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| IALA GUIDELINE |

GXXXX

The Use of the Automatic Identification System (AIS) in Marine Aids to Navigation Services

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THE USE OF THE AUTOMATIC IDENTIFICATION SYSTEM (AIS) IN MARINE AIDS TO NAVIGATION SERVICES

# Introduction

The Automatic Identification System (AIS) is an autonomous broadcast system, operating in the VHF maritime mobile band. It exchanges information such as vessel identification, position, course, speed, etc. between stations. It handles multiple reports, using Time Division Multiple Access (TDMA) technology ensuring reliable and robust operation. The carriage requirements for AIS equipment on vessels are set in Chapter V of the 1974 SOLAS Convention (as amended)[[1]](#footnote-1).

The main purpose of shipborne AIS is:

* to be used in ship-to-ship mode for situational awareness and collision avoidance;
* as a means for littoral States to obtain information about a ship and its cargo; and
* as a VTS tool, i.e., ship-to-shore (traffic management).

AIS, as applied to Marine Aids to Navigation (AtoN), improves and enhances services provided to mariners. The purpose of this document is to provide recommendations and guidance for the use of AIS in this field.

# AIS as a Marine Aid to Navigation

The International Organization for Marine Aids to Navigation (IALA) defines a Marine Aid to Navigation as:

*“a device, system or service, external to a vessel, designed and operated to enhance safe and efficient navigation of individual vessels and vessel traffic”*

The application of AIS as a Marine Aid to Navigation is through the broadcast of an Aids-to-navigation report message (Message 21) from an AIS AtoN Station or base station. The AIS AtoN is implemented as a physical, synthetic or virtual aid.

The primary purpose of AIS AtoN is to promote and enhance safety and efficiency of navigation by one or more of the following:

providing a positive and all-weather means of identification;

complementing existing services (e.g., racons) from AtoN;

transmitting accurate positions of floating AtoN;

indicating if a floating AtoN is off position;

promulgation of Application Specific Messages (ASM) including:

* marking or delineating tracks, routes, areas, and limits (for example, areas to be avoided and Traffic Separation Schemes (TSS));
* marking offshore structures (for example, wind turbines, wave and tidal energy devices, oil and gas platforms); and
* providing weather, tidal, and sea state data;

providing additional AtoN capability through use of Virtual AIS AtoN, where installation of physical AtoN is technically or operationally difficult;

enabling timely marking of new immobile hazards; and

enabling marking of mobile hazards by use of Mobile AtoN (MAtoN).

The criteria for the use of AIS as an AtoN should be based on the navigational requirement derived from assessment of risk.

When planning AIS AtoN it is important to bear in mind that not all vessels are equipped with AIS. In addition, for those vessels that are AIS equipped, the display of AIS data can range from limited text display, to full ECDIS and Radar overlay. In the absence of ECDIS or Radar overlay users will not be able to fully use AIS AtoN functionality.

It is also very important when considering deploying AIS AtoN to note the mariner’s need for appropriate, relevant, accurate and unambiguous information.

Particular care must be exercised with the activation and promulgation of virtual AIS AtoN so as to avoid errors, particularly errors in position, and to avoid the unintentional creation of situations where mariners could be faced with too much information, irrelevant information, or information that results in confusion or distraction.

For further information regarding Mobile AtoN refer to IALA Guideline *G1154 Use of Mobile Aids to Navigation. [1]*

See Annex B for guidance on criteria for establishing AIS AtoN.

# The Aids to navigation report (message 21)

Establishing an AIS AtoN service enables AtoN providers to broadcast information about an AtoN. The Aids to Navigation Report (Message 21) can include the following information:

* Type of AtoN
* Name of the AtoN
* Position of the AtoN
* Accuracy of AtoN position
* Type of position fixing device
* Position status (for floating AtoN)
* Whether physical or Virtual AtoN
* Dimension of the AtoN and reference positions
* Status of AtoN systems

See Annex B for more detail on the information included in Message 21.

# Physical, Synthetic, and Virtual AIS AtoN

AIS AtoN can be implemented in three ways – Physical, Synthetic and Virtual.

## Physical AIS AtoN

A Physical AIS AtoN is an AtoN that physically exists and is fitted with an AIS AtoN station broadcasting its own Message 21. It is displayed as a solid line diamond with crossed lines centred at the reported position of the AtoN.

## Synthetic AIS AtoN

A Synthetic AIS AtoN is an AtoN that physically exists; however, its Message 21 is transmitted from a geographically separated AIS AtoN station. It is displayed as a solid line diamond with crossed lines centred at the reported position of the AtoN.

There are 2 types of Synthetic AIS AtoN, “Monitored Synthetic AIS AtoN” and “Predicted Synthetic AIS AtoN”.

### Monitored Synthetic AIS AtoN

A “Monitored Synthetic AIS AtoN” has a communication link between the physical AtoN and the broadcasting AIS AtoN Station. The location and status information of the physical AtoN is received by the AIS AtoN Station and included in the Message 21.

### Predicted Synthetic AIS AtoN

A “Predicted Synthetic AIS AtoN” does not have a communication link to update the location and status information of the physical AtoN to the broadcasting AIS AtoN station.

As a result, the Predicted Synthetic AIS AtoN Message 21 does not confirm the location and status of the AtoN, and therefore is not recommended for use on floating AtoN.

The use of Predicted Synthetic AIS AtoN broadcasts for fixed AtoN is acceptable as the location will not change, but the status of the AtoN is not verified.

## Virtual AIS AtoN

A “Virtual AIS AtoN” (VAtoN) is transmitted as a Message 21 for an AtoN that does not physically exist. It is displayed as a thin dashed line diamond with crossed lines centred at the reported position of the AtoN.

When a Virtual AIS AtoN is used, the AtoN symbol or information would be available for presentation to a mariner, even though there is no physical AtoN such as a buoy or beacon. A base station or geographically separate AtoN station would broadcast this message.

The “Virtual AtoN Flag” in Message 21 would be set to 1, to clearly identify this as a Virtual AIS AtoN.

An example of where Virtual AIS AtoN could be useful is the marking of hazards to navigation on a temporary basis (see IALA Recommendation *R1015 Marking of Hazardous Wrecks*, and IALA Guideline *G1046 Response plan for the Marking of New Wrecks*).

