must be defined in future standards, in order to ensure that the same information is available to all users at all times. (The IEC 62388 radar standards defines when AIS class A and B vessel targets are lost – approximately when the nominal repetition rate has been exceeded by a factor of 6. This general rule is recommended to be implemented for the display of Virtual AtoN in future display standards.)

Some Virtual AtoN objects (like the emerging application specific messages) may themselves contain a definition of their own lifetime – time of issue and time of expiration. These Virtual AtoN objects – and Virtual AtoN objects relying on repeated transmissions with repetition, but with a long timeout – should be accompanied by a mechanism for cancellation, in case they become obsolete during their defined lifetime or contain errors. Such a cancellation mechanism also constitutes a mitigation measure to ensure that erroneous or malicious transmissions can be cancelled.

When the lifetime of a Virtual AtoN object is timed out or cancelled, it should be removed from display systems. Objects relying on repeated transmissions that have exceeded the nominal reporting rate, but have not yet reached the timeout should, when queried for additional information, clearly indicate that the information may not be up to date.

9 NOTIFICATION

Having elected to deploy Virtual AtoN, administrations should arrange for detailed information related to such aids to be made available to all concerned.

Administrations should use all available means to ensure that mariners have the necessary information concerning the presence and purpose of virtual aids, including the intended duration of deployment. These means may include MSI broadcast via NAVTEX, INMARSAT Enhanced Group Call (EGC) or VHF/HF/MF radio. The administration should send specific notification to their hydrographic offices for inclusion in notices to mariners.

As with other aids to navigation, mariners have an obligation to report malfunctioning virtual aids to navigation to the competent authority.

10 RISKS AND LIMITATIONS

The Virtual AtoN will not be visible on the displays of many ships and, if visible, the symbols may differ from one display to another. The consequences may be confusion, lack of information for the user and the undermining confidence in ECDIS, the chart and other systems. It is likely to take at least a decade to harmonise the provision of Virtual AtoN as a result of the

’grand-fathering‘ clauses in the carriage requirement program for ECDIS and the likely schedule for the adoption of IBS & e-Navigation.

Radar will only display Virtual AtoN as an overlay of a diamond with a V inside if they are compliant with IEC 62388. This test specification came into force in 2008. At the current rate of fitting new equipment, 10-15 years appears to be a realistic timescale for the majority of ships to benefit from the provision of display of Virtual AtoN.

Navigational displays compliant with IEC 62288, which came into force in 2008 will show Virtual AtoN as an overlay of a diamond with a V inside.

ECDIS equipment fitted prior to 2009 will not show Virtual AtoN until the equipment is upgraded or replaced, which is unlikely under the current “grand-fathering” arrangements. There is currently no provision for Virtual AtoN in S-57, or a symbol in S-52, but this is capable of implementation. However, even when Virtual AtoN are reflected in S-57 and S-52, existing ECDIS will only show an orange “?” upon encountering a Virtual AtoN object in the ENC database. The orange “?” can be interrogated for further detail.

The MKD should display AIS AtoN, including the virtual flag, but it is known that some MKDs do not meet this requirement.

10.1 Risk Mitigation

Table 1 Potential risk mitigation measures

Risk	Potential Mitigation
Not all mariners will receive or be able to display Virtual AtoN	MSI should be maintained as primary system, Virtual AtoN supplements MSI Encourage integration with navigation displays, where fitted Development of e-Navigation and S Mode
Information overload	Use of lines and areas versus points Only competent authorities may approve issue Area specific display Development of e-Navigation Limited use of Virtual AtoN in any area
Lack of user awareness or understanding	Training Clear promulgation of information Develop educational material
Confusion from varying symbology	Standardisation of symbology by IMO, IHO, IALA, IEC.
Equipment may be set up not to show data	Education and training S Mode
Confusion from message options for locations, area and lines	IMO / IALA to define message formats

