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IALA GUIDELINES

ON

UNIVERSAL SHIPBORNE AUTOMATIC IDENTIFICATION SYSTEM

(AIS)

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Foreword

IALA's Role in the AIS Standards Development

International Association of Aids to Navigation and Lighthouse Authorities (IALA) has been the primary organisation sponsoring and co-ordinating the development of the Universal Shipborne Automatic Identification System (AIS) station. In 1996, the VTS and Radionavigation Committees of IALA prepared the draft recommendation that, with further refinement within IMO NAV, became the basis for the IMO Performance Standard on AIS.

In October 1997, at the request of several emerging AIS equipment manufacturers, IALA hosted a working group of manufacturers and maritime administrations to agree on a standard technology for AIS stations. The group, which was formally designated the IALA AIS Working Group, completed a draft recommendation, which was submitted by Sweden, on behalf of Finland, Germany, Canada, South Africa, and the United States to the International Telecommunications Union – Sector for Radiocommunications (ITU-R).

Renamed the IALA AIS Steering Group, this body met twice yearly under the IALA umbrella to continue the development of system standards and applications as well as the development of these "*IALA Guidelines on Universal Shipborne Automatic Identification System (AIS)"*, a significant project in itself. In December 1999 the IALA Council agreed that, in view of the international significance of the implementation of AIS, the Steering Group should become the AIS Committee of IALA.

PREFACE

INTRODUCTION

It has long been realised that an automatic reporting device fitted to a ship would be beneficial to the safety of navigation and the control and monitoring of the maritime environment. Ten to twenty years ago such a device, although technically feasible would have been complicated and very expensive. With the advent of GPS and DGPS and modern data communication techniques a maritime transponder is now feasible and moderately inexpensive to provide.

An automatic reporting system has been developed for the maritime industry using the maritime VHF band for the transmission and reception of it's data signals, and has been defined as a Universal Shipborne Automatic Identification System (AIS).

These Guidelines have been prepared by IALA for IALA members and for use by the Maritime Communities concerned with AIS matters. These Guidelines are divided into two parts, Part 1, Operational aspects of AIS and, Part 2 Technical aspects of AIS together with shore based detail including system networking. These are not intended to be a complete manual on AIS, they are provided to give guidance to the reader about the AIS.

PURPOSE

The purpose of this publication is to provide a description of the operational and technical aspects of AIS and to provide some guidelines on how this advanced technology can be applied to achieve efficiency and effectiveness in a wide range of shore-based applications.

Although the ship-to-ship mode of operations is briefly mentioned in the publications, in view of IALA's charter these guidelines are primarily aimed at ship-to-shore and shore-based applications of AIS generated information, such as Vessel Traffic Services (VTS), Ship Reporting Systems (SRS) and Aids to Navigation (AtoNs).

The preface provides general information about the development and inception of AIS. It is a relatively young system at the time (2002). This is also the first edition of these Guidelines and there will be new developments in this system.

Part 1 is provided to give some guidance to users of AIS. It is written from the users point of view. The perspective taken is that of Pilots, VTS operators, managers and students. It essentially views the AIS station as a tool. The relevant operational document for the shipborne use of AIS is an International Maritime Organisation (IMO) document. With respect to the shore based AIS the Competent Authority establishes the use and requirements of AIS within their responsibility and within the technical specifications of the AIS itself.

Part 2 is provided to give a more detailed look at the AIS station and to some extent what is inside the AIS station. This will vary depending upon its use (as shipborne device, a VTS shore based device, an Aid to Navigation device or as a SAR information device). It is not intended to be a complete technical manual for the design of AIS devices or systems. The shipborne, shore based, and, Aids to Navigation AIS stations are described as well as networking concerns for the shore based systems. The detailed technical documents concerning the AIS are the relevant International Telecommunication Union (ITU-R) and the International Electrotechnical Commission (IEC) documents. IALA also publishes the IALA Recommendation on the interpretation of ITU-R 1371-1.

BACKGROUND

This section describes the international requirements and current situation to enable the Universal AIS to become a carriage requirement under the revised International Maritime Organisation (IMO) Safety of Life at Sea Convention (SOLAS) which covers ships from 300* tons upwards. Also for ships not covered by SOLAS which include fishing vessels and pleasure craft, and as an Aid to Navigation device which would enhance the current service provided by Lighthouse Authorities.

THE INTERNATIONAL AIS APPROVAL ROUTE.

Ships covered by the SOLAS Convention are required to fit as a mandatory requirement various ‘navigation aids’ e.g. compass, radar etc. New equipment proposed for inclusion in the schedule of SOLAS requirements must have International approval to the following Standards

IMO Performance Standard.
ITU Technical Specification.
IEC Test specification.

INTERNATIONAL MARITIME ORGANISATION (IMO) PERFORMANCE STANDARD.

What is the International Maritime Organisation (IMO)? IMO, which met for the first time in 1959, is a specialised agency of the United Nations. Its headquarters are located in London and it is devoted to maritime affairs.

* Under review at IMO.

The main interest of IMO can be summed up in the phrase *safer shipping and cleaner oceans.* One of the most important IMO conventions is the International Convention for the Safety of Life at Sea, better known as SOLAS.

An initiative to introduce AIS stations as a SOLAS requirement was made by the International Association of Lighthouse Authorities during the early nineties using the proposed Global Maritime Distress and Safety System (GMDSS) that had already been approved and was being implemented. The proposed system was primarily intended to identify ships and the ships position in Vessel Traffic Services (VTS) area of coverage and in areas of restricted waters. The system used the proposed maritime VHF Channel 70, which had been designated for Digital Selective Calling (DSC).

Following the initiative with the DSC transponder, IMO received a further proposal from the Scandinavian Authorities to consider a more robust transponder system. This would be automatic in operation, suitable for ship to shore and ship to ship purposes, use the maritime VHF band and could cope with the density of ships in congested areas.

The proposal was considered and IMO decided to adopt a single universal system based on the Scandinavian proposal. The system was called a Universal Shipborne Automatic Identification System (AIS).

The IMO Sub-Committee on Safety of Navigation (NAV)was requested to prepare a Performance Standard for such a system and this was concluded during its forty-third session during 1997. It was titled Recommendation on Performance Standards for a Universal Shipborne Automatic Identification System (AIS) and was subsequently approved by the IMO Maritime Safety Committee (MSC) at its sixty-ninth session (May 1998) under resolution MSC.74 (69).

What is a Performance Standard? A Performance Standard specifies the **operational requirement** as perceived by the user/operator and states for example that the AIS equipment shall have the following functions:

Ship to Ship working.
Ship to Shore working.
Automatic and continuous operation.
Provide information messages.
Use Maritime VHF channels.

At the same time that the IMO Sub-Committee on Safety of Navigation agreed the Performance Standard, they requested the International Telecommunications Union (ITU) based in Geneva to prepare a Recommendation on the Technical Characteristics for the Universal AIS. Also to allocate two worldwide channels for its use within the maritime VHF band.

The International Telecommunications Union has its headquarters in Geneva and is a specialised agency of the United Nations within which governments and the Private Sector co-ordinate global telecommunication networks and services.

IMO requested that two maritime VHF channels be assigned for AIS at the ITU World Radiocommunication Conference (WRC) in Geneva during October/November 1997. Two channels were designated and a footnote added to Appendix S18 of the ITU Radio Regulations titled “Table of Transmitting Frequencies in the VHF Maritime Mobile Band” as follows: -

“These channels (AIS 1 and AIS 2) will be used for an automatic ship identification and surveillance system capable of providing worldwide operation on high seas, unless other frequencies are designated on a regional basis for this purpose”

The channels allocated are: AIS 1 (161.975 MHz.) and AIS 2 (162.025 MHz.).

Under the initiative of IALA a draft of the Technical Characteristics was prepared and submitted to a meeting of the ITU Radiocommunication Study Group, Working Party 8B in March 1998. A draft new Recommendation ITU–R M.1371-1 was prepared and agreed titled, “Technical Characteristics for a Universal Shipborne Automatic

Identification System (AIS) Using Time Division Multiple Access in The Maritime Mobile Band”. This document has now been formally approved by ITU (November 1998) and is now the adopted technical standard for AIS.

This Recommendation specifies for example the following technical criteria:

Transceiver characteristics.
Modulation.
Data format, messages and packaging.
Time division multiple access (TDMA).
Channel management.

INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC) AND THE UNIVERSAL AIS STANDARD.

Founded in 1906, the International Electrotechnical Commission (IEC) is the world organisation that prepares and publishes international standards for electrical, electronic and related technologies. The IEC has its headquarters in Geneva and prepares the Type Approval Test Specifications for ships mandatory equipment required under SOLAS.

Following the adoption of the IMO Performance Standard and the ITU Technical Characteristics for the Universal AIS there remains one more Standard to prepare and adopt. This is the IEC Standard titled “IEC 61993 Part 2: Universal Shipborne Automatic Identification System (AIS). Operational and Performance Requirements, Methods of Testing and Required Test Results”. This Standard will be used by Administrations to “type approve” Universal AIS equipment fitted on SOLAS Convention ships. The IEC Technical Committee 80 Working Group 8 (IEC/TC80/WG8) is carrying out the work, and the Standard was adopted in June 2001, and includes for example the following:

Test specification.
Data in/out standard.
Connector standard.
Built-in Test Unit details.

INTERNATIONAL MARITIME ORGANISATION (IMO) CARRIAGE REQUIREMENT.

With the IMO Performance Standard, the ITU-R Technical Characteristics Standards, and the IEC Test Standard, IMO has included the Universal AIS as a carriage requirement within the newly revised SOLAS Chapter V. AIS has been included in the schedule of shipborne navigational equipment proposed in Regulation 19 to be provided in all new ships from the year 2002. The provision of the Regulation 19 equipment on other vessels is yet to be agreed.

NON SOLAS CONVENTION SHIPS.

There are no international regulations that state the navigation equipment that should be fitted on non-SOLAS Convention ships, which comprise fishing vessels, pleasure craft, coastal ships and inland waterway ships. It is expected however that these maritime industries will quickly realise the potential of AIS and its enhancement of

Safety at Sea in particular. For instance pleasure craft will not require all of the available data provided by AIS and will primarily be interested in ensuring that large ships identify them and recognise that they are a small craft. It is therefore expected that AIS will be produced and sold to the fishing and pleasure industries but probably using less data and therefore should be cheaper to provide. It is also expected that ships on inland and coastal waterways will use AIS equipment built to the International Standards mentioned earlier.

ADMINISTRATION/COMPETANT AUTHORITY SHORE INSTALLATIONS

The AIS concept began with ship to ship objectives and transisitioned to the ITU and IEC standards for vessel equipment. As the productivity of shore AIS is recognised, guidelines for AIS adoption within shore installations and networks will continue to exploit technology. ITU-R M.1371-1 compatibility must be the objective of shore equipment as installations prepare for the implementation of carriage requirements, both international and domestic.

UNIVERSAL AIS KEY DATES.

The development and acceptance of the Universal AIS has in international timescales been short, as can be seen from the following key dates.

1997 IMO Sub-Committee on Safety of Navigation approves a draft Universal AIS Performance Standard.
1997 ITU World Radiocommunication Conference allocates two AIS VHF Channels.
1998 IMO Maritime Safety Committee adopts the Universal AIS Performance Standard.
1998 IMO Maritime Safety Committee includes the Universal AIS within SOLAS Chapter V, Regulation 20.
1998 ITU adopts the AIS Technical Characteristics.
2001 IEC approves AIS Test Performance.
2001 IALA publishes the IALA Recommendation on 1371-1
2002 IALA publishes IALA Guidelines on AIS.
2002 IMO carriage requirement starts for AIS.

RECOMMENDATIONS, STANDARDS AND GUIDELINES.

The following International Recommendations, Standards and Guidelines apply to AIS equipment fitted on SOLAS Convention ships.

- **IMO** Recommendation on Performance Standards for a Universal Shipborne Automatic Identification System (AIS), (MSC.74(69))
- **ITU** Radio Regulations, Appendix S18, Table of Transmitting Frequencies in the VHF Maritime Mobile Band.
- **ITU** Recommendation on the Technical Characteristics for a Universal Shipborne Automatic Identification System (AIS) Using Time Division Multiple Access in the Maritime Mobile Band (ITU-R M.1371-1).
- **IEC** Standard 61993 Part 2: Universal Shipborne Automatic Identification System (AIS) Operational and Performance Requirements, Methods of testing and required test Results.