1. Use cases for AIS AtoN

|  |  |  |  |
| --- | --- | --- | --- |
| Element to be addressed | Physical | Synthetic | Virtual |
| Low power availability at site |  | X | X |
| Difficult to access site |  | X | X |
| Space limitations on site |  | X | X |
| Requirement for remote monitoring | X |  |  |
| Additional functionality – met./hydro. data, etc. | X |  |  |
| Location – difficult Environmental conditions (including tide / current; cyclone /hurricane; extreme temperature) |  | X | X |
| Need for spatial awareness | X | X | X |
| Waterway use for SOLAS vessels only |  |  | X |
| Waterway use mixed vessels | X | X |  |
| Temporary marking of new danger / wreck |  |  | X |

See Annex C for more details on Virtual AIS AtoN.

# The VHF Data link

AIS uses TDMA protocols, this is the method used to communicate using pre-defined messages (sentences), which are exchanged between stations via two designated VHF frequencies, AIS1 (161.975MHz) and AIS2 (162.025MHz). The protocols, frequencies and the messages together are defined as the VHF data link (VDL). The VDL is similar to an internet email service where international compatibility is assured by a strict protocol, whatever the content of the message might be.

AIS AtoN typically transmit a message every three minutes.

## How does it operate?

The VDL is divided into a number of equal time slots which hold a set amount of data and are synchronized using GNSS time. The primary methods by which AIS devices access the link (as detailed in ITU-R M.1371) are:

* Self-Organized (SOTDMA) is the basic access method for mobile stations (vessels). Stations preannounce when they are going to transmit and plan their transmissions based on slot use information collected from other stations in order to prevent slot collisions (two stations picking the same slot to transmit their data packet).
* Random Access (RATDMA)[[2]](#footnote-2) is used by AIS stations to access the link for unscheduled transmissions.
* Fixed Access (FATDMA)[[3]](#footnote-3) is used by AIS stations that have a requirement to transmit data at predetermined intervals, and involves the reservation of particular slots for their exclusive use.
* Carrier Sense (CSTDMA) also known as “polite” behaviour is used by some mobile stations which can access the link only when they find an unused slot. These stations must listen to the beginning of a slot to detect occupancy and are therefore limited to a single slot transmission.

AIS base stations manage the network in a similar manner to telephone “cell” towers.

## Protocol for data transmission

### Timing

Correct synchronization of each user's equipment is imperative to ensure proper functioning of the TDMA.

For both the two AIS frequencies, each minute of time (known as the “frame”) is divided into 2250 slots, giving a total of 4500 slots. To ensure all units are synchronized, every AIS station contains a GNSS receiver, which provides Universal Time Co-ordinated (UTC) as a timing reference.

### Position

Although AIS relies on GNSS for timing it may also obtain its position reference from an external source. (E.g. surveyed position for a fixed AtoN)

## VHF data link ADMINISTRATION

AIS has been designed for short range, VHF coverage, normally referred to as “line of sight”. Although most AIS messages only use one slot, some can occupy up to five consecutive time slots. The greater the number of slots used by a message, and the larger the number of vessels in a coverage area, the greater the potential for data packet (slot) collisions. Since most AIS base stations typically have a high antenna position and large coverage area, this may result in messages not being decoded from more distant AIS units in an area where there are a very large number of AIS stations operating. However, data from these distant stations would continue to be transmitted and received correctly by closer AIS stations.

FATDMA reservations are required for Type 1 AIS AtoN Stations (see section 7). Individual slots allocations for AIS AtoN Stations require transmission of a message type 20 (Data Link Management) in the coverage area. This can be transmitted by an AIS base station that is capable of control of the VDL. Administrations should organize the usage of the VDL by appropriate FATDMA reservations and consider the total load on the VDL before introducing additional services which rely on AIS.

Efficient use of the FATDMA allocations can be improved by having several AtoN in the same area using the same slots but in different frames. For example, 3 buoys, each with a 3-minute reporting interval, in the same area could be configured such that Buoy A transmits in frames 0, 3, 6, … Buoy B transmits in frames 1, 4, 7,…. and Buoy C transmits in frames 2, 5, 8,…. all using the same slots.

The information exchanged via the VDL is safety related and the usage of the VDL should be monitored and controlled to safeguard its proper function and avoid overloading.

Even though there are potentially some scenarios in which data collisions may occur, AIS is quite robust and has been designed to work at high VDL loading.