Risk	Potential Mitigation
Loss of signal	Published standards for availability, continuity, integrity Verification of transmission by originator Redundancy Integrity warning Correlation with MSI and / or chart
GNSS vulnerability	AIS semaphore mode Satellite monitoring / RAIM DGNSS integrity message Electronic terrestrial backup
Virtual AtoN vulnerability; jamming / spoofing	Verification of transmission by originator Correlation with MSI and / or charts Data link monitoring by authorities Counter-spoofing (cancelation methods)
No confirmation of receipt of message	Repeated or addressed / acknowledged transmissions Verification of transmission by originator Multiple transmission paths (MSI) Development of e-Navigation
Erroneous message transmitted	Procedures for message checking Verification of transmission by originator
Dynamic prediction accuracy i.e. floating object	Estimation of zone of uncertainty Updated verification Remove position from message after time

10.2 Limitations

10.2.1 GNSS vulnerability

Ships may lose their positioning capability when the GNSS service is lost due to jamming or interference, unless they have an alternative positioning system. Poor installation or failure of on board equipment can similarly interfere with or degrade GNSS reception.

Delivery of a Virtual AtoN Service through the AIS VDL would not necessarily be affected immediately by loss of GNSS, since the position part of the message is fixed and transmitted independent of GNSS. However, when the Virtual AtoN is transmitted in an AIS channel, the synchronization is dependent upon GNSS.

10.2.2 Spoofing and Jamming of Virtual AtoN

Depending on the medium, a Virtual AtoN service can be spoofed and jammed easily. Jamming can be unintentional or intentional while spoofing would typically be intentional.

Some spoofing methods can be detected through careful monitoring of the transmission channel. One possibility is to monitor MMSI numbers within the service coverage area. Duplicate or non-existing MMSI numbers within the coverage area may indicate spoofing.

Increased spoofing detection capability can be achieved through regional co-operation between neighbouring countries, exchanging valid MMSI numbers and co-operating on identifying invalid MMSI numbers, for example handing over MMSI numbers from one authority to another authority when vessels crossing the administrative boundaries of these authorities. Such a scheme is implemented on the administrative boundary between the Malacca and Singapore straits.

Authorities who provide Virtual AtoN services should maintain a database of all valid MMSI numbers assigned to Virtual AtoN. This database should be shared with such stakeholders as neighbouring countries.

Both spoofing and jamming can compromise and/or shut down a Virtual AtoN service. Jamming will typically block the service in a certain geographic region. Spoofing is more sinister since the targeted receiver cannot detect the deception (i.e. the signal appears to be genuine), which could mislead the navigator.

10.2.3 AIS VDL capacity and FATDMA planning

Virtual AtoN services transmitted on an AIS VDL typically use the FATDMA protocol.

If the population of Virtual AtoN in a given area is too high, this may overload the VDL FATDMA slot capacity. This should be overcome through careful FATDMA planning (IALA Recommendation A-124 refers).

10.2.4 Display Limitations

Although there are clear benefits that can be gained by providing safety information through Virtual AtoN, it must be borne in mind that very few SOLAS class ships, or other craft, may have the ability to display the Virtual AtoN. Some craft may never have the ability to display Virtual AtoN.

MKD – All SOLAS class vessels are required to be fitted with Class A AIS station and many non SOLAS vessels voluntarily carry Class A AIS or Class B AIS stations. However, currently, few vessels integrate the AIS data into a navigation display such as ECDIS or Radar. The display of Virtual AtoN on an AIS Minimum Keyboard Display (MKD) is limited to alpha-numeric text and, on some units, a graphic display, although there is no standard for such display.

Radar – Only radars that meet the revised performance standard, which came into force in 2008, have a requirement to be capable of displaying a Virtual AtoN. However there is currently no requirement for the AIS to be integrated or displayed on the Radar.

ECDIS – ECDIS mandatory carriage requirement for certain classes of SOLAS vessels is being implemented from 2012 – 2018, however the current ECDIS performance standard MSC 232(82) does not require AIS or other Virtual AtoN to be able to be displayed, nor to be integrated.