GUIDELINES

ON

UNIVERSAL
AUTOMATIC SHIPBORNE IDENTIFICATION SYSTEM (AIS)

PART 1

OPERATIONAL ASPECTS OF AIS

CHAPTER 1

OPERATIONAL AND FUNCTIONAL REQUIREMENTS

1.1 GENERAL DESCRIPTION

Initially called the "Ship-Ship, Ship-Shore (4S)" broadcast transponder, a term coined by its Swedish/Finnish developers, this version formed the basis of what eventually became known as the "Universal Shipborne Automatic Identification System (AIS)". This type replaced the DSC version and has been previously adopted by the IMO and ITU-R as the AIS standard.

Very simply, the AIS is a broadcast system, operating in the VHF maritime mobile band. It is capable of sending ship information such as identification, position, course, speed and more, to other ships and to shore. It can handle multiple reports at rapid update rates and uses Self-Organising Time Division Multiple Access (SOTDMA) technology to meet these high broadcast rates and ensure reliable and robust ship-to-ship operation.

It has long been realised that an automatic electronic reporting device fitted to a ship would be beneficial to the safety of navigation and the identification and monitoring of maritime traffic. With the advent of Global Navigation Satellite Systems (GNSS), Differential GNSS (DGNSS) and modern data communication techniques an automatic reporting system was developed for maritime applications. It uses the maritime mobile VHF band for the transmission and reception of its data signals and has been defined as a Universal Automatic Identification System (AIS).

1.2 MANDATORY REQUIREMENTS

Ships covered by the SOLAS Convention[1] are required to fit as a mandatory requirement various 'navigation aids' e.g. compass, radar etc. New equipment proposed for inclusion in the schedule of SOLAS requirements must have international approval to the following Standards:

- a Performance Standard adopted by the International Maritime Organization (IMO)
- a Technical Specification adopted by the International Telecommunications Union (ITU)
- a Test (Type Approval) specification adopted by the International Electrotechnical Commission (IEC)

1.2.1 IMO Performance Standard

The Performance Standard specifies the operational requirement as perceived by the user/operator and states, for example, that the AIS equipment shall have the following functions*:*

- Ship to Ship working.
- Ship to Shore working, including long range applications.

[1] International Convention on the Safety of Life at Sea (SOLAS) 1974

- Automatic and continuous operation.
- Provide information messages.
- Use Maritime VHF channels.

IALA developed the initial draft of the “universal” standard for the IMO, gathering a special group of industry and national members for the task. This was refined at NAV 43 (July 1997) and formally adopted by MSC 69 on 11 May 1998, being issued as *Annex 3 to IMO Resolution MSC.74 (69) – Recommendation on Performance Standards for a Universal Shipborne Automatic Identification System (AIS).*

At the same time the IMO NAV 43 requested the ITU to prepare a Recommendation on the Technical Characteristics for the Universal AIS and to allocate two worldwide channels for its use within the maritime mobile VHF band.

1.2.2 Functional Requirements

In terms of system functionality, IMO Resolution MSC.74 (69), the Performance Standards for AIS, requires that the system should be capable of operating:

- in the ship-to-ship mode, to assist in 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)

This functionality is further expanded in the Performance Standards to require the capability of:

- operating in a number of modes:
  - an "autonomous and continuous" mode for operation in all areas. This mode should be capable of being switched to/from one of the following alternate modes by a competent authority;
  - an "assigned" mode for operation in an area subject to a competent authority responsible for traffic monitoring such that the data transmission interval and/or time slots may be set remotely by that authority; and
  - a "polling" or controlled mode where the data transfer occurs in response to interrogation from a ship or competent authority.
- providing information automatically and continuously to a competent authority and other ships, without involvement of ship's personnel;
- receiving and processing information from other sources, including that from a competent authority and from other ships;
- responding to high priority and safety related calls with a minimum of delay; and
- providing positional and manoeuvring information at a data rate adequate to facilitate accurate tracking by a competent authority and other ships.

It should be capable of sending ship information such as identification, position, course, speed, ship length, draught, ship type and cargo information, to other ships (and aircraft) and to the shore.

1.2.2.1 ITU Technical Standard

This specifies the technical characteristics of the system and lays down how to meet the operational requirements of the performance standard. It provides the technical criteria for the AIS, for example:

- Transceiver characteristics.
- Modulation.
- Data format, messages and packaging.
- Time division multiple access (TDMA).
- Channel management.

The International Telecommunications Union (ITU), headquartered in Geneva, is a specialised agency of the United Nations within which governments and the private sector coordinate technical standards for global telecommunication networks and services.
Under the initiative of IALA a draft of the Technical Characteristics was prepared and submitted to a meeting of the ITU Radiocommunication (ITU-R) Study Group, Working Party 8B in March 1998. A new ITU Recommendation was prepared and formally approved by the Union in November 1998, being issued as:

ITU-R Recommendation M.1371-1 - Technical Characteristics for a Universal Shipborne Automatic Identification System Using Time Division Multiple Access in The Maritime Mobile Band.[2]

1.2.2.2 VHF Channel Allocation

The IMO request for two maritime VHF channels for AIS was submitted to the ITU World Radiocommunication Conference (WRC) in Geneva during October/November 1997. Two channels were designated and a footnote added to Appendix S18 of the ITU Radio Regulations titled "Table of Transmitting Frequencies in the VHF Maritime Mobile Band" as follows: -

These channels (AIS 1 and AIS 2) will be used for an automatic ship identification and surveillance system capable of providing worldwide operation on high seas, unless other frequencies are designated on a regional basis for this purpose"

The channels allocated are AIS 1 (161.975 MHz.) and AIS 2 (162.025 MHz.)

1.2.3 IEC Test Standard

Founded in 1906, the Geneva-based IEC is the international organisation that prepares and publishes international test standards for electrical, electronic and related technologies. The Commission also prepares the Type Approval Test Specifications for ships mandatory equipment required under SOLAS, which in the case of AIS includes:

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[2] The ITU-R had earlier issued another AIS related recommendation (without any formal request from IMO) entitled *"ITU-R M.825-2 - Characteristics of a transponder system using DSC techniques for use with VTS and Ship-to-ship identification."*

- Test specification.
- Data in/out standard.
- Connector standard.
- Built-in Integrity Test (BIIT) details.

The IEC Test Standard for AIS is 61993-2 - Universal Shipborne Automatic Identification System (AIS) Operational and Performance Requirements, Methods of Testing and Required Test Results".[3]

1.3 SOLAS CARRIAGE REQUIREMENTS

The international requirement for the carriage AIS as shipborne navigational equipment on vessels is detailed within Chapter V (Safety of Navigation) Regulation 19, of the SOLAS Convention.

In mandating the new carriage requirement a phased approach was taken to its implementation. SOLAS Regulation V/19 requires that *"All ships of 300 gross tonnage and upwards engaged on international voyages and cargo ships of 500 gross tonnage and upwards not engaged on international voyages and passenger ships irrespective of size shall be fitted with Automatic Identification System (AIS), as follows:*

.1 ships constructed on or after 1 July 2002;

.2 ships engaged on international voyages constructed before 1 July 2002:

.2.1 in the case of passenger ships not later than 1 July 2003;

.2.2 in the case of tankers, not later than the first [survey for safety equipment] after 1 July 2003;

.2.3 in the case of ships, other than passenger ships and tankers, of 50.000 gross tonnage and upward, not later than 1 July 2004;

.2.4 in the case of ships, other than passenger ships tankers, of 10.000 gross tonnage and upwards but less than 50.000 gross tonnage, not later than 1 July 2005;

.2.5 in the case of ships, other than passenger ships and tankers, of 3.000 gross tonnage and upwards but less than 10.000 gross tonnage, not later than 1 July 2006;

.2.6 in the case of ships, other than passenger ships and tankers, of 300 gross tonnage and upwards but less than 3.000 gross tonnage, not later than 1 July 2007; and

[3] This standard supersedes IEC Standard 61993-1 on DSC AIS transponders.

.2.7 ships not engaged on international voyages constructed before 1 July 2002, not later than 1 July 2008."

There is nothing in the SOLAS regulations, which prevents Administrations from requiring their nationally registered (domestic) vessels within their jurisdiction to implement the new SOLAS regulation in advance of the promulgated date.

1.4 NON-SOLAS VESSELS

Administrations also have scope under SOLAS V/1.4 to determine to what extent the provisions of the AIS regulation will apply to:

.1 ships below 150 gross tonnage on all voyages;
.2 ships below 500 gross tonnage not engaged on international voyages; and
.3 fishing vessels.

Some coastal States can be expected to apply the AIS requirements to include a wider range of smaller vessel categories including fishing vessels, recreational craft and port services vessels.

1.5 CLASS A AND B SHIPBORNE MOBILE EQUIPMENT

In recognition of this requirement, allowance has been made in the AIS Technical Standards (ITU-R M.1371-1) for a Class A and Class B Shipborne Mobile Equipment. Class A equipment complies with the IMO AIS carriage requirement while the Class B provides facilities that are not necessarily fully compliant with IMO requirements.

Class B equipment, for example, transmits reports at less frequent intervals than the Class A standards. (see Tables 1A and 1B)

1.6 INLAND WATERWAYS

As a result of research projects in Europe and The Unite States, AIS is proposed for vessels on the European inland waterways for real time, safety related communication. This has been done for those areas where there is a mix of sea going vessels and inland vessels in a common traffic situation. The operational use of AIS for inland vessels in particular, will be described in future European publications of the regulatory bodies of the European waterways (e.g. Rhine Commission, Danube Commission).

For inland applications special mobile equipment will be used. This equipment will be based and behave as a Class-A Shipborne Mobile Equipment but, not falling under the IMO requirements, in an adapted configuration. For the use in European waterways no DSC components will be included. Because normally inland vessels are not equipped with a position system, the internal GNSS system will be used as the position sensor, also for external applications. Furthermore the interfaces to external equipment, such as Inland ECDIS or board computers, can be different.

There are no special applications defined at this moment. This will be done during succeeding European projects. If special applications are needed for inland vessels, the normal standard procedures with international/regional identifiers for messages will be followed.

1.7 AIDS TO NAVIGATION

In addition to its primary role in ship-ship and ship-shore role, an AIS station can be used as an aid to navigation. When positioned at a significant geographic point or danger to navigation the equipment can provide information and data that would serve to:

- complement or replace an existing aid to navigation;
- provide identity, state of "health" and other information such as real time tidal height, tidal stream and local weather to surrounding ships or back to the shore authority;
- provide the position of floating aids (primarily buoys) by transmitting an accurate position (based on DGPS corrections) to monitor that they are "on station";
- provide information for performance monitoring, with the connecting data link serving to remotely control changes of AtoN parameters or switching in back-up equipment;
- provide longer range detection and identification in all weather conditions, as a future replacement for radar transponder beacons (racons), and
- provide very complete information on all AIS fitted shipping traffic passing within VHF range of the site.

CHAPTER 2

INFORMATION TRANSFER AND COMMUNICATIONS

2.1 DATA TRANSFER WITH AIS

The AIS station normally operates in an autonomous and continuous mode using SOTDMA (Self Organizing Time Division Multiple Access) reports, regardless of whether the fitted vessel is operating in the open seas, coastal waters or on inland waterways. To work properly on the radio link there are also RATDMA (Random), ITDMA (Incremental), and FATDMA (Fixed) protocols. The main purpose of those different protocols is:

- RATDMA is used to access the radio link and randomly allocate a slot. It can also be used if the ship needs to send more frequently.
- ITDMA is also used to allocate slots in the next minute and to prepare for SOTDMA. For example, when the ship has to update at a faster rate i.e. when changing course.
- SOTDMA is the normally used protocol and allocates the slots three to seven frames ahead. It means that all other AISs will have three to seven times chance to receive the allocation of the ships using SOTDMA. This makes the radio link robust.
- FATDMA is reserved for use by AIS shore stations

The required VHF reports are essentially for short range and require a substantial increased data rate and must not suffer from interference for this purpose two VHF frequencies in the maritime mobile band are utilized in parallel. The modulation method used is FM/GMSK (Frequency Modulation/Gaussian Minimum Shift Keying) due to its robustness, its bandwidth efficiency and its widespread application in mobile digital communications.

The AIS station communicates on two parallel VHF channels. Each minute of time is divided into 2 * 2250 slots per channel and these are accurately synchronized using GNSS time information as a first phase timing mechanism and are able to operate using a secondary independent timing mechanism if required, which provides timing accuracy of better than 10 µs. These 2250 slots constitute a frame and each frame is repeated every minute.

Each station determines its own transmission schedule (slot allocation), based upon data link traffic history and knowledge of future actions by other stations. A position report message from one AIS station fits into one of 2250 time slots, established every 60 seconds.