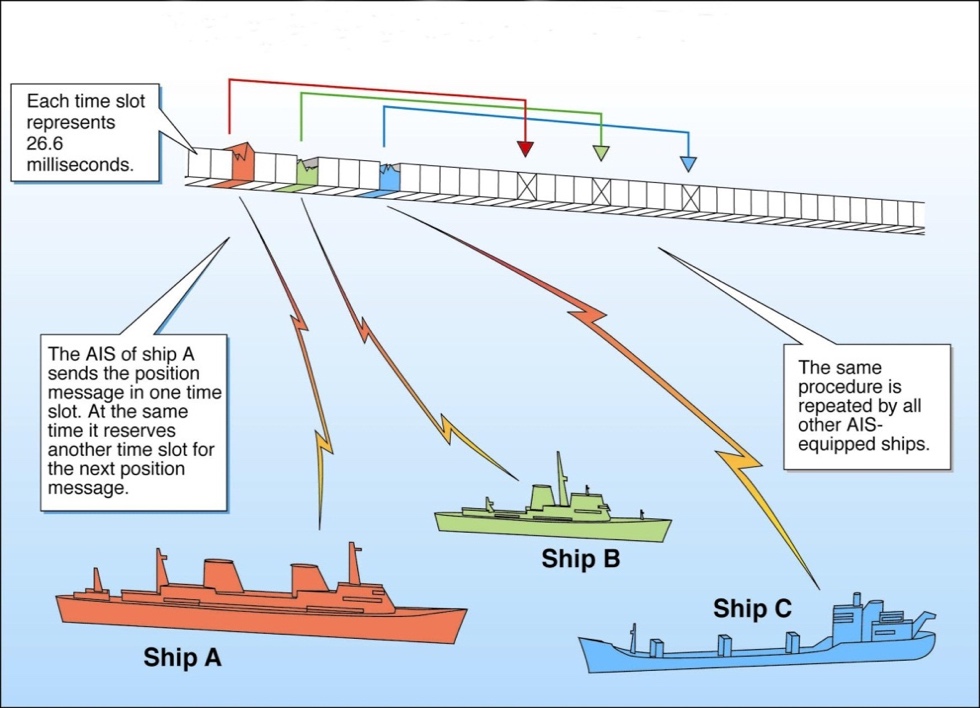


Figure 1 - Protocol for AIS data transmission

# Authorisation of AIS AtoN

The use of AIS AtoN should be overseen by the competent authority. AIS AtoN require a radio licence and the radio licensing authority may be different from the maritime administration. In such cases, there may be a need for a coordinated procedure to ensure that AIS AtoN are correctly licensed and authorised, without unnecessarily delaying or obstructing their deployment.

The authorities involved can be diverse and include maritime administrations, communications regulators, hydrographic services, lighthouse authorities and other governmental and non-governmental organizations and agencies.

The authorities should agree in advance who has responsibility for:

* allocation of Maritime Mobile Service Identity (MMSI);
* ITU reporting; and
* AIS Slot map allocations where applicable.

# Technical standard for AIS AtoN Stations

There are two types of physical AIS AtoN station, with different functionality. They are summarized below and are fully described in IEC document *IEC62320-2 AIS AtoN stations - Minimum operational and performance requirements - methods of test and required test results*.

## Type 1 AIS AtoN Station

The Type 1 AIS AtoN Station is a transmit-only station, operating in FATDMA mode. The slots used by the Type 1 AIS AtoN Station need to be reserved by a national competent authority, using Message 20, transmitted from an AIS station in the coverage area. The Type 1 unit must be configured to use the slots reserved for it before being placed into service.

This is the simplest type of AIS AtoN station, with relatively low cost and power consumption.

## Type 3 AIS AtoN Station

The Type 3 AIS AtoN Station is more complex and incorporates two AIS receiving processes (FATDMA and RATDMA) that allow it to participate fully on the VDL.

The Type 3 station is therefore capable of:

* Autonomous operation, not requiring slot reservations (RATDMA).
* Autonomous operation using slots reserved by a national competent authority, using message 20, transmitted from another AIS Station in the coverage area (FATDMA).
* Receiving and relaying AIS messages, including control and configuration messages for itself or for other AIS AtoN stations in a chain. See *IEC 62320-2* for more details of chaining.
* Repeating AIS messages.

# INSTALLATION AND MAINTENANCE OF ais aton

The installation of AIS AtoN requires careful placement to avoid system failures, damage or interference with other electronic devices. Particular attention is required to the correct programming of the AtoN.

See Annex D for advice on installation, maintenance and training.

# Supplementary AIS AtoN Messages

In addition to Message 21 an AIS AtoN may also transmit other message types including 6, 7, 8, 12, 13, 14, and 25.

AIS also incorporates the facility for an authority to develop their own regional messages. These are referred to as Application Specific Messages (ASM). A summary of common AIS AtoN messages is shown in Table 2.

1. Summary of most common AIS AtoN Station messages

| Msg ID | Message Name | Message Description | Application examples |
| --- | --- | --- | --- |
| 6 | Binary Addressed Message | Binary data for addressed communication | Monitoring of AtoN lantern, power supply, etc. |
| 7 | Binary acknowledge message | Acknowledge of addressed binary message |  |
| 8 | Binary Broadcast Message | Binary data for broadcast communication | Meteorological and hydrological data |
| 12 | Addressed Safety Related Message | Safety related data for addressed communication | Warn AtoN malfunctioning |
| 13 | Safety related acknowledge message | Acknowledge of addressed safety related message |  |
| 14 | Broadcast Safety Related Message | Safety related data for broadcast communication | Warn AtoN malfunctioning |
| 25 | Single slot binary message | Binary data for addressed or broadcast communication | Status report |
| 28 | single slot AtoN report | Mobile AtoN ?? |  |

IALA maintains a register of regional Application Specific Messages. The purpose of this register is harmonization. Go to https://www.iala.int/asm/ for further information.

More than one AIS message format may be transmitted as noted above. The national competent authority for the AtoN should establish procedures to verify the broadcast information and the correct operation of the AIS AtoN Station.

## Reporting intervals for SUPPLEMENTARY messages

Reporting intervals for supplementary messages should be based on operational requirements. Two examples follow:

* Message 6 for AtoN monitoring.

This message need only be sent as often as the operator data is required. However, in practice, power consumption by the AIS AtoN will be minimized if this message is sent just before or just after a message 21. This is because most AIS AtoN devices will power down parts of their operating system between transmissions (“sleep mode”).

* Message 8 for Meteorological and Hydrological data.

Again, this should be coordinated with the wake-sleep cycle for Message 21. However, by its nature, this message is required less frequently, so that a multiple of the Message 21 reporting interval would be appropriate. In situations where the Message 8 for Meteorological and Hydrological data is repeated by an AIS Base Station, the reporting interval at the AIS AtoN station might be reduced to 30 or 60 minutes, for example.

See IALA Guideline *G1095 Harmonized implementation of ASM for more details.*

# AIS DATA Management

AIS data can be gathered from local, regional, national or international network systems of AIS base stations and can be used to further improve and enhance services provided to mariners.

AIS AtoN could provide information including the following:

* Monitoring the status of an AtoN.
* Tracking an AtoN that is off position.
* Identifying ships involved in collisions with AtoN.
* Gathering real-time information on the “state of health” of an AtoN.
* Remotely controlling changes in AtoN parameters.
* Providing statistics on reliability of AtoN.
* Extending the coverage of AIS monitoring.

More information regarding uses of AIS data can be found in IALA Guideline *G1050 Management and monitoring of AIS information.*

# cybersecurity

AIS is an open communication protocol lacking in inherent security and this should be considering within any use in AtoN. Further guidance on cybersecurity can be found in IALA Guideline *G1182 Cyber security specifics from an IALA perspective.*

# Implementation

## AIS AtoN service availability

The AIS AtoN service shall have a service availability corresponding to IALA Category 1, 2, or 3 (depending on the importance of AtoN) for the intended transmissions. The service availability for all AIS AtoN shall be calculated as a three-year rolling average. See IALA Recommendation *R0130 Categorisation and Availability Objectives for Short Range Aids to Navigation*.