Administrations should take into account the limited display capabilities for AIS, or other forms of transmission, for all classes of seaborne craft when assessing the value and risks associated with transmitting Virtual AtoN.

11 LEVEL OF SERVICE

11.1 Availability

The basic principles for categorising AtoN in accordance with their importance is described in Recommendation O-130 (IALA Category 1, 2, or 3). Virtual AtoN Services should be categorised in the same manner.

If a transmitting site is transmitting signals for multiple Virtual AtoN, the most critical one would determine the availability requirements for the service. It should be noted that Virtual AtoN transmitting sites must deliver a specified minimum signal strength at the user antenna within a specified service area.

IALA Recommendation A-126 defines the required availability for AIS Virtual AtoN and sets the service area criteria in terms of required signal strength.

Similar signal strength criteria should be defined for transmissions transmitted via means other than AIS.

Availability is determined by the ability to deliver the specified reporting rate, signal strength and valid information content. Virtual AtoN criteria should be specified for each of these elements in order to clearly define when the service is no longer available (failure state).

11.2 Integrity alerting

Authorised service providers should have the ability to provide users with warnings within a specified time when a Virtual AtoN service is not available.

The warning should be given within a time frame compatible with the criticality of the AtoN (IALA Categories 1, 2 and 3).

Warnings may be issued as a navigational warning and, in the case of AIS, using the flags of message 21, using message 14 or by any other appropriate means.

There is a requirement for integrity monitoring. Such monitoring schemes should be independent of the system providing the basic service. Integrity monitoring can take place both onboard a vessel and ashore.

Shipborne monitoring is limited to validity checking of the received datagram and the reporting rate of the Virtual AtoN.

11.3 Continuity

Continuity is the probability that, assuming a fault-free system at the receiving end, the Virtual AtoN will be received and displayed on the navigational display over the time interval applicable for a particular operation.

The continuity of a Virtual AtoN service should be determined as described in Recommendation R-121. The time interval should be chosen as 3 hours, or a suitable time frame as determined by the authority providing the service.. The probability should be according to the category (IALA categories 1, 2 and 3) of each Virtual AtoN. If a transmitting site is transmitting signals for multiple Virtual AtoN, the most critical one would determine the continuity requirements for the service.

12 DEVELOPMENT CONSIDERATIONS

For the full benefits of Virtual AtoN to be realised, a number of issues must be addressed in consultation with other bodies, including:

- appropriate training and education of all mariners and providers as to the provision of Virtual AtoN, symbology, display, and limitations;
- harmonisation of integration and ship navigation system specification to enable the display of AIS Virtual AtoN for SOLAS and other users;
- a strategy for implementation of Virtual AtoN using non-AIS based systems;
- the harmonisation of the use of MSI by Virtual AtoN within the context of the IMO's e-Navigation concept;
- harmonised presentation of Virtual AtoN.

13 REFERENCES

[1] IMO Res. A.917(22) 2001 Guidelines for the Onboard Operational Use of Shipborne AIS

[2] IMO Res. A.956(23) 2003 Amendments to the Guidelines for the Onboard Operational Use of Shipborne AIS

[3] MSC 232(82) Performance Standards for ECDIS

[4] MSC.192(79) Performance standards for radar equipment

[5] MSC.191(79) Performance Standards for the Presentation of Navigation-Related Information on Shipborne Navigational displays

[6] MSC 86/23/7 New symbols for AIS-AtoN - Submitted by Japan

[7] IMO SN/Circ 243 – Amendments to Guidelines for the Presentation of Navigation-Related Symbols, Terms and Abbreviations

[8] IMO SN/Circ 266 Maintenance of ECDIS Software

[9] IMO SN/Circ [t.b.d, NAV 55/21/Add.1 draft SN Circ] Guidance of the Use of AIS Application Specific Messages < will supersede SN circ 236 >, pending decision at MSC87, May 2010