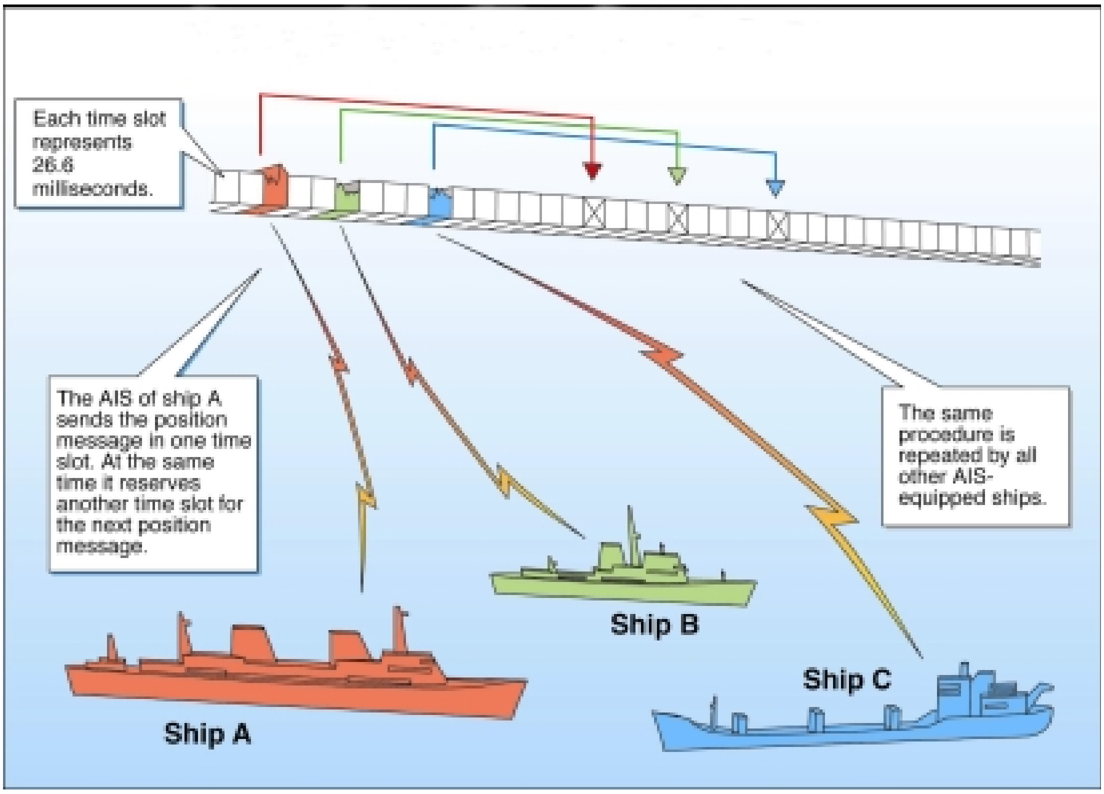


Figure 2-1: Principles of ITDMA

2.1.1 VHF Data Link (VDL) Capacity

AIS can use both 25 kHz and 12.5 kHz simplex channel bandwidths. When operating with either of these bandwidths, the resulting capacity is 2250 slots /minute at a transmission rate of 9600 bits per second.

When both AIS channels (AIS 1, AIS 2) are used the reporting capacity is 2 times 2250 i.e. 4500 slots /minute.

As the system operates in the VHF radio band it is capable of communicating within "line of sight". Should the number of AIS stations within line of sight range of a receiving AIS station exceed the frame capacity in terms of reports per minute the SOTDMA algorithm and the GMSK/FM modulation ensures that the effective radio cell for each AIS station slowly decreases. Transmissions from AIS stations farthest away are suppressed giving priority to those closer to the receiving station.

The overall effect is that, as a channel approaches an overloaded state, the TDMA algorithm produces a progressive reduction of the radio cell size. The effect is to drop AIS reports from vessels farthest from the centre of operations, while maintaining the integrity of the (more important) closer range reports.

However, when using 12.5 kHz channels the communication range is slightly reduced. The size of the radio cell in the 12.5 kHz channel, in an overload situation, shrinks to approximately one half the size compared to that in the 25 kHz channel.

This effect has to be taken into consideration when planning 12.5 kHz channel areas.

2.2 REQUIRED UPDATE RATES

The IMO Performance Standards and the IMO liaison statement to ITU-R provide the type of data to be exchanged. The IALA VTS Committee studied this problem with regard to potential VTS/Ship Reporting System requirements. Considerations were based on current radar techniques, timing of consecutive DGNSS position fixes and finally, the worst case scenario of peak traffic situations in the Singapore and Dover Straits.

Using a theoretical maximum VHF radio range of 40 nm radius an estimate of about 3000 reports per minute was calculated for the Singapore Straits. A similar calculation for Dover Strait gave a requirement for about 2,500 reports per minute. On practical grounds, a figure of 2000 reports per minute was chosen as the minimum requirement together with the following update rates:

Ship's Manoeuvring Condition	**Nominal Reporting Interval**
Ships at anchor or moored and not moving faster than 3 knots	3 minutes
Ships at anchor or moored and moving faster than 3 knots	10 seconds
Ship 0-14 knots	10 seconds
Ship 0-14 knots and changing course	$3^{1/3}$ seconds
Ship 14-23 knots	6 seconds
Ship 14-23 knots and changing course	2 seconds
Ship >23 knots	2 seconds
Ship >23 knots changing course	2 seconds

Table 2-1: Update intervals Class A Shipborne Mobile Equipment (SME)

* *In order to predict the turning rate and track when ships are altering course an increased update rate is needed. A rate that is three times faster than standard has been selected based on the required position accuracy.*

Platform's Manoeuvring Condition	Nominal Reporting Interval
Class B SME not moving faster than 2 knots	3 minutes
Class B SME moving 2-14 knots	30 seconds
Class B SME moving 14-23 knots	15 seconds
Class B SME moving >23 knots	5 seconds
Search and Rescue aircraft (airborne mobile equipment)	10 seconds
Aids to Navigation	3 minutes
AIS Base Station [2]	10 seconds

Table 2-2: Update intervals Class B Shipborne Mobile Equipment (SME)

(1) In certain technical conditions related to synchronisation, a mobile station's reporting rate may increase to once every 2 seconds.

(2) The Base Station rate increases to once every $3^{1/3}$ seconds if the station detects that one or more stations are synchronising to it (the base station).

2.3 DISPLAY REQUIREMENTS

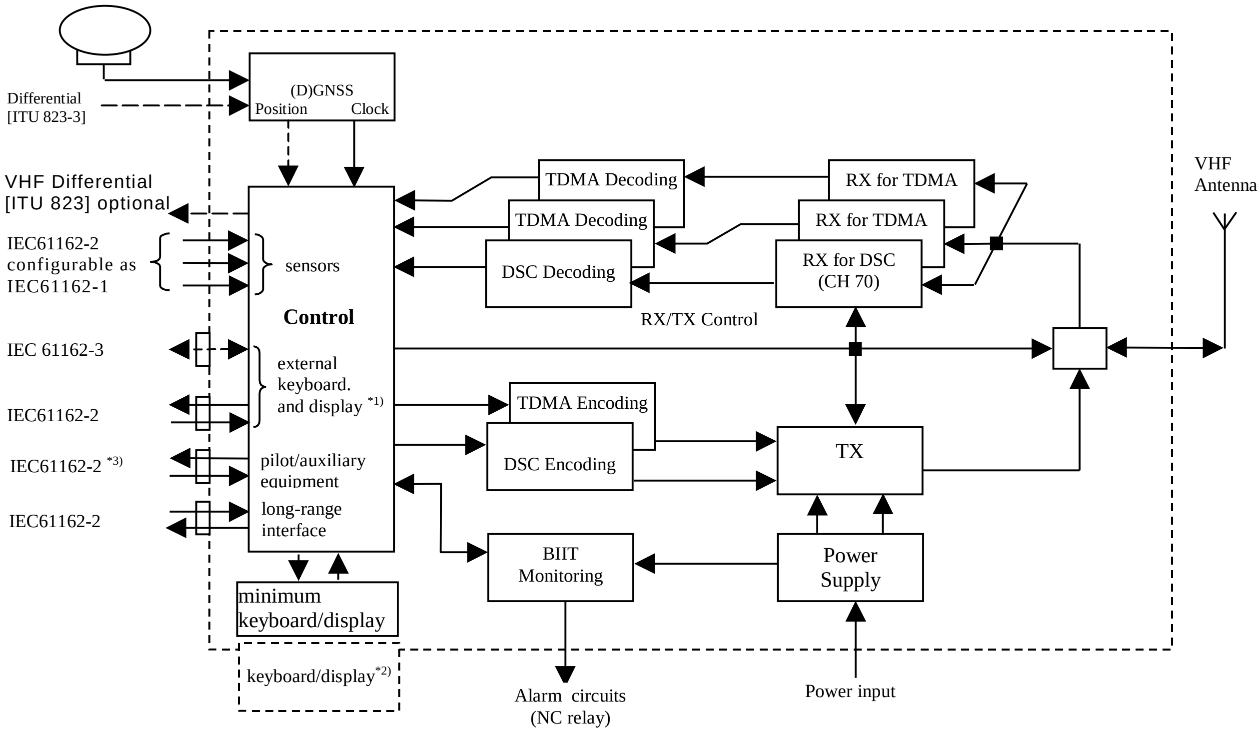
In developing the Test Standard IEC 61993-2, the IEC Technical Committee 80 specified a "minimum display requirement for AIS" in order to validate the proposed test functions. This requires, as a minimum, a display of at least three lines of 16 alphanumeric characters, which is sufficient to obtain the target vessel's identity and position. This positional information is displayed relative to the observing vessel.

To obtain the full benefit of the AIS capability, the system should be integrated to one of the existing graphical displays on the bridge, or a dedicated graphical display. Greater functionality will be provided by a more capable graphical display but selection of the type of display is dependent on the user requirement and options offered by manufacturers.

The IMO Performance Standard leaves the question of display requirements unspecified although the assumption has been that, ideally, the AIS information would be displayed on the ship's radar, electronic chart display and information system (ECDIS) or a dedicated display. This would provide the greatest benefit to the mariner. The danger of overloading the screen would need to be considered and correlation between primary radar targets and AIS targets is likely to be required. The AIS has the facility to send its information to external display medium such as Radar, ECDIS or an Integrated Navigation System (INS).
Shore based systems can also use the external display facility to allow display on VTS consoles, and Radar.

2.4 SHIPBORNE INSTALLATIONS

The shipborne AIS is designed to provide identification, navigational information and vessel's current intentions to other ships. Options may include connection to external GNSS/DGNSS equipment and sources of navigational information from ship's equipment. Interfacing is in accordance IEC 61162 series standards (see Figure 2-2). Chapter 3 gives full details of the transmitted data included in AIS messages.



*1) The external keyboard/display may be e.g. radar, ECDIS or dedicated devices.
*2) The internal keyboard/display may optionally be remote.
*3) Appendix 12- A describes the installation of the "pilot plug".

Figure 2-2: Schematic Diagram of AIS

2.5 COMMUNICATIONS REQUIREMENTS

AIS must be able to operate autonomously in "ship-ship" mode, everywhere and at all times. Thus, the shipborne AIS is required to simultaneously support both "ship-shore" and "ship-ship" modes when in a VTS or Ship reporting area. To meet this requirement and mitigate the effects of radio frequency interference (since one channel may be jammed due to interference) shipborne AIS stations are designed to operate on two frequency channels simultaneously.

The AIS standard provides for automatic channel switching (channel management using DSC and frequency-agile AIS stations) and for duplex as well as simplex channels.

2.5.1 Radio Frequency Allocations

In response to a request from the IMO seeking global frequencies for AIS, the 1997 ITU World Radio Conference (WRC-97) designated two worldwide channels from the VHF maritime mobile band for this purpose. The channels are AIS 1 - 87B (161.975 MHz) and AIS 2 - 88B (162.025 MHz). Two channels were selected to increase capacity and mitigate RF interference. Again at the request of IMO, the ITU-R developed and approved a technical standard for AIS, Recommendation ITU-R M.1371-1.

The WRC-97 also provided for administrations to designate "regional frequency channels for AIS" where channels 87B and 88B are unavailable and, if necessary, to derive new Appendix S18 channels using Recommendation ITU-R M.1084-2 (simplex use of duplex channels and/or 12.5 kHz narrowband channels). WRC-97 further stated that "these regions should be as large as possible" for navigation safety purposes.

This requirement arose because some maritime nations experienced problems in releasing the WRC-97 designated channels for AIS and therefore needed separate regional frequencies for use in their areas. In the United States, for example, the Federal Communications Commission (FCC) was unable to set aside the two international channels (87B and 88B) specifically for AIS purposes as these had previously been allocated to non-maritime or other maritime users. The FCC has identified VHF channel 228B for ship-to-ship AIS operations, the Coast Guard has identified a second channel for ship-ship AIS operations on a nationwide basis. The Coast Guard has the necessary ship-shore frequencies for use in VTS areas.