The AIS AtoN transmissions containing the AtoN information shall have a signal level of greater than or equal to –107dBm when measured at the air-antenna interface of the user’s receiver (IEC 61993-2 standard) within the following coverage areas:

* 5-10 M of the AIS AtoN for floating AtoN depending on height of AtoN.
* 10-25 M of the AIS AtoN for fixed AtoN depending on height of AtoN.

Synthetic and Virtual AIS AtoN signal sent from an AIS Base Station might have different coverage areas depending on the location of the AtoN inside the AIS Base Station coverage area (the edge, centre, etc.). National competent authorities shall develop their own procedures for dealing with coverage area and consider the use of multiple stations if necessary.

Expected signal strength can be computed for a suitable measuring point using standard propagation calculations.

# definitions

The definitions of terms used in this Guideline can be found in the *International Dictionary of Marine Aids to Navigation* (IALA Dictionary) at http://www.iala-aism.org/wiki/dictionary and were checked as correct at the time of going to print. Where conflict arises, the IALA Dictionary should be considered as the authoritative source of definitions used in IALA documents.

# abbreviations

AtoN Aid to Navigation

MAtoN Mobile Aid to Navigation

VAtoN Virtual AIS Aid to Navigation

TBF

# References

1. ITU, Technical Characteristics for a Universal Automatic Identification System Using Time Division Multiple Access in the VHF Maritime Mobile Band, ITU-R M.1371-5.
2. IEC 62320-2 AIS AtoN stations - Minimum operational and performance requirements - methods of test and required test results
3. IMO SN.1/Circ.289 Guidance on the use of AIS Application-Specific Messages
4. ITU-R M.585 Assignment and use of maritime mobile service identities

Reference documents are the latest from the date of issuance of these guidelines. Readers have to consider that some will be amended or revoked and care should be taken to follow up with the most up to date information.

# further reading

Insert text if required.

1. CRITERIA FOR PROVIDING AIS AtoN

The criteria for any AIS AtoN should be based on the navigational requirement derived from the assessment of risk.

1. PHYSICAL AIS AtoN
2. Lighthouses and beacons

The primary purpose of providing AIS AtoN functionality to lighthouses and beacons is to provide the mariner with a fixed point of reference. The optional provision of AtoN functionality information gives advance information to the mariner on whether key AtoN are performing correctly and allows for revision of the passage plan if required.

AIS AtoN functionality should be provided on lighthouses and beacons where a navigational assessment identifies the requirement set out above. Typical locations for consideration would include offshore stations, headland stations, landfall stations, stations that are commonly used as waypoints, stations that mark points on featureless coastlines, or isolated dangers.

1. Floating aids

In addition to the point of reference and AtoN information purposes described above for fixed AtoN the provision of AIS AtoN functionality on floating AtoN provides confirmation of the floating AtoN position. Confirmation of position provides the mariner with an assurance that the AtoN can be used and improves spatial awareness. Advance confirmation of the position of floating AtoN is a significant improvement in the service available to the mariner.

AIS can improve the conspicuity of AtoN on mariners’ displays. Typical locations for consideration would include Major Floating AtoN, gateway buoys at the approach to narrow channels, buoys that are commonly used as waypoints, buoys marking isolated dangers, buoys marking the extremities of shoal areas and buoys that are critical to the mariner’s spatial awareness.

1. Virtual AIS AtoN

Permanent or temporary Virtual AIS AtoN could be used where it is not possible to put physical AtoN on station, or where AtoN provision can be improved. Examples include ice conditions, new wrecks and dangers, AtoN in very close proximity to shipping movements, marking of temporary fairways, marking of temporary hazards or debris fields, or where additional AtoN can be provided to enhance safety of navigation.

The criteria for use of virtual AIS AtoN will be influenced by the practicality of providing a physical AtoN. Where physical AtoN cannot be provided, for example in ice or severe weather conditions, virtual AIS AtoN can contribute to reducing the risk and provide additional information for the user.

The need to rapidly mark wrecks and other new dangers with virtual AIS AtoN, often in advance of laying physical AtoN, will be based on an assessment of the danger posed to shipping in the area. Any replacement of existing physical AtoN with virtual AtoN will require a detailed risk assessment.



Figure B.2 - Flow chart for decision process, AIS AtoN

1. Risks and Limitations

AIS AtoN are increasingly portrayed on the displays of ships, though there are still some challenges to be addressed. These challenges include the lack of consistent symbology causing confusion, equipment not being properly configured to show data, information overload or absence, and some displaying a position offset.

Other risks and limitations may include GNSS or radio wave vulnerability, jamming and spoofing, and overloading of the VHF datalink.

1. Limitations
   * 1. GNSS Vulnerability

In the event of GNSS service interruption due to jamming or interference, ships may lose their positioning capability unless they have an alternative positioning system. Poor installation or failure of shipborne equipment can similarly interfere with or degrade GNSS reception.

Errors in the GNSS position, for example, those caused by time lag, will directly impact the appearance of the AIS AtoN symbol on the radar, potentially misleading mariners into thinking that the AIS AtoN broadcast position is faulty.

* + 1. Spoofing and jamming of AIS AtoN

Some spoofing methods can be detected through careful monitoring of the transmission channel, for example by monitoring MMSI numbers within the service coverage area. Duplicated or non‐existent MMSI numbers within the coverage area may indicate spoofing.

Increased spoofing detection capability can be achieved through regional cooperation between neighbouring countries, exchanging valid MMSI numbers and cooperating on identifying invalid MMSI numbers.

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

Both spoofing and jamming can compromise and/or shut down an AIS AtoN service. Jamming will typically block the service in a certain geographic region. Spoofing of virtual AIS AtoN is more sinister since the targeted receiver cannot detect the deception, which could mislead the navigator.

## B4 Risk mitigation

This section provides some potential mitigation measures for the different risks.