[10] ITU-R M.1371 Technical Characteristics for Automatic identification System using Time Division Multiple Access in the VHF Maritime Mobile Band

[11] IHO S-4 Chart Specifications of the IHO and Regulations for International (INT) Charts

[12] IHO S-52 Specifications for Chart Content and Display Aspects of ECDIS

[13] IHO S-57 Transfer Standard for Digital Hydrographic Data

[14] IHO S-57 Appendix B.1 ENC Product Specification

[15] IHO S-100 Universal Hydrographic Data Model

[16] IHO S-101 ENC Product Specification (ENC Product Specification based on S-100 (not to be adopted before 2012 at the earliest))

[17] IALA Recommendation R-121 For the performance and monitoring of a DGNSS Service in the band 283.5 – 325 kHz

[18] IALA Recommendation A-124 IALA Recommendation A-124 on Automatic Identification System (AIS) Shore Station and Networking Aspect relating to the AIS Service

[19] IALA Recommendation A-126, on the Use of the Automatic Identification System (AIS) in Marine Aids to Navigation Services, Edition 1.4, Dec. 2008

[20] IALA Recommendation O-130 on Categorisation and Availability Objectives for Short Range Aids to Navigation

[21] IALA Recommendation O-133 Emergency Wreck Marking Buoy

[22] IALA Guideline 1062 on the establishment of AIS as an Aid to Navigation

[23] IALA Recommendation V-125 on the Use and Presentation of Symbology at a VTS Centre (including AIS)

[24] IEC 61174 ECDIS – Operational and Performance Requirements, Methods of Testing and Required Test Results

[25] IEC 61193-2 Class A shipborne equipment of the universal automatic identification system (AIS) - Operational and performance requirements, methods of test and required test results AIS Class A

[26] IEC 62288 Presentation of navigation-related information on shipborne navigational displays

[27] IEC 62320-2 AIS AtoN stations - Minimum operational and performance requirements - methods of test and required test results

[28] IEC 62388 Maritime navigation and radio-communication equipment and systems – Shipborne radar - Performance requirements, methods of testing and required test results

14 ACRONYMS / INITIALISMS

AIS	Automatic Identification System
AtoN	Aid to Navigation
DGPS	Differential Global Positioning System
ECDIS	Electronic Chart Display and Information System
ECS	Electronic Chart System
EGC	Enhanced Group Calling
FATDMA	Fixed Access Time Division Multiple Access
GNSS	Global Navigation Satellite System
GPRS	General Packet Radio Service
GPS	Global Positioning System
HF	High Frequency
IALA	International Association of Marine Aids to Navigation and Lighthouse Authorities
IBS	Integrated Bridge System
IEC	International Electro-technical Commission
IHO	International Hydrographic Organization
IMO	International Maritime Organization
INMARSAT	International Maritime Satellite Organization
ITU	International Telecommunication Union
ITU-R	ITU Radiocommunications Sector
ITU-R-M	ITU-R M series Recommendations and ITU-R M series Reports
LORAN	LOng RAnge Navigation
MF	Medium Frequency
MIO	Marine Information Overlay
MKD	Minimum Keyboard and Display
MMSI	Maritime Mobile Service Identity
MSC	Maritime Safety Committee (IMO)
MSI	Maritime Safety Information
NAV	Sub-Committee on Safety of Navigation (IMO)
NAVTEX	Navigational Telex
RAIM	Receiver Autonomous Integrity Monitoring
RCC	Rescue Co-ordination Centre
SAR	Search and Rescue
SN/Circ.	Safety of Navigation Circular (IMO)
SOLAS	United Nations Convention on Safety of Life at Sea
t.b.d.	to be decided

Virtual AtoN	Virtual Aid to Navigation
VDL	VHF Data Link
VHF	Very High Frequency
VTS	Vessel Traffic Services
VTSO	Vessel Traffic Services Operator
WiMAX	Worldwide Interoperability for Microwave Access