This is but one example and the use of AIS operating channels, different to those allocated by the WRC, also applies in other areas of the world. However, because of the channel management and automatic switching techniques being employed, this will be largely transparent to the user and will have little impact on international shipping and the operation of AIS.

2.5.2 Channel Management

WRC-97 and ITU-R M.1371-1 both specified that the two frequencies for AIS use on the high seas and any regional frequencies designated by administrations are to be from within the VHF maritime band as defined in Appendix S18 of the International Radio Regulations. As mentioned, the WRC-97 also provided for the use of 12.5 kHz narrowband for AIS where administrations might need it due to lack of channel availability.

In order to facilitate the full use of the frequency band and to enable automatic frequency channel switching for ships and shore stations, the AIS standard utilises Digital Selective Calling (DSC). The standard refers to this as *"channel management.*"

As discussed earlier VHF DSC was originally implemented and adopted as part of the Global Maritime Distress and Safety System and is therefore mandatory equipment on ships on international voyages. Because some administrations use DSC to automatically identify ships (for example, the Channel Navigation Information System in the Dover Straits and the VTS in Valdez, Alaska), the new AIS standard also provides for "DSC Compatibility."

AIS channel switching is accomplished when the shore stations switch ships' AIS stations to VTS/AIS designated working frequencies (or regional frequencies). Switching of any frequencies can be done using several methods which include automatic switching by the shore base stations, or manual switching by the AIS operator on the ship. Switching from shore can be performed by a VTS base station using SOTDMA protocols or by a GMDSS A1 Area station using DSC.

2.6 LONG RANGE MODE

The IMO performance standard for AIS requires that the equipment should function *"as a means for littoral States to obtain information about a ship or its cargo"* when a vessel is operating in that State's area of maritime responsibility. An AIS long-range communications and reporting mode is required to satisfy this function and to assist administrations in meeting their responsibilities for wide area or offshore monitoring of shipping traffic.

One key objective of maritime administrations is to ensure that its waterways are safe, protective of the environment and at the same provide an economically effective environment for ship traffic. This task is met by enforcing appropriate national and international regulations that govern how ships enter and operate in the territorial waters of a country. AIS, in combination with VTS (or Coast Guard station), provide an excellent tool to achieve these objectives over the short-range distances provided by the underlying VHF transmission system. However, AIS, in combination with a long-range communication medium, also provides an excellent tool to meet the long-range ship tracking and monitoring requirements of a VTS.

The responsibility of administrations for wide area or offshore monitoring of ship traffic includes safety of navigation, search and rescue (SAR), resource exploration and exploitation and environmental protection in offshore areas including the continental shelf and economic exclusion zones (EEZ). In certain areas tank vessels must move in strict conformance with established Tanker Exclusion Zone (TEZ) regulations. Examples are:

- There is currently a TEZ on the West Coast of Canada.
- There is a mandatory route for larger tankers from North Hinder to the German Bight and vice versa as described in IMO document MSC 67/22/Add 1 - Annex 11.
- There are two reporting systems in Australia: AUSREP and REEFREP, both adopted by IMO, which will use the long-range application.

Adherence to these regulations must be monitored. Currently ship reporting schemes are approved by IMO and follow specific reporting formats as laid down in IMO resolution A.851 (20) 'General principles for ship reporting systems and ship reporting requirements, including guidelines for reporting incidents involving dangerous goods, harmful substances and/or marine pollutants'. The long-range mode of AIS provides an effective alternative or complementary tool to allow ships to comply effectively with these rules.

2.7 REPORTING FORMAT

Table 2-3 describes the long-range functions, which are available as standard in the AIS. If the Function Identifier ID has the indication 'Not available', the information is not available in the standard AIS system at this moment. It should be possible to gather this type of information from an external source.

2.7.1 Requirements

When contemplating the use of AIS for their long-range ship monitoring function administrations are encouraged to take into account the following planning parameters.

- The long-range application of AIS must operate in parallel with the VDL. Long-range operation will not be continuous. The long-range system will not be designed for constructing and maintaining a real time traffic image on a large area. Position updates will be in the order of 2-4 times per hour (maximum). Some applications may require an update of just two times a day. Consequently, the long-range application presents a low traffic workload to the communication system or the AIS stations and will not interfere with the normal VDL operation.
- The long-range mode will be initiated by a general all-ships broadcast message directed to a specific, geographically defined area. Once a specific ship has been identified and captured in the appropriate VTS database, it will subsequently polled by addressed interrogations as defined in the applicable AIS specifications. When responding, ships will use the standard message formats such as position reports and voyage-related data.

ID	Function	Remarks
A	Ship name / Call sign / MMSI / IMO number	MMSI number shall be used as a flag identifier
B	Date and time in UTC	Time of composition of message shall be given in UTC only. Day of month, hours and minutes
C	Position	WGS84; Latitude / Longitude degrees and minutes
D		Not available
E	Course	Course over ground (COG) in degrees
F	Speed	Speed over ground (SOG) in knots and 1/10 knots
G, H		Not available
I	Destination / ETA	At masters discretion; ETA time format see B
J, K, L, M, N		Not available
O	Draught	Actual maximum draught in 1/10 of meters
P	Ship / Cargo	As defined in AIS message 5
Q, R, S, T		Not available
U	Length / Beam / Type	Length and beam in meters Type as defined in AIS message 5, tonnage not available
V		Not available
W	Number of persons on board	
X,Y		Not available
Z		Not used

Table 2-3: Long-Range Message Content

CHAPTER 3

AIS MESSAGES

3.1 MESSAGE TYPES AND FORMATS

Ship's speed and manoeuvring status are used as the means of governing update rates and ensuring the appropriate levels of positional accuracy for ship tracking. A similar process is applied to the content of ship information messages to ensure that the more important message data being communicated is not encumbered with static or low priority information. The different information types, identified as "static", "dynamic" or "voyage related" are used in messages and are valid for different time periods, thus requiring different update rates. "Short safety related messages" are sent as required and are independent of timing.

"Static" information is entered into the AIS on installation and need only be changed if the ship changes its name or undergoes a major conversion from one ship type to another. "Dynamic" information is automatically updated from the ship sensors connected to AIS and "voyage related" information is manually entered and updated during the voyage. The ship information to be provided within the various AIS messages includes:

• ***Static information:***	*Every 6 minutes and on request by competent authority*
MMSI	Maritime Mobile Service Identity. Set on installation - note that this might need amending if the ship changes ownership
Call sign and name	Set on installation – note that this might need amending if the ship changes ownership
IMO Number	Set on installation
Length and beam	Set on installation or if changed
Type of ship	Select from pre-installed list (see Table 3-6)
Location of position fixing antenna	Set on installation or may be changed for bi-directional vessels or those fitted with multiple position fix antennae
Height over keel	Set on installation; (aft of bow and port/starboard of centreline). Transmitted at Master's discretion and on request by a competent authority

• ***Dynamic information:***	*Dependent on speed and course alteration (see Tables 2-1 and 2-2)*
Ship's position with accuracy indication and integrity status	Automatically updated from the position sensor connected to the AIS. The accuracy indication is for better or worse than 10 m.
Position Time stamp in UTC	Automatically updated from ship's main position sensor connected to AIS. (e.g. GPS)
Course over ground (COG)	Automatically updated from ship's main position sensor connected to the AIS, provided that sensor calculates COG.(This information might not be available)

Speed over ground (SOG)	Automatically updated from the position sensor connected to the AIS, provided that the sensor calculates SOG (This information might not be available).
Heading	Automatically updated from the ship's heading sensor connected to the AIS.

Navigational status	Navigational status information has to be manually entered by the OOW and changed, as necessary, for example: - underway by engines - at anchor - not under command (NUC) - restricted in ability to manoeuvre (RIATM) - moored - constrained by draught - aground - engaged in fishing - underway by sail In practice, since all these relate to the COLREGS, any change that is needed could be undertaken at the same time that the lights or shapes were changed.
Rate of turn (ROT)	Automatically updated from the ship's ROT sensor or derived from the gyrocompass. (This information might not be available).
<u>Note:</u> Provision must be made for inputs from external sensors giving additional information where available (e.g. angle of heel, pitch and roll etc)	

• **Voyage related information:**	*Every 6 minutes, when data is amended or on request*
Ship's draught	To be manually entered at the start of the voyage using the maximum draft for the voyage and amended as required; e.g. after de-ballasting prior to port entry.
Hazardous cargo (type)	As required by competent authority. To be manually entered at the start of the voyage confirming whether or not hazardous cargo is being carried, namely: - DG Dangerous Goods - HS Harmful Substances - MP Marine Pollutants Indications of quantities are not required.
Destination and ETA	At Master’s discretion. To be manually entered at the start of the voyage and kept up to date as necessary.
Route plan (waypoints)	At Master’s discretion, and upon interrogation by a competent authority only. Textual description, to be manually entered at the start of the voyage and updated if required.
Number of persons onboard	Including crew. At Master’s discretion and on request by a competent authority only.

Short safety-related messages:	*As required*
Free format short text messages would be manually entered and addressed either to a specific addressee, a selected group of addressees or broadcast to all ships and shore stations.	

Table 3-1

3.2 STANDARD MESSAGE FORMATS

The information required to be transferred between ships and between ship and shore is packaged into a series of standard formatted messages and transmitted at pre-determined intervals, when their content data is amended or on request by a competent authority. There are some [22] different types of messages included in the AIS Technical Standard, ITU-R M.1371-1 which not only contain the transmitted information but serve various other system or data link functions including message acknowledgement, interrogation, assignments or management commands.

Further description of these message types and functions is included in Part 2 - Technical, with full details of message structures in ITU-R M.1371-1. The following listing (Table 3-2) shows the primary message grouping of interest to the operators of AIS and indicates the operational modes associated with each message (AU = autonomous, AS = assigned, IN = polling/interrogation). Paragraph 1.2.2 provides further explanation of operating modes and some further description of the more relevant messages is provided in the following paragraphs.

Message Identifiers	Description	Operation Mode
1,2,3	Position Report - scheduled, assigned or response to polling	AU,AS,
4	Base Station Report – position, UTC/date and current slot number	AS
5	Static and Voyage Related Data - Class A SME	AU,AS
6,7,8	Binary Messages – addressed, acknowledge or broadcast	AU,AS,IN
9	Standard SAR Aircraft Position Report	AU,AS
10,11	UTC/Date - enquiry and response	AS,IN
12,13,14	Safety Related Message – addressed, acknowledge or broadcast	AS,IN
15	Interrogation – request for specific message type	AU,AS,IN
16	Assignment Mode Command - by competent authority	AS
17	DGNSS Broadcast Binary Message	AS
18,19	Class B SME Position Report – standard and extended reports	AU,AS
20	Data Link Management – reserve slots for Base Stations	AS
21	Aids to Navigation Report – position and status report	AU,AS,IN
22	Channel Management	AS

Table 3-2 – Primary Message Types (in groupings) and Operating Modes

3.2.1 Position Report (Messages 1,2 or 3)

The Position Report message, which contains primarily dynamic data and would normally constitute the priority message, is shown below at Table 3-3.

Parameter	Description
MSG ID	Identifier for this message (1, 2 or 3)
Repeat Indicator	0-3. Used by the repeater to indicate how many times the message has been repeated; default = 0; 3 = do not repeat again.
User ID	MMSI number (Unit serial number as substitute)
Navigational Status	0 = underway using engine; 1 = at anchor; 2 = not under command; 3 = restricted manoeuvrability; 4 = constrained by draught; 5 = moored; 6 = aground; 7 = engaged in fishing; 8 = underway sailing; 9 = (reserved for HSC category); 10 = (reserved for WIG category); 15=Default
Rate of Turn	±708 degrees/min. (-128 indicates not available which is the default) (see Chapter [ ] §[ ])
SOG	Speed Over Ground in 1/10 knot steps (0 -102.2 knots) 1023 = not available; 1022 = 102.2 knots or higher
Position Accuracy	1 = High (<10m. Differential mode of e.g. DGNSS receiver); 0 = Low (> 10m; Autonomous mode of e.g. GNSS receiver or other electronic position fixing device); default = 0
Longitude	Longitude in 1/10 000 minute (±180 degrees, East = positive, West = negative); 181 degrees = not available = default
Latitude	Latitude in 1/10 000 minute (±90 degrees, North = positive, South = negative); 91 degrees = not available = default
COG	Course Over Ground in 1/10 degree (0 – 3599); 3600 = not available = default
True Heading	Degrees (0-359) (511 indicates not available = default
Time stamp	UTC second when the report was generated (0-59,) or 60 - if time stamp is not available which should also be the default) or 61 - if the electronic position fixing system is in manual input mode; or 62 -if the positioning systems is in estimated [dead reckoning] mode, or 63 - if the positioning system is inoperative.
Reserved for regional applications	Reserved for definition by a competent regional authority. Shall be set to 0, if not used for regional application.
RAIM Flag	(Receiver Autonomous Integrity Monitoring) flag of electronic position fixing device; 0= RAIM not in use = default; 1 = RAIM in use.
Communications State	SOTDMA/ITDMA status

Table 3-3: Position Report (message 1, 2 & 3, Content and Format)

3.2.2 Base Station Report

This message is used for reporting UTC time and date and, at the same time, position. A Base Station uses Message 4 in its periodical transmissions, while a Mobile Station outputs Message 11 only in response to interrogation by Message 10.