1. Potential risk mitigation measures

|  |  |
| --- | --- |
| Risk | Potential mitigation measures |
| Reliance on AIS AtoN. | Mariners should not rely solely on AIS AtoN but cross-check them with other data or information. |
| Not all mariners will receive or be able to display AIS AtoN. | MSI should be maintained as the primary notification.  Encourage the integration of AIS AtoN with navigational displays, where fitted. |
| Information overload | Use of lines and areas (such as ASM) instead of points.  Only competent authorities are permitted to approve.  Limit use of AIS AtoN in any area. |
| Loss of AIS AtoN signal. | Publish standards for availability, continuity, and integrity.  Verification of transmission by originator.  Provide redundancy and integrity warnings.  Include relevant information in MSI and chart.  Shipborne navigational displays able to manage and display the lost target symbol. |
| AIS AtoN vulnerability; jamming/spoofing. | Verification of transmission by originator.  Correlation with MSI / charts.  Data link monitoring by competent authority. |
| No confirmation of receipt of message. | Repeated or addressed / acknowledged transmissions.  Verification of transmission by originator. |
| Erroneous message transmitted. | Procedures for message checking.  Verification of transmission by originator. |

1. the Aids to Navigation Report (message 21)

The definition of an AIS AtoN is an AIS transceiver broadcasting a Message type 21. The message configuration will determine the type of AIS AtoN (physical, synthetic, virtual) as well as the AtoN specifications.

The message 21 broadcast includes the following information.

Maritime Mobile Service Identity (MMSI) number

Type of AtoN

AtoN name

Position of the AtoN (Latitude and Longitude)

Type of position fixing device

Position accuracy indicator

On/Off position status

Whether Physical or Virtual AtoN

Status of AtoN systems

Time stamp

Dimension of the AtoN and reference positions

1. MMSI NUmbers for AIS Aton

All AIS AtoN Stations should have a radio licence.

All AIS AtoN Stations must include a MMSI number in its own transmissions. The MMSI is a unique identifier issued by the appropriate national MMSI issuing authority.

All AIS AtoN MMSI numbers have the format 99 followed by a three-digit Maritime Identification Digit (MID) followed by a four-digit unique identifier. The MID identifies the country that issues the VHF licence for the AIS AtoN Station. The four-digit unique identifier starts with 1 (99MID1XXX) for physical and synthetic AtoN Stations; 6 (99MID6XXX) for virtual AtoN Stations, and 8 (99MID8XXX) for Mobile AtoN.

Table 3 - AtoN and MMSI

|  |  |  |
| --- | --- | --- |
| Type of AIS AtoN or AtoN | MMSI format  ITU-R M..585-8 | Virtual AtoN Flag |
| Physical | 99MID1XXX | 0 |
| Synthetic | 99MID1XXX | 0 |
| Virtual | 99MID6XXX | 1 |
| MAtoN | 99MID8XXX | 1 or 0 |

The competent authority should be aware that the number of MMSIs available for use is a finite resource.

A.1.2 Type of Marine Aid to Navigation

The types of Marine Aids to Navigation listed below are based on the IALA Maritime Buoyage System, where applicable.

The nature and type of AtoN can be indicated with 32 different codes:

Table 4 - Codes for type of AtoN

|  | Code | Definition |
| --- | --- | --- |
|  | 0 | Default, Type of AtoN not specified |
|  | 1 | Reference point |
|  | 2 | RACON or MAtoN |
|  | 3 | Fixed structure, such as oil platforms, wind farms. (Note: This code should identify an obstruction that is fitted with an Aid-to-Navigation AIS station.) |
|  | 4 | Emergency Wreck Marking Buoy |
| Fixed AtoN | 5 | Light, without sectors |
|  | 6 | Light, with sectors |
|  | 7 | Leading Light Front |
|  | 8 | Leading Light Rear |
|  | 9 | Beacon, Cardinal N |
|  | 10 | Beacon, Cardinal E |
|  | 11 | Beacon, Cardinal S |
|  | 12 | Beacon, Cardinal W |
|  | 13 | Beacon, Port hand |
|  | 14 | Beacon, Starboard hand |
|  | 15 | Beacon, Preferred Channel port hand |
|  | 16 | Beacon, Preferred Channel starboard hand |
|  | 17 | Beacon, Isolated danger |
|  | 18 | Beacon, Safe water |
|  | 19 | Beacon, Special mark |
| Floating AtoN | 20 | Cardinal Mark N |
|  | 21 | Cardinal Mark E |
|  | 22 | Cardinal Mark S |
|  | 23 | Cardinal Mark W |
|  | 24 | Port hand Mark |
|  | 25 | Starboard hand Mark |
|  | 26 | Preferred Channel Port hand |
|  | 27 | Preferred Channel Starboard hand |
|  | 28 | Isolated danger |
|  | 29 | Safe Water |
|  | 30 | Special Mark |
|  | 31 | Light Vessel / LANBY / Rigs |

## A.5 A.1.3 Name of AtoN

Message 21 has two name fields, the main field (20 characters) and the extended field (14 characters), allowing for a total name length of 34 characters (including spaces). Note that not all shipborne navigational equipment may display the extended field.

Given the lack of uniformity worldwide concerning naming, some guiding principles will enable more consistency. Some of the important elements to consider are:

* The name should help to identify the location and function of the AtoN.
* Using a short name will prevent cluttering the shipborne display when users are displaying the name tag. Recognized international or national abbreviations or acronyms might help reduce the length.
* Use of numbering and lettering that respect IALA’s Maritime Buoyage System (e.g., Even or odd, numbered from seaward, etc.).
* Avoid repeating some of the information already available in other fields of the Message 21 and/or Nautical Publications (fixed, floating, MMSI, virtual, colour, etc.).

## A.1.4 Type of Electronic Position Fixing Device

For fixed AtoN and virtual AtoN the surveyed position should be used. The accurate position enhances its function as a radar reference target. Floating AIS AtoN Station should transmit its current position as given by GNSS.

## A.1.5 Position monitoring for floating aToN

The position derived from GNSS can be used in conjunction with the reference, or charted, position and a “guard zone” to monitor the position of floating AtoN. When the GNSS position of the AtoN is outside guard zone parameters (indicating that the position threshold has been exceeded) an “Off position” alarm sets the off-position indicator bit (flag) in message 21. If it is not properly set, it will either never alarm or alarm constantly. Further information can be found on IALA Guideline G1180 Resilient Position, Navigation and Timing (PNT), section 3.1 Marine Aids to Navigation.

Guard zone parameters for a floating aid (with mooring) need to be determined and entered into the physical AIS AtoN unit configuration settings. Assuming no movement of its anchor, the area within which a floating aid will always be found is determined by the movement permitted by its mooring length, the minimum depth of water and errors inherent in the positioning method used (including accuracy of the fixing method when the AtoN was deployed). When these factors are added together, they determine the area within which a floating aid should remain. A tolerance factor may be added to reduce the likelihood triggering an “Off position” alarm.

More information on a floating AtoN swinging radius calculation can be found in the IALA Guideline *G1066 The Design of Floating Aid to Navigation Moorings.*

Further information on position source and accuracy can be found in ITU-R M1371-5

## A.1.6 Physical or Virtual AtoN.

Where no physical AtoN exists, the virtual AtoN flag is set to 1. Table 3 show the relationship between the virtual AtoN flag and MMSI format each type of AIS AtoN.

## A.1.6 Dimensions of AtoN

This field should indicate the size of the AtoN object itself and not the dimensions of the area in which a floating AtoN can move (guard zone) or dimensions of a “dangerous zone” around the AtoN.

Fixed AtoN;

* A numeric value should be used. as noted in the table below. The orientations established by the dimensions A, B, C and D should face true north, south, west and east respectively. For Example. Setting A and C to zero, the reference point becomes the north-west corner.

Floating AtoN;

* Larger than 2m x 2m. The dimensions of the AtoN should always be given as a circle, i.e., the dimensions should always be as follows: A=B=C=D>1. This is due to the fact that an orientation of the floating AtoN is not transmitted.
* Smaller than or equal to 2m x 2m. The fields should be set to A=B=C=D=1.

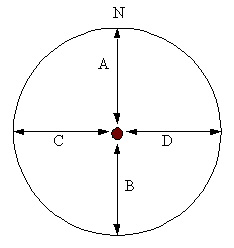
Offshore structures that are not fixed (Table 4, Code 31) and fixed offshore structures (Table 4, Code 3);

* “Dimension/reference for position” parameter as determined below. Hence, all offshore AtoN and structures have the dimension determined in the same manner and the actual dimensions are contained in message 21.

Virtual AtoN.

* The dimension should be set to A=B=C=D=0 (=default). This should also be the case, when Type of AtoN is set to “reference point”.

|  |  |
| --- | --- |
| **Dimensions for a floating AtoN and both fixed and floating offshore structures** | |
| A+B ≤ 2m | A=B=C=D=1 |
| A+B > 2m | A=B=C=D>1 |



A diagram of a rectangular object with a straight line

Description automatically generated

|  |  |
| --- | --- |
| **Dimension/reference for position, for a fixed AtoN** | |
| **Dimension** | **Numeric (m)** |
| A | 0 - 511 |
| B | 0 - 511 |
| C | 0 - 63 |
| D | 0 - 63 |

## A.1.7 AtoN Status Bits

AIS message type 21 provides for eight status bits that are intended to provide information on the operating status of the AtoN and/or its components. This includes light on/off/inoperative, Racon installed/operational/inoperative. The format is shown below:

Table 5 - Recommended use of status bits (light, racon and health)

|  |  |  |  |
| --- | --- | --- | --- |
| **AtoN light, RACON and health status 8 bits format**: 111 XX XX X | | | |
| **Page id**  **(8th, 7th and 6th bit)** | **RACON Status**  **(5th and 4th bit)** | **Light Status**  **(3rd and 2nd bit)** | **Health Status**  **(1st bit)** |
| 111 | 00 = No RACON installed | 00 = No light or no monitoring | 0 = Good Health |
|  | 01 = RACON installed but not monitored | 01 = Light ON | 1 = Alarm |
|  | 10 = RACON operational | 10 = Light OFF |  |
|  | 11 = RACON Error | 11 = Light fail or at reduced range |  |

NOTES

1. Manufacturer’s default setting for the eight AtoN Status bits of message type 21 should be all zeros.
2. Health Status - The 1st bit is used for alerting that there is a problem at the AIS AtoN Station. Health flag alarm should be set to 1 to indicate a fault in or failure of the AtoN system or AIS AtoN station, at this location.
3. Main Light Status - For the main light, a fail is a situation where:
   1. The light is off when it should be on.
   2. The flash character is incorrect (e.g., an optic drive failure).
   3. The “Main light fail” may be set if the main light is operating at a reduced range (e.g. running on emergency lower range lanterns).
4. Racon Status - For the Racon, a fail is a situation where the Racon unit signals a failure from an on-board built-in integrity test (BIIT). It may also signify a power failure for the Racon. If the RACON error flag is set, the health flag alarm should be set to 1.

## A.2 Reporting intervals for AIS AtoN messages

The reporting interval for message type 21 should be chosen so that an approaching vessel receives the AtoN information message within an appropriate timeframe between entering into range of the AIS AtoN broadcast and reaching the AIS AtoN location.

Factors to take into account are:

Vessel speed of approach

Topology, for example, vessels approaching from around a headland

Nominal transmission range

VDL loading

ANNEX C VIRTUAL AtoN

1. General Considerations

Virtual AtoN (VAtoN) can be used to inform mariners about dangers to navigation, safe waterways, areas where extra caution may be necessary and areas to be avoided. These are usually in the form of specific VAtoN i.e., as per Message 21 but can also be used to represent a line, area, position or other forms that may be displayed graphically in the form of Application Specific Messages.

VAtoN may be used as temporary deployments, where there is a time-critical consideration, and also in a permanent context, where permanent physical AtoN cannot be established or maintained. These two applications of Virtual AtoN, temporary and permanent, should be reflected in Maritime Safety Information (MSI). Competent authorities should use all available means to ensure that mariners have the necessary information concerning the presence and purpose of VAtoN and notify their national hydrographic offices for inclusion and updates in nautical publications, including charts.

The potential benefits of VAtoN include enhancing safety and environmental protection, timely notification, quick deployment and modification, ease of presentation and low cost in comparison to physical AtoN.