Parameter	Description
Message ID	Identifier for this message (4, 11) 4 = UTC and position report from base station; 11 = UTC and position response from mobile station.
Repeat Indicator	Used by the repeater to indicate how many times a message has been repeated. 0 - 3; default = 0; 3 = do not repeat again.
User ID	MMSI number
UTC year	1 - 9999 ; 0 = UTC year not available = default.
UTC month	1 - 12 ; 0 = UTC month not available = default
UTC day	1 - 31 ; 0 = UTC day not available = default.
UTC hour	0 - 23 ; 24 = UTC hour not available = default
UTC minute	0 - 59 ; 60 = UTC minute not available = default;
UTC second	0 - 59; 60 = UTC second not available = default.
Position accuracy	1= high (<10 m; Differential Mode of e.g. DGNSS receiver) 0= low (>10 m; Autonomous Mode of e.g. GNSS receiver or of other electronic position fixing device); default = 0
Longitude	Longitude in 1/10 000 minute (±180degrees, East = positive, West = negative); 181 degrees = not available = default
Latitude	Latitude in 1/10 000 minute (±90degrees, North = positive, South = negative); 91 degrees = not available = default
Type of Electronic Position Fixing Device	use of differential corrections is defined by field 'position accuracy' above; 0 = Undefined (default), 1 = GPS, 2 = GLONASS, 3 = Combined GPS/GLONASS, 4 = Loran-C, 5 = Chayka, 6 = Integrated Navigation System, 7 = surveyed, 8 - 15 = not used;
RAIM-Flag	Receiver Autonomous Integrity Monitoring (RAIM) flag of electronic position fixing device; 0 = RAIM not in use = default; 1 = RAIM in use)
Communication State	SOTDMA/ITDMA Communication State

Table 3-4: Base Station Report (message 1, 2, & 3, Content and Format)

3.2.3 Static and Voyage Related Data

This message is only used by Class A Shipborne Mobile Equipment when reporting static or voyage related data. As well as being transmitted routinely at 6-minute intervals, or in response to a polling request, this message will also be sent immediately after any parameter value has been changed.

Parameter	Description
Message ID	Identifier for this message (5)
Repeat Indicator	Used by the repeater to indicate how many times a message has been repeated. 0 - 3; default = 0; 3 = do not repeat again.
User ID	MMSI number
AIS Version Indicator	0 = Station compliant with AIS Edition 0 (Rec. ITU-R M.1371-1); 1 - 3 = Station compliant with future AIS Editions 1, 2, and 3.
IMO number	1 – 999999999 ; 0 = not available = default
Call sign	7 x 6 bit ASCII characters, "@@@@@@@" = not available = default.
Name (Ship)	Maximum 20 characters 6 bit ASCII, "@@@@@@@@@@@@@@@@@@@@"=not available = default.
Type of ship and cargo type	0 = not available or no ship = default; 1 - 99 = as defined in Table 5A; 100 - 199 = reserved, for regional use; 200 - 255 = reserved for future use.
Dimension/Reference for Position	Reference point for reported position; Also indicates the dimension of ship in metres (see Figure 3-1)
Type of Electronic Position Fixing Device	0 = Undefined (default); 1 = GPS, 2 = GLONASS, 3 = Combined GPS/GLONASS, 4 = Loran-C, 5 = Chayka, 6 = Integrated Navigation System, 7 = surveyed, 8 - 15 = not used
ETA	Estimated Time of Arrival; MMDDHHMM UTC
	month; 1 - 12; 0 = not available = default;
	day; 1 - 31; 0 = not available = default;
	hour; 0 - 23; 24 = not available = default;
	minute; 0 - 59; 60 = not available = default
Maximum Present Static Draught	in 1/10 m; 255 = draught *25.5 m* or greater, 0 = not available = default; in accordance with IMO Resolution A.851
Destination	Maximum 20 characters using 6-bit ASCII; "@@@@@@@@@@@@@@@@@@@@" = not available.
DTE	Data terminal ready (0 = available 1 = not available = default)

Table 3-5: Ship Static and Voyage Related Data Report (Content and Format)

Identifiers Used by Ships to Report Their Type*

First digit	Second digit
0 – Not used	0–All ships of this type
1 – Reserved for future use	1– Carrying DG, HS, or MP IMO hazard or pollutant category A
2 – WIG	2– Carrying DG, HS, or MP IMO hazard or pollutant category B
3 – See Table 6b below	3– Carrying DG, HS, or MP IMO hazard or pollutant category C
4 – HSC	4– Carrying DG, HS, or MP IMO hazard or pollutant category D
5 – See Table 6b below	5– reserved for future use
6– Passenger ships	6- reserved for future use
7– Cargo ships	7–reserved for future use
8– Tankers	8 – reserved for future use
9– Other types of ship	9 – No additional Information

* This formatter requires two digits: The first is any digit from the column on the left, the second is any digit from the column on the right

DG = Dangerous Goods; HS = Harmful Substances; MP = Marine Pollutants

Table 3-6a: Ship Type Identifiers

Identifier No.		**Identifiers Used by Special Craft to Report Their Type**
First Digit	Second Digit	
5	0	Pilot vessel
5	1	Search and rescue vessels
5	2	Tugs
5	3	Port tenders
5	4	Vessels with anti-pollution facilities or equipment
5	5	Law enforcement vessels
5	6	Spare – for assignments to local vessels
5	7	Spare – for assignments to local vessels
5	8	Medical transports (as defined in the 1949 Geneva Conventions and Additional Protocols)
5	9	Ships according to Resolution No 18 (Mob-83)

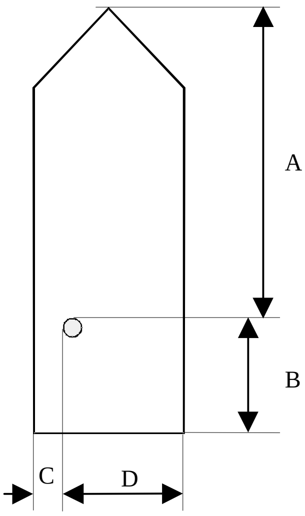
Table 3-6b: Special Craft

Identifier No.		**Identifiers Used by Other Ships to Report Their Type**
First Digit	Second Digit	
3	0	Fishing
3	1	Towing
3	2	Towing and length of the tow exceeds 200 m or breadth exceeds 25 m
3	3	Engaged in dredging or underwater operations
3	4	Engaged in diving operations
3	5	Engaged in military operations
3	6	Sailing
3	7	Pleasure Craft
3	8	Reserved for future use
3	9	Reserved for future use

Table 3-6c: Other Ships

3.2.4 Extended Static and Voyage Related Data

Additional information, particularly height over keel (static) and number of persons on board [pitch and roll](voyage related) can be provided through the use of international function identifier applications.



	Distance in meters
A	0 - 511
B	0 - 511
C	0 - 63 ; 63 = 63 m or greater
D	0 - 63 ; 63 = 63 m or greater

Reference point of reported position not available, but dimensions of ship are available: A = C = 0 and B ≠ 0 and D ≠ 0.
Neither reference point of reported position nor dimensions of ship available: A = B = C = D = 0 (=default)
For use in the message table, A = Most Significant Field

Figure 3-1: Vessel Dimensions and Reference for Position

3.2.5 Ship Dimensions and Reference for Position

3.2.6 Binary Messages

Binary messages can be addressed to a particular mobile or shore station or broadcast to all stations in the area. They are also used to acknowledge Short Safety Related Messages, where necessary. Addressed Binary Messages are variable in length depending on the size of the binary data to be sent and can be between 1 and 5 message slots. In effect, this means that up to 160 6-bit ASCII characters can be included in the text of each message

3.2.7 Short Safety Related Messages

Short Safety Related Messages, are a category of Binary Messages and can be either "Addressed", to a specified destination (MMSI) or "Broadcast" to all AIS fitted ships in the area. Messages can include up to 160 x 6-bit ASCII character in the text of the message but should be kept as short as possible. They can be fixed or free format text messages and their content should be relevant to the safety of navigation, e.g. an iceberg sighted or a buoy not on station.

Operator acknowledgement may be requested by a text message in which case a Binary Acknowledge Message will be used.

Short Safety Related Messages are an additional means to broadcast maritime safety information. Their usage does not remove any of the requirements of the Global Maritime Distress Safety System (GMDSS).

3.3 NON STANDARD MESSAGES

3.3.1 SAR Aircraft Position Report

This message (9) is used for a standard position report from aircraft involved in SAR operations instead of Messages 1, 2, or 3. Stations other than aircraft involved in SAR operations should not use this message. The default reporting interval for this message is 10 seconds.

Parameter	Description
Message ID	Identifier for message (9); always 9
Repeat Indicator	Used by the repeater to indicate how many times a message has been repeated. 0 - 3; default = 0; 3 = do not repeat again.
User ID	MMSI number
Altitude (GNSS)	Altitude (derived from GNSS) expressed in metres (0 – 4094 metres) 4095 = not available, 4094 = 4094 metres or higher
SOG	Speed over ground in knot steps (0-1022 knots) 1023 = not available, 1022 = 1022 knots or higher
Position accuracy	1 = high (< 10 m; Differential Mode of e.g. DGNSS receiver) 0 = low (> 10 m; Autonomous Mode of e. g. GNSS receiver or of other Electronic Position Fixing Device) ; default = 0
Longitude	Longitude in 1/10 000 min (± 180 degrees, East = positive, West = negative). 181 degrees (6791AC0 hex)= not available = default
Latitude	Latitude in 1/10 000 min (± 90 degrees, North = positive, South = negative, 91 degrees (3412140 hex) = not available = default)
COG	Course over ground in 1/10 (0-3599). 3600 (E10 hex) = not available = default; 3601 – 4095 should not be used
Time stamp	UTC second when the report was generated (0-59) or 60 if time stamp is not available, = default, or 62 if Electronic Position Fixing System operates in estimated (dead reckoning) mode, or 61 if positioning system is in manual input mode or 63 if the positioning system is inoperative.
Reserved for regional applications	Reserved for definition by a competent regional authority. Should be set to zero, if not used for any regional application. Regional applications should not use zero.
DTE	Data terminal ready (0 = available 1 = not available = default)
RAIM-Flag	RAIM (Receiver Autonomous Integrity Monitoring) flag of Electronic Position Fixing Device; 0 = RAIM not in use = default; 1 = RAIM in use)
Communication State	SOTDMA/ITDMA status.

Table 3-7: SAR Aircraft Position Report

3.3.2 DGNSS Broadcast Message

Broadcasting differential GPS corrections from ashore or correlating the ship’s position on board by DGPS connection via the SOTDMA data link to all vessel AIS stations enables those recipients to navigate with differential accuracy. The position broadcast from the vessels will have differential accuracy, the built in functionality using the best available correction available at that instant.

This type of system could serve as the primary system in a port or VTS area or as a back-up for the IALA DGPS MF Beacon System. For full compatibility with the IALA DGPS MF Beacon System it should be provided with capabilities for integrity monitoring and to transfer that information to the user.

3.3.2.1 GNSS Broadcast Binary Message

This message (17) is transmitted by a base station, which is connected to a DGNSS reference source, and configured to provide DGNSS data to receiving stations. The contents of the data should be in accordance with ITU-R M.823-2, excluding preamble and parity formatting.

Parameter	Description
Message ID	Identifier for message (17); always 17
Repeat Indicator	Used by the repeater to indicate how many times a message has been repeated. 0 - 3; default = 0; 3 = do not repeat again.
Source ID	MMSI of the base station.
Spare	Spare. Should be set to zero.
Longitude	Surveyed Longitude of DGNSS reference station in 1/10 min (±180 degrees, East = positive, West = negative). If interrogated and differential correction service not available, the longitude should be set to 181°.
Latitude	Surveyed Latitude of DGNSS reference station in 1/10 min (±90 degrees; North = positive, South = negative). If interrogated and differential correction service not available, the latitude should be set to 91°.
Data	Differential Correction data (drawn from Recommendation ITU-R M.823-2). If interrogated and differential correction service not available, the data field should remain empty (zero bits). This should be interpreted by the recipient as DGNSS Data Words set to zero.

Table 3-8: GNSS Broadcast Binary Message

3.3.3 Aid to Navigation Message

The main functions of aids to navigation (AtoNs) such as racons, buoys, beacons and lights are the location and identification of hazards and marks used for navigation. However, suitably equipped, they could provide additional information of a meteorological and/or oceanographic nature of benefit to the mariner. In addition, information on the operational status of the aid, which is of value both to the mariner and the service provider, could be provided.

Through AIS it is now possible to have an AtoN site transmit its identity, its state of “health” and other information such as real time tidal height, tidal stream and local weather to surrounding ships or back to the shore authority. Buoys, which can transmit an accurate position (perhaps based on the DGPS corrections arriving on the SOTDMA data link, described earlier), can be closely monitored to ensure that they are "on station".

The information received ashore via the data link to the AIS station fitted AtoN can not only be used for performance monitoring but also for remotely controlling a change of AtoN parameters or switching on back-up equipment at the AtoN site.

3.3.3.1 Aids-to-Navigation Report Message

This message (21) is used by a station mounted on an Aid-to-Navigation. The message should be transmitted autonomously at a Reporting Rate of once every three (3) minutes or it may be assigned by an Assigned Mode Command (Message 16) via the VHF data link, or by an external command. It will also be transmitted immediately after any parameter value changes. (Refer also to the description of International Function Identifiers at paragraph 3.4).

Parameter	Description
Message ID	Identifier for this message (21)
Repeat Indicator	Used by the repeater to indicate how many times a message has been repeated; 0 - 3; default = 0; 3 = do not repeat any more.
ID	MMSI number
Type of Aids-to-Navigation	0 = not available = default; 1 - 15 = Fixed Aid-to-Navigation; 16 - 31 = Floating Aid-to-Navigation; refer to appropriate definition set up by IALA
Name of Aids-to-Navigation	Maximum 20 characters 6 bit ASCII, "@@@@@@@@@@@@@@@@@@@@" = not available = default.
Position accuracy	1 = high (< 10 m; Differential Mode of e.g. DGNSS receiver) 0 = low (> 10 m; Autonomous Mode of e. g. GNSS receiver or of other Electronic Position Fixing Device) ; Default = 0
Longitude	Longitude in 1/10 000 min of position of Aids-to-Navigation (±180 degrees, East = positive, West = negative. 181 degrees = not available = default)
Latitude	Latitude in 1/10 000 min of Aids-to-Navigation (±90 degrees, North = positive, South = negative, 91 degrees = not available = default)
Dimension/ Reference for Position	Reference point for reported position; also indicates the dimension of Aids-to-Navigation in metres, if relevant.
Type of Electronic Position Fixing Device	0 = Undefined (default); 1 = GPS, 2 = GLONASS, 3 = Combined GPS/GLONASS, 4 = Loran-C, 5 = Chayka, 6 = Integrated Navigation System, 7 = surveyed 8 - 15 = not used;
Time Stamp	UTC second when the report was generated (0 –59),or 60 if time stamp is not available, which should also be the default value, or 61 if positioning system is in manual input mode, or 62 if Electronic Position Fixing System operates in estimated (dead reckoning) mode, or 63 if the positioning system is inoperative.
Off-Position Indicator	For floating Aids-to-Navigation, only; 0 = on position; 1 = off position; Note: This flag should only be considered valid by receiving

	station, if the Aid-to-Navigation is a floating aid, and if Time Stamp is equal to or less than 59.
Reserved for regional or local application	Reserved for definition by a competent regional or local authority. Should be set to zero, if not used for any regional or local application. Regional applications should not use zero.
RAIM-Flag	RAIM (Receiver Autonomous Integrity Monitoring) flag of Electronic Position Fixing Device; 0 = RAIM not in use = default; 1 = RAIM in use)

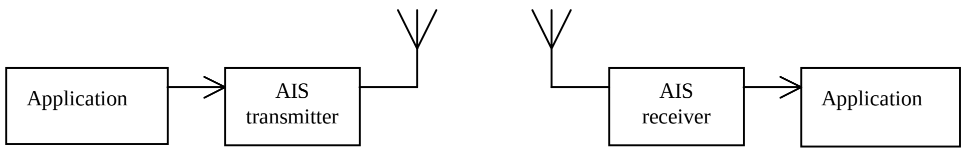
Table 3-9: Aid-to-Navigation Report Message

3.4 INTERNATIONAL APPLICATION IDENTIFIERS (IAIS)

3.4.1 Binary Messages and Functional Identifiers

AIS allows the transfer of Binary Messages via the VDL as a means of communication for external applications as specified in ITU-R M.1371-1.

Binary messages can be broadcast (Message 8) in such a way that every receiver within the VHF range will receive them, and they can be addressed (Message 6) to one particular receiving station due to the MMSI of the recipient. The last situation will result in a Binary Acknowledgement (Message 7) to confirm that the addressed binary message was received.
All binary messages are composed by an external application on the transmission side and can only be used by the same external application connected to the AIS on the receiver side.
The general set-up of the use of binary messages is as follows:

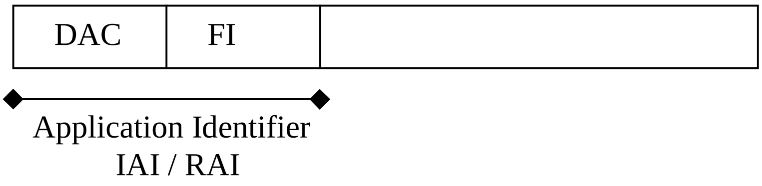


To distinguish the different types of applications the following 'Application Identifier' header will be used as part of the binary data stream, consisting of:

- Designated Area Code (DAC)
- Function Identifier (FI)

} Application Identifier

The 'Binary Data' field in both messages 6 and 8 looks as follows:



Applications for binary messages can be defined as international applications, which can be used by groups of users world-wide (International Branch). The DAC identifies the international branch of applications if its value is 001 and in combination with the FI it is called the International Application Identifier (IAI). Examples of international applications are: the transfer of VTS targets or number of persons onboard.
There is also a possibility to define local or regional applications, which can be used by systems in a limited area or for a specially defined group of users. In this case the DAC identifies the regional branch of applications if its value is in the range between 001and 999. In combination with the FI it is called the Regional Application Identifier (RAI). DAC identifies a certain region or country as given by the Maritime Identification Digits (MID), as defined by ITU-R, which are the leading three digits of the MMSI. An example of a regional application can be: sending specifically formatted messages to service vessels e.g. tug boats, in one particular port or country. The DAC value of 000 is reserved for test purposes only. Values between 1000 and 1023 are reserved for future expansions of general capabilities.
The FI identifies the application itself. Each branch, international and each region, has 64 different identifiers available for specific applications. Each branch can group its 64 identifiers into specific categories of applications.
For the IAI the following groups have been defined:

- General Usage (Gen)
- Vessel Traffic Services (VTS)
- Aids-to Navigation (A-to-N)
- Search and Rescue (SAR)

The allocation and maintenance of function identifiers as part of the IAI, will be done by IALA in accordance with ITU-R M.1371-1 recommendation 3, which will also publish them and submit them to IMO and ITU.

For the Regional Application Identifier (RAI) at least two groups must be defined:

- Regional or national public applications
- Regional or national private organisations applications

A local competent authority located in this DAC, and following the guidelines as described in the ITU-R Recommendation M.1371-1, will do the allocation and maintenance of function identifiers as part of the RAI.

Binary messages can occupy 1 to 5 slots, depending on the amount of application specific data and are defined as follows (two numbers are given: first in data bytes, second if the binary message is used for sending 6-bit ASCII characters):

Number of slots	Addressed Binary Message (Message 6)	Binary Broadcast Message (Message 8)
1	8 / 8	12 / 14
2	36 / 46	40 / 51
3	64 / 83	68 / 88
4	92 / 120	96 / 126
5	117 / 158	121 / 163

The difference between the available capacity is due to the MMSI addressing of the recipient in case of addressed messages.
It is recommended that any application minimises the use of slots by limiting the number of binary data bytes. The throughput time of binary messages is strongly dependent on the required number of subsequent slots to be used.

The use of binary messages is dependent of the availability of applications external to the AIS stations. The binary messages are transparent to the AIS itself. To determine the availability of applications of a station, an addressed binary message with International Function Message 3: ‘Capability Interrogation’, can be send by a ship or base station. This must be done for both the international branch and the regional branch separately. The reply is a binary message to the requesting station with International Message 4: ‘Capability Reply’, containing a list of all applications of the requested area (international or regional). When no external device is connected to the AIS station, no response will be given. After this procedure the available applications can be used. The external unit will neglect all other applications.

Function Identifiers (FI) allow for the operation of several applications on the same VHF Data Link (VDL) of the AIS. There are 64 FIs available, all of which must be allocated to one of the following groups of application fields:

- General Usage (Gen)
- Vessel Traffic Services (VTS)
- Aids to Navigation (AtoN)
- Search and Rescue (SAR)

While most FIs are currently designated as "reserved for future use", some have been allocated to certain internationally recognised applications, being termed International Function Identifiers (IFIs). The applications are activated through the use of International Function Messages (IFMs) within Binary Messages using 6-bit ASCII text.

3.4.2 VTS Targets

A proven application of AIS, variously termed "Radar Target Broadcasting" or "VTS Footprinting", is the process of converting radar target information from a VTS centre and retransmitting it to AIS fitted vessels in the area as pseudo AIS targets. This allows all AIS fitted vessels in the vicinity to view all VTS held radar targets and AIS targets as well as those tracks held on their own radar(s).

IFM 16 is used to transmit VTS targets, to a maximum of 7 in any one message. Because of the impact on VDL channel loading, IFM 16 should only be transmitted to provide the necessary level of safety. Each VTS target message is structured as in Table 3-10:

Parameter	Description
Type of Target Identifier	Identifier Type: 0 = The target identifier should be the MMSI number. 1 = The target identifier should be the IMO number. 2 = The target identifier should be the call sign. 3 = Other (default).
Target ID	Target Identifier. The Target ID should depend on Type of Target Identifier above. When call sign is used, it should be inserted using 6-bit ASCII. If Target Identifier is unknown, this field should be set to zero. When MMSI or IMO number is used, the least significant bit should equal bit zero of the Target ID.
Latitude	Latitude in 1/1000 of a minute.
Longitude	Longitude in 1/1000 of a minute.
COG	Course over ground in degrees (0-359); 360 = not available = default.
Time Stamp	UTC second when the report was generated (0-59, or 60 if time stamp is not available, which should also be the default value)
SOG	Speed over ground in knots; 0-254; 255 = not available = default.

Table 3-10: VTS targets - Message Structure

Note: A VTS target should only be used when the position of the target is known. However, the target identity and/or course and/or time stamp and/or speed over ground may be unknown.

3.4.3 International Function Message 17 (IFM 17) - Ship Waypoints/Route Plan

IFM 17 is used by a ship to report its waypoints and/or its route plan. If the reporting ship uses this IFM 17 within an Addressed Binary Message, then the waypoints and / or the route plan will only be available to the addressed station, that is a Base Station (VTS centre) or another ship. If the reporting ship uses IFM 17 within a Broadcast Binary Message, then the information will be available to all other AIS stations in its vicinity.

When transmitting a Route Plan the transmitting station can include up to 14 Next Waypoints (NWP), if available, and/or a route specified by a textual description. The NWPs should be transmitted in the sequence of the intended passage.

Parameter	Description
NWP	Number of Next Waypoints (NWP) available (1 -14); 0 = no Next Waypoint available = default; 15 = not used
WP **i**.Lon	Longitude of Next Waypoint **i** in 1/10 000 min (±180 degrees, East =positive, West = negative). Field required if and as often as 1 ≤ **i** ≤ NWP, **i** = 1, 2, 3,…,14; Field not required if NWP = 0.
WP **i**.Lat	Latitude of Next Waypoint **i** in 1/10 000 min (± 90 degrees, North = positive, South = negative). Field required if and as often as 1 ≤ **i** ≤ NWP, **i** = 1, 2, 3, …..,14; Field not required if NWP = 0.
Route specified by Textual Description	Description of the route information in textual form, e. g. "West Channel"; maximum 20 characters using 6-bit ASCII; "@@@@@@@@@@@@@@@@@@@@" = not available (field must not be omitted).