1. Technical Deployment

For a VAtoN using message 21, the MMSI number represents the unique identity of the AtoN itself, rather than the transmitting source.

The repeat indicator field is used to identify whether the signal is transmitted from another station. It allows an AIS base station to repeat the message type 21 of another entity which may extend the coverage of a less powerful mobile station. Competent authorities should consider broadcasting a VAtoN from more than one AIS base station to ensure redundancy.

The nominal report rate of VAtoN broadcasts is specified by ITU. However, due to the limitations in data link capacity, a more flexible approach is recommended, taking data link capacity and power consumption at transmitting stations into account. VAtoN transmitting sites should deliver a specified minimum signal strength at the user antenna within a specified service area.

It may be advisable to use VAtoN to identify temporary restriction areas, to prevent intrusion. If the area is marked with several VAtoN, the name for each object should be the name together with the serial number as shown in Figure 3. It should be noted that the display of the user terminal may be limited, and the AtoN name may be too long to be fully displayed, so important information such as the serial number should be prioritised at the front.

A blue and purple square with text

AI-generated content may be incorrect.

Source: Swedish Maritime Administration and Swedish Transport Agency

Figure 3 - Four VAtoN marking the limits of a military area

The number of VAtoN and/or their reporting interval (i.e. refresh rate) that can be provided within a local area may be limited due to the capacity of the communication link. There is a limit to the number of VAtoN that can be in the same area due to available timeslots in the AIS system, and multiple VAtoN could increase clutter on the user display. To mark areas, AIS ASM may be used, rather than multiple VAtoN.

1. Use cases for VAtoN

Potential use cases are listed in the table below.

Table 6 - Application of VAtoN

| Application Mode | Function | Conditions | Suggested Type of Virtual AIS AtoN | Consideration |
| --- | --- | --- | --- | --- |
| Permanent Marking | Marking of Shoals and Reefs, Fairway and its Limits | Virtual AtoN can be effectively utilized where it is difficult to place or maintain a physical AtoN due to meteorological, topographical or hydrographical conditions. | Isolated Danger Marks, Cardinal Marks, and Lateral Marks | Conditions could be sea state such as crashing waves and submerged reef, strong current, water depth, strong ice movement, poor holding ground, etc. | |
| Permanent Marking | Marking of Fairway | VAtoN can be effectively utilized where it enhances vessel traffic flow patterns.  Potential applications are to mark the centre of each traffic lane or the separation between two lanes of a TSS and other usual routes. | Safe Water Marks and Lateral Marks | The efficiency of vessel traffic flow patterns is the goal of this application. | |
| Permanent Marking | Marking of Fairway | VAtoN can be effectively utilized in approaches to a harbour entrance where a ship changes its course and where it is difficult to install a physical AtoN. | Safe Water Marks and Lateral Marks |  | |
| Permanent Marking | Marking of Fairway | Virtual AtoN can be effectively utilized where it is difficult to deploy or maintain a physical AtoN due to vessel to vessel or vessel to AtoN interaction. | Lateral and Cardinal Marks | Existing AtoN with history of impacts/contacts and with no repositioning options are good candidates. | |
| Permanent Marking | Marking Reference Points | Virtual AtoN can be effectively utilized where there is a need to verify if a potential AIS position offset exists on shipborne navigational displays using schematic reference point patterns.  This is generally a need in confined waters where high accuracy and performance of shipborne equipment is required. | Reference Points | Predefined accurate coordinates as well as distance and bearing between virtual marks need to be used and made available through publications. | |
| Permanent Marking | Marking of Special Area (e.g., anchorage area, area to be avoided) | Virtual AtoN can be effectively utilized where precaution or special caution required. | Special Marks. | A clear marking of special areas will improve safety of navigation. | |
| Temporary or Permanent Marking | Marking of Special Area | Virtual AtoN can be effectively utilized where it enhances the protection of the environment and/or the protection of species. | Special Marks | Risk of damaging the seafloor of a sensitive area with a physical AtoN might be a consideration.  Timely speed reduction zones or restricted areas for protecting mammals or other species. | |
| Temporary Marking | Marking of a Navigational Restricted Areas (time critical only) | Virtual AtoN can be effectively utilized when navigation restriction is required due to military operations, marine accidents or when marking a wreck or offshore operations. | Cardinal Marks, Emergency Wreck Marks, Isolated Danger Mark & Special Marks | Need to be monitored/updated.  Timely deployment is required where it is difficult to have the proper resource available for a physical AtoN deployment.  The dynamic nature of the event, i.e., short duration or having to relocate an AtoN, requires the use of a VAtoN. | |
| Temporary Marking | Designation of temporary fairway (time critical only) | Virtual AtoN can be effectively utilized for indication of fairways when a large scale disaster hits the area. | Lateral Marks & Safe Water Marks |
| Temporary Marking | Marking of AtoNs that are Malfunctioning or Off Position | Virtual AtoN can be effectively utilized when a physical AtoN has lost its ability to perform regular functions. | Same as the physical AtoN, or Isolated Danger Marks | Timely deployment required. | |
| Temporary Marking | Pilot Boarding | Virtual AtoN will be useful in marking a pilot boarding station where the position is dependent on sea/ice conditions. |  | Timely deployment required. | |

1. annex D planning and considerations for AIS AtoN

This Annex gives guidance on the selection, installation and maintenance of AIS AtoN equipment.

* 1. SELECTION OF EQUIPMENT

When selecting AIS AtoN equipment, the following points should be considered:

* Life cycle cost analysis
* Reliability
* Size of unit compared to available space
* Simplicity to configure and interrogate
* Ease to upgrade if necessary
* After-sales service and support
* Ease of installation
* Connectivity requirements (Example: high-integrity external connections.)
* Power consumption
  1. INSTALLATION
     1. Power requirement

There needs to be sufficient power available to operate the system, noting the power consumption of co-located AtoN such as lights etc. to deliver the required autonomy. The power consumption of the overall configuration should be measured, rather than rely on the manufacturer’s generic data

The power requirement of an AIS AtoN station is dependent on a number of factors which are usually available for setting via the unit configuration method. These are:

* VDL access method – FATDMA will give substantially lower power drain than RATDMA.
* FATDMA slot selection – the channels AIS1 and AIS2 slots should be close together in time, to minimize the period for which processes in the AIS AtoN unit are active.
* Reporting interval – an extended reporting interval will reduce power drain, but the interval should satisfy the relevant guidance.
* Configuration of the AIS AtoN unit - the AIS AtoN unit could be designed or configured to enter into a “sleep”mode when not active.