Table 3-11: Ship Waypoints/Route Plan - Message Structure

The number of slots used for this message depends on the number of Next Waypoints transmitted as follows:

Number of Next Waypoints transmitted	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Number of slots used for this message	2	2	2	3	3	3	3	4	4	4	4	5	5	5	5

3.4.4 IFM 18 -Advice of VTS Waypoints/Route Plan

IFM 18 is used by a VTS centre to advise ships of the waypoints and/or route plans used in that particular VTS area. If the VTS uses this IFM 18 message within an Addressed Binary Message, then the information will only be available to the addressed recipient, that is, one ship. If the VTS uses IFM 18 within a Broadcast Binary Message, then the information will be available to all other ships in VHF reception range of the transmitting VTS centre.

When transmitting this information the VTS centre can include up to 12 Advised Waypoints (AWP), if available, and/or a route specified by a textual description. If waypoints are transmitted, then a recommended turning radius can be included for each waypoint.

Parameter	**Description**
AWP	Number of Advised Waypoints (1 - 12); 0 = no waypoint = default; 13 - 15 = not used
WP **i**.Lon	Longitude of Advised Waypoint **i** in 1/10 000 min (±180 degrees, East = positive, West = negative). Field required if 1 ≤ **i** ≤ AWP, **i** = 1, 2, 3, ….., 12; Field not required if AWP = 0.
WP **i**.Lat	Latitude of Advised Waypoint **i** in 1/10 000 min (± 90 degrees, North = positive, South = negative). Field required if 1 ≤ **i** ≤ AWP, **i** = 1, 2, 3, …, 12; Field not required if AWP = 0.
Advised Turning Radius **i**	Advised Turning Radius at Advised Waypoint **i** in metres; 0 = not available = default; 1 - 4 095 metres. Field required if and as often as 1 ≤ **i** ≤ AWP, **i** = 1, 2, 3, ….., 12; Field not required if AWP = 0.
Advised Route specified by Textual Description	Description of the advised route in textual form, e. g. "West Channel"; maximum 20 characters using 6-bit ASCII; "@@@@@@@@@@@@@@@@@@@@" = not available (field must not be omitted).

Table 3-12: Advice of VTS Waypoints/Route Plan - Message Structure

The number of slots used for this message depends on the number of Next Waypoints transmitted as follows:

Number of Advised Waypoints transmitted	0	1	2	3	4	5	6	7	8	9	10	11	12
Number of slots used for this message	2	2	2	3	3	3	4	4	4	4	5	5	5

3.4.5 IFM 19 - Extended Ship Static and Voyage Related Data

IFM 19 is used by a ship to report height over the keel (air draught), as a component of voyage related data. This additional information would normally be supplied at the Master's discretion or on request from a competent authority..

Parameter	Description
Height over keel	in 1/10 m; 2047 = height over keel 204.7 m or greater, 0 = not available = default
This IFM uses one slot	

Table 3-13: Height over Keel

3.4.6 IFM 40 - Number of Persons Onboard

IFM 40 is used by a ship to report the number of persons on board, normally provided at the Master's discretion or on request from a competent authority.

Parameter	Description
Number of Persons	Current number of persons onboard, including crew members: 0- 8191; default = 0 = not available; 8191 = 8191 or more
This IFM uses one slot	

Table 3-14: Number of Persons Onboard

CHAPTER 4

USING AIS SUPPLIED INFORMATION

4.1 BASIC OPERATION PROCEDURES

The shipborne AIS unit is connected to a power source, an antenna and to a variety of on board equipment, or to the integrated navigation system. In addition, at the time of installation, important, static, ship-related information has to be entered; this includes identity, length and beam, type of ship and the location of the position-fixing antenna.

The unit will be fitted with, at least, a minimum keyboard and display (MKD) or a dedicated dynamic display which interfaces with the AIS and performs two functions: display the unit's operational status (which should be regularly checked) and target information which is used as described in the following paragraphs.

4.2 OPERATION DURING THE VOYAGE

The AIS, once activated, will continuously and autonomously broadcast the vessel's position and all the static and dynamic information as required by IMO.

However, while the vessel's speed and rate of turn manoeuvres will automatically determine the update rate there remains a need for the Master or an authorised person to manually input, at the start of the voyage and whenever changes occur, the following "voyage related data"

- ship's draught;
- type of hazardous cargo (most significant hazard carried);
- destination and ETA (at master's discretion);
- route plan (way-points – at master's discretion);
- the correct and actual navigational status; and
- short safety related short messages, when appropriate.

CAUTION

NOT ALL SHIPS CARRY AIS

The Officer of Watch (OOW) should always be aware that other ships and, in particular, leisure craft, fishing boats and warships, and some coastal shore stations including Vessel Traffic Service (VTS) centres, might not be fitted with AIS.

The OOW should always be aware that AIS fitted on other ships as a mandatory carriage requirement, might, under certain circumstances, be switched off on the Master's professional judgement.

The potential of AIS as an anti-collision device is recognised and AIS may be recommended as such a device in due time. When used in conjunction with the application of the COLREG's and good watchkeeping practice, it will enhance situational awareness. To this end all target information within VHF range is displayed on the minimum display at all times and can be further integrated into an ECDIS, ECS or radar display.

The minimum mandated display provides not less than three lines of data consisting of bearing, range and name of a selected ship. Other data of the ship can be displayed by horizontal scrolling of data, but scrolling of bearing and range is not possible. Vertical scrolling will show all other ships known to AIS.

4.2.1 Activation

AIS should always be in operation. It is recommended that the AIS is not switched off during port stays because of the value of the ship information to port authorities.

Whether at sea or in port, if the Master believes that the continued operation of AIS might compromise the ship's safety or security, the AIS may be switched off; however, the equipment should be reactivated as soon as the source of danger has disappeared. This might be the case in sea areas where pirates and armed robbers are known to operate. It may be necessary to switch off AIS or to reduce the transmission power during some cargo handling operations. Actions of this nature should always be recorded in the ship's logbook.

If the AIS is shut down, static data and voyage related information remains stored. Restart is achieved by simply switching on the power to the AIS unit. Own ship's data will be transmitted after a two-minute initialisation period.

4.2.2 Integrity Check

AIS provides:

- a built-in integrity test (BIIT) running continuously or at appropriate intervals;
- monitoring of the availability of the data;
- an error detection mechanism of the transmitted data; and
- error checking of the received data.

If no sensor is installed or if the sensor (*e.g.* the gyro) fails to provide data, the AIS automatically transmits the "not available" data value. However, the integrity check cannot validate the contents of the data presented to the AIS.

4.3 OPERATION IN A VTS AREA OR TSS

AIS also assists vessels operating in a Vessel Traffic Service (VTS) area or Traffic Separation Scheme (TSS) at the same time ensuring that the responsible shore authorities have the ability to easily identify vessels, to automatically receive from them a wealth of useful information and to communicate with them using the AIS functionality.

Information received and transmitted through AIS enables shore authorities to better monitor and organise the traffic in the particular area of the VTS or Ship Reporting System (SRS) and to provide related information, assistance or transmit instruction to the vessel related to its voyage in the VTS area.

4.4 OPERATION IN A COASTAL AREA, SHIP REPORTING SYSTEM (SRS) AREA OR EXCLUSIVE ECONOMIC ZONE (EEZ)

Additionally, AIS allows shore authorities to monitor vessels operating within their coastal waters, designated mandatory SRS area or EEZ as appropriate. All vessels fitted with AIS should be able to provide, automatically, the majority of any reports required through the AIS's continuous broadcast of the related static, dynamic and voyage related information.

This will ensure a quicker response to emergencies such as Search and Rescue as well as environmental pollution and will enable the coastal state to assess the navigational requirements or improvements that may be necessary to navigational safety in such areas. Much value can arise from such monitoring, such as better traffic routeing, port and harbour planning and more safety related information exchange.

AIS is also provided with a two-way interface for connecting to long range communication equipment. Initially, it is not envisaged that AIS would be able to be directly connected to such equipment. A shore station would first need to request that the ship makes a long range AIS information transmission. Any ship-to-shore communication would always be made point-to-point, and not broadcast, and once communication had been established (e.g. INMARSAT C), the ship would have the option of setting its AIS to respond automatically to any subsequent request for a ship report, from that shore station.

The long distance reporting and polling functions allow areas to be monitored and vessel reports to be transmitted outside the normal AIS (VHF range) operational areas and allows for one type of equipment to perform all these functions automatically.

4.5 POTENTIAL OF AIS IN COLLISION AVOIDANCE

A study of the German Marine Boards of Inquiry into the causes of collisions at sea in the period 1983-1992 indicated that most of the so called "radar assisted collisions" (see figure 4.1) occurred in restricted visibility when radar provided insufficient, incomplete or ambiguous data[4] The study concluded that many of these collisions could have been avoided if the navigators involved had been able to access timely, and dynamic information (position, heading, speed and rate of turn etc) on the other vessel involved. AIS in the ship-ship application can now provide such dynamic information accurately and at high update rates, when target information is available on the ships involved.

[4] IMO Paper NAV 43/7/16, Automatic Identification Systems (AIS), Note by Germany dated 16 May 1997.

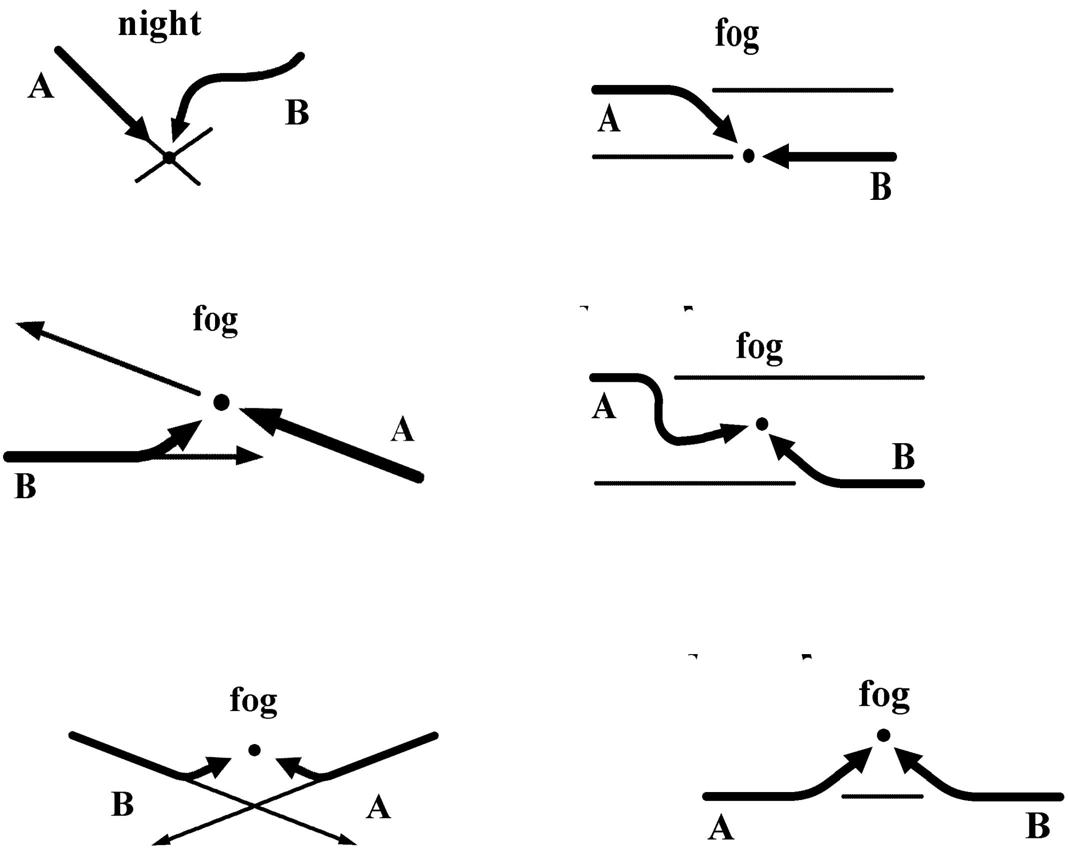


Figure 4-1 Some Examples of Collision Scenarios at Sea

4.5.1 Risk of Collision

COLREG Rule 7 - Risk of Collision - states that *"Every vessel shall use all available means appropriate to the prevailing circumstances and conditions to determine if risk of collision exists. If there is any doubt such risk shall be deemed to exist."*

The COLREGs oblige ships to apply all available means to detect the danger of collision and to take preventive measures. One of these means, especially during reduced visibility, is shipborne radar; another aid now available is AIS.

The following sections contrast the performance of radar and demonstrate how AIS could mitigate many of the limitations of radar.

4.5.2 Limitation of radar performance

When considering radar performance for collision avoidance, a distinction needs to be made between raw radar targets and tracked radar targets. The reliability of both, as discussed in the following section, involves issues of accuracy and the degree of delay of presentation.

4.5.2.1 Raw Radar Targets

The shape of raw radar echo targets does not normally give a true representation of the real dimensions of a target. From the azimuth perspective, and depending on the target aspect and distance, the echo may be smaller at very long range or considerably larger at medium ranges. This is a function of the antenna beam width. Thus, a ship at long range, approaching the observing radar may appear to be a vessel orientated at right angles to its true movement .

This distortion of target information is especially true in the case of a large vessel such as a tanker with a high superstructure aft, where the visible radar echo is probably reflections from the after structure and not the centre of the ship.

4.5.2.2 Radar in collision avoidance

There are further aspects, such as the resolution of the monitor used and raw radar processing, which presents targets that are neither equivalent to the real target's dimension nor symmetrical to it. Thus, in most cases, one cannot reliably assess, from radar observation alone, the heading of a vessel, which may also differ from the course over ground.

When altering course, a vessel's hull experiences two actions. Altering the position of the rudder, e.g. to starboard, causes the vessel to turn around its centre of rotation, which may be located a third of the ship's length from the stem. This centre itself still moves straight on over ground, while the part ahead of the centre moves to starboard of the centre while the part aft of it turns to port of it. As a consequence the whole ship begins to change course over ground.

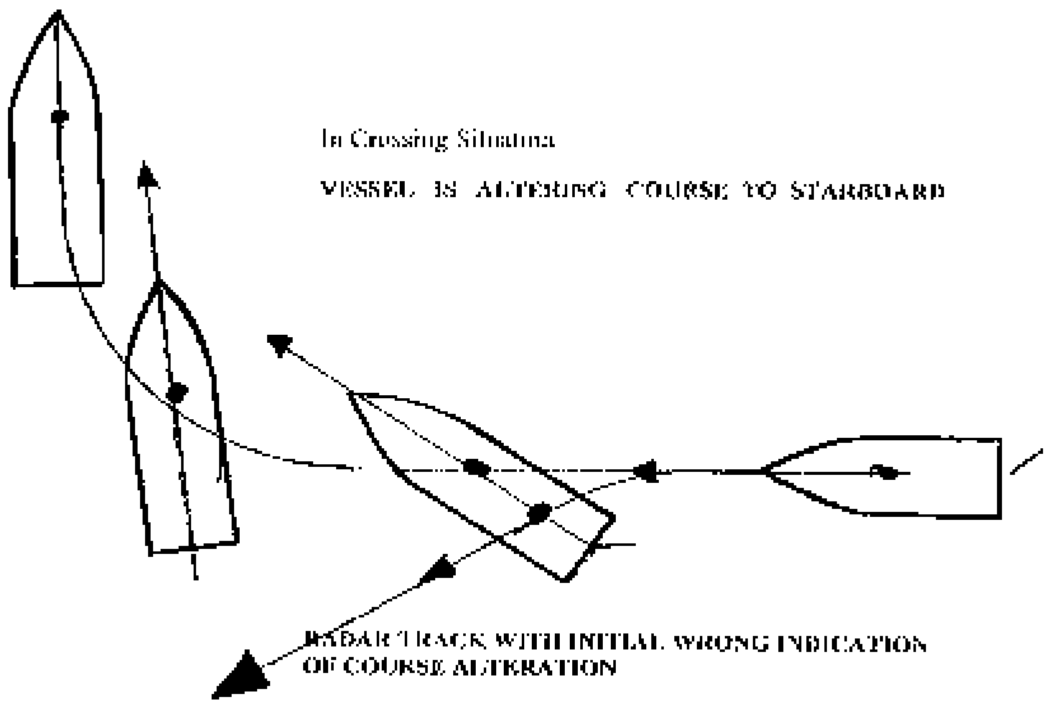


Figure 4-2

At the commencement of a course alteration the larger (radar reflecting) part of a vessel moves in a direction opposite to the actual direction of turn and may give a stronger radar echo because of the higher superstructure of the ship. It may, therefore, be difficult to instantaneously decide, from its raw radar presentation alone, the actual direction of a manoeuvre by another vessel. Indeed, the instantaneous assessment may be misleading and dangerous if acted upon.

4.5.2.3 Tracked Radar Targets

The radar track of a vessel is usually "smoothed" by a filtering process to remove the deviations caused by the alterations of reflectivity, pitch, roll and yaw. This process reduces true positional accuracy and creates a display delay. In the case of a course alteration, it may take 5-10 antenna rotations to determine a target vessel's movement. If the radar plot position of a target vessel is aft of its true centre of rotation, this may also produce a false indication of the target ship's direction of turn.

4.5.2.4 ARPA/ATA

The limitations of automatic radar plotting aids (ARPA) and automatic tracking aids (ATA) are apparent from the IMO Performance standards. It should be noted that the inaccuracies mentioned therein refer to a movement on an unmodified course for one to three minutes. For course alterations there is no specification at all.

4.5.2.5 AIS Performance

AIS broadcasts the identity, position, heading, course over ground (COG), speed over ground (SOG) and certain other relevant ship data at an update rate dependent upon the ship's speed or rate of turn during course alterations. Its performance enhances shipborne radar in three aspects:

- AIS aims to achieve a positional accuracy of better than 10 m when associated with DGNSS corrections. This compares favourably with radar whose accuracy is a function of frequency, pulse repetition rate and beam width and which will often achieve a positional accuracy of 30-50 m
- Due to this higher position accuracy of AIS and less need for plot filtering, the position and changes of course over ground can be presented with less delay than by radar.
- The AIS provides further supplementary information, that is not readily available from radar, about other vessels, such as identity, heading, COG, SOG, rate of turn and navigational status.

On the basis of this more accurate and complete information, the passing distance between vessels can be determined with higher accuracy and reliability. Cancelling actions can be avoided due to the fact that the relevant dynamic information can be provided without delay and without wrong interpretation. From the navigational status information any manoeuvring restrictions on a vessel become immediately evident and can be taken into account.

As a result, it can be seen that AIS provides more complete information than shipborne radar. When used in conjunction with radar, it enhances the available information. AIS can also assist in the identification of targets by name or call sign and by ship type & navigational status, thus reducing verbal information exchange.

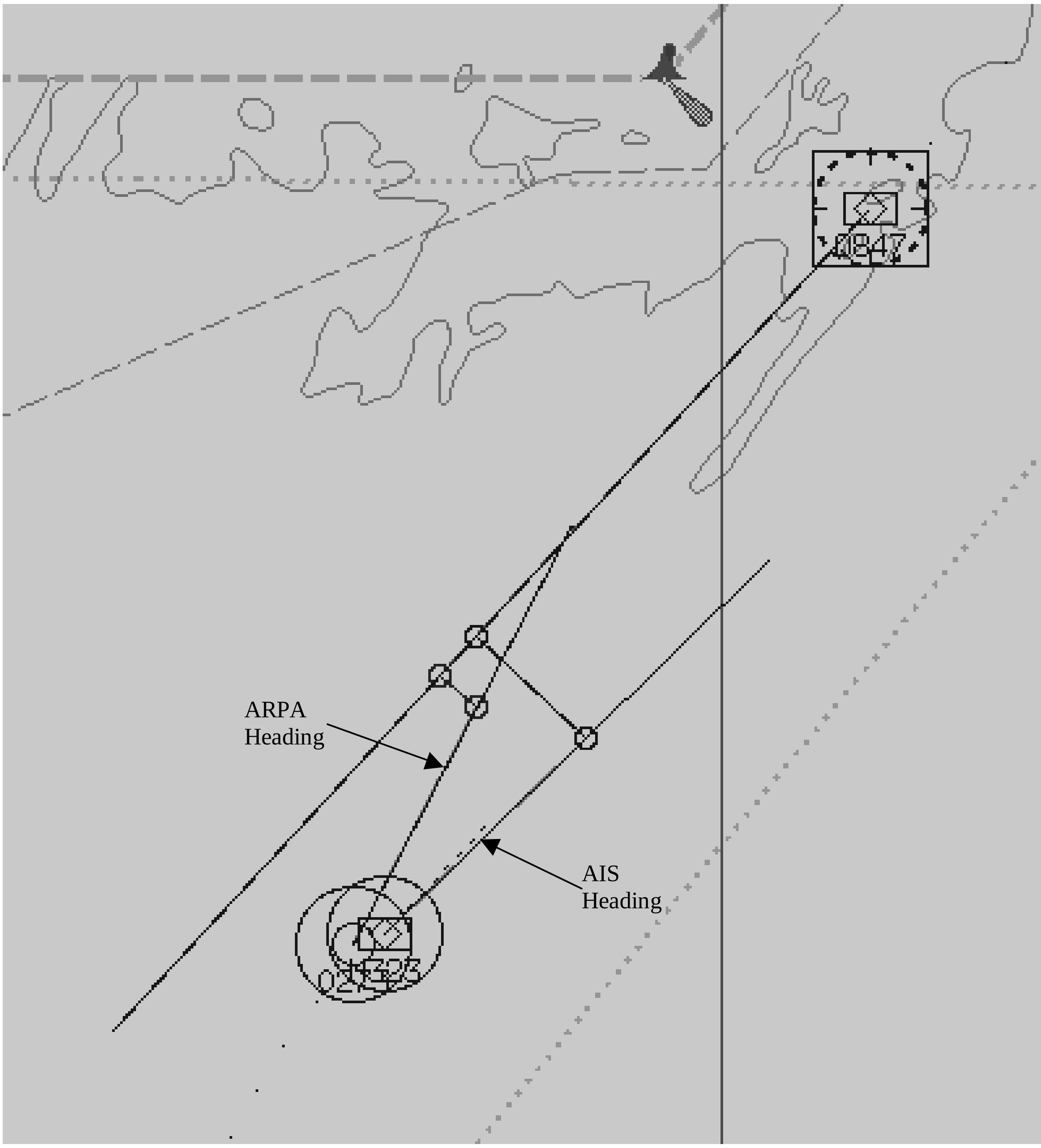


Figure 4.3 – Comparison of Radar (ARPA) and AIS

The attached screen shot clearly shows the difference between the radar-ARPA and the AIS information for collision avoidance. While the ARPA shows a crossing situation the AIS clearly indicates the red to red situation

4.5.3 Display of AIS Target Information

The information provided here is for guidance only and is intended to apply to the display and integration of AIS target data in 'stand alone' as well as integrated navigational devices or systems. The aim is to provide performance based guidelines rather than seek to stipulate operational user procedures.

Again, while certain recommendations for the display of AIS information are indicated, these do not exclude the application of alternative solutions, provided the functional requirements of these guidelines are met.

4.5.4 Definitions

Sleeping target	A target symbol indicating the presence and orientation of a vessel equipped with AIS in a certain location. No additional information is presented until activated thus avoiding information overload.
Activated target	A symbol representing the automatic or manual activation of a sleeping target for the display of additional graphically presented information including: - a vector (speed and course over ground); - the heading; and - ROT or direction of turn indication (if available) to display actually initiated course changes.
Selected target	A symbol representing the manual selection of any AIS target for the display of detailed information in a separate data display area. In this area, received target data as well as the calculated CPA and TCPA values will be shown.
Dangerous target	A symbol representing an AIS target (activated or not) whose data contravene pre-set CPA and/or TCPA limits.
Lost target	A symbol representing the last valid position of an AIS target before the reception of its data was lost.

4.6 OPERATIONAL REQUIREMENTS

In addition to the relevant performance standards, AIS information may be presented and displayed according to the following interim guidelines.

4.7 PRESENTATION OF INFORMATION

If AIS information is made available for a graphical display, at least the following information should be displayed: (see resolution MSC.74(69), Annex 3 (AIS), paragraph 6):

- position
- course over ground
- speed over ground
- heading
- rate of turn, or direction of turn, as available

4.7.1 If information provided by AIS is graphically presented, the symbols described in Appendix 4-1 should be applied. In the case of a radar display, radar signals should not be masked, obscured or degraded.

4.7.2 Whenever the graphical display of AIS targets is enabled, the graphical properties of other target vectors should be equivalent to those of the AIS target symbols, otherwise the type of vector presentation, (radar plotting symbols or AIS symbols), may be selectable by the operator. The active display mode should be indicated.

4.7.3 The presentation of AIS target symbols, except for sleeping or lost targets, should have priority over other target presentations within the display area, including targets from EPA, ATA or ARPA. If such a target is marked for data display, the existence of the other source of target data may be indicated, and the related data may be available for display upon operator command.

4.7.4 The mariner should be able to select additional parts of the information from AIS targets, which should then be presented in the data area of the display, including the ship's identification, at least the MMSI. If the received AIS information is not complete, this should be indicated.

4.7.5 A common reference should be used for the superimposition of AIS symbols with other information on the same display, and for the calculation of target properties (e.g. TCPA, CPA.).

4.7.6 If AIS information is graphically displayed on a radar, the equipment should be capable of appropriately stabilising the