Repetition of the AIS AtoN messages by a local AIS shore station, during the reporting interval of the AIS AtoN station, may allow the reporting interval of the AIS AtoN unit to be extended, reducing the power requirement. For example, the AIS AtoN may have a 10 minute reporting interval, but the local AIS shore station repeats the AIS AtoN message every frame, i.e., every minute. Consideration should be given to the coverage areas of the AIS AtoN unit and the shore station to ensure that operational requirements are met. An advantage of repeating from an AIS shore station may be to increase the coverage area of the AIS AtoN Station.

* + 1. Antennae
       1. VHF Antenna

It is normal practice to use a dedicated VHF dipole antenna located as high as practically possible, whilst noting the physical vulnerability that results.

* + - 1. GNSS Antenna

When planning the installation of a GNSS antenna, it is a priority that it be clear of any vertical obstruction at all times and position as far as practical from any potential interference source.

* + - 1. Choice of location for antennae

In the case of floating AtoN, installing VHF and GNSS antennae at the uppermost section of a superstructure may be a disadvantage from the structural point of view, as they are vulnerable to damage if the buoy is struck by a passing ship or when the buoy is being recovered for maintenance.

* + 1. **Transmission range**

The transmission range is a function of the transmitter power, antennae height and antenna gain. In areas of very heavy traffic, the volume of AIS transmissions may overload a receiver reducing the effective range.

In certain regions and specific environmental conditions, super-refraction or ducting of the VHF signal can occur, significantly enhancing the VHF coverage at times. This particular phenomenon should not be relied on to provide enhanced coverage.

* + 1. **Selection of VHF antenna**

The selection of VHF antenna should be specific for the AIS frequencies (161.975 MHz and 162.025 MHz) and be suitably designed for the maritime environment.

* 1. **Ingress protection (IP) rating**

Electronic equipment installed on an AtoN will be subject to severe environmental exposure.

To safeguard integrity of the equipment, increase its lifespan and ensure its reliability, the installation must prevent the condensation cycle from starting. A sufficient IP rating of not less than IP56 should be specified.

* 1. **Lightning protection.**

Surge protection to guard the equipment against an atmospheric discharge is essential in any installation of electronic equipment.

Lightning protection can take the form of diode-based surge protectors, varistors, gas discharge units and good grounding.

* 1. **Grounding**

Good equipotential bonding between the AtoN superstructure, mounted equipment and sea water will provide some protection against raised electrical potential during a lightning storm, and will also prevent static build up.

* 1. **AIS FOR MONITORING AtoN Units**

AIS can be used for monitoring AtoN lantern and racon health information via message 6, and position via message 21.

AIS AtoN can be supplied as an integrated unit within lanterns or as a standalone unit, in which case a connection to the lantern is necessary for monitoring. It should be noted that when equipment has been integrated by the supplier there is a lower risk of failure to the internal connections, external antenna connection, etc. User implemented AIS equipment runs a higher risk of failing.

1. COMMISSIONING & TESTING
   1. **Configuration**

AIS AtoN units require programming with the following parameters as a minimum:

* MMSI
* Name and type of Navigation Aid
* Charted position
* Guard ring (off-position alarm)
* For type 1 AtoN: Transmission interval, Slot allocation
* AIS function (Physical, Virtual or Synthetic)
* Dimensions of the AtoN

Confirmation of all on site programmed information needs to be recorded with the Competent Authority.

* 1. **testing**
     1. **Tests pre-deployment**

Prior to deployment, the AIS AtoN should be set-up for transmission testing at an approved location and its performance monitored remotely. For floating AtoN testing of the off-position alarm should also be part of the testing sequence by moving it beyond its guard ring. When testing the AIS AtoN that is not in its assigned position, agreement must be gained with the licensing authority to avoid confusion to local shipping.

* + 1. **Tests post deployment**

After deployment, a functional test should be conducted including checks of the transmitted position and range of reception.

1. **MAINTENANCE & OPERATION**
   1. **Maintenance requirements**
      1. **Technical Staff**

It is essential to maintain attention to detail when programming AIS AtoN as this is the most common point of failure.

Technical staff are responsible for verifying:

* AIS AtoN operation
* Watertight integrity of glands and connectors
* VHF and GNSS antenna cables
* Non-intrusive inspection of the condition of VHF antenna, of its flexibility and of the GNSS antenna if external
* Condition of wiring and connectors, stiffness, cracks, moisture and oxidation
* Power supply
* Mounting arrangements
* Transmission range and coverage measurement
  + 1. **Configuration Management**

The technician needs to be well acquainted with the configuration software. Good configuration management methodology should be in place to ensure accurate tracking of configuration of the AIS AtoN and the embedded software version.

* 1. **Training**
     1. **Capabilities required**

The technical staff associated with the maintenance and operation of AIS AtoN should have specific training to enable them to work safely and competently on the AIS AtoN.

The skills required to maintain and programme AIS AtoN units at sea are at a higher level than that required to maintain basic AtoN. Since AIS AtoN maintenance and implementation on AtoN is not a routine task, their performance should be assessed and monitored periodically.

* + 1. **Training documentation**

As with all training, manuals need to be plain, concise, reader-friendly and readily available to the maintainer.

* 1. **Spares**

It is necessary to have spare transponders and antennae to replace those that fail, which are damaged by passing ships, vandalized or out of service. The best way to maintain the service is to replace a malfunctioning transponder onsite and to repair offsite (if appropriate).

1. As stated in SOLAS Chapter V, Regulation 19, 2.4. [↑](#footnote-ref-1)
2. Shore authorities should use FATDMA whenever possible instead of RATDMA to avoid slot collisions [↑](#footnote-ref-2)
3. Shore authorities are responsible for the allocation and reservation of FATDMA slots. [↑](#footnote-ref-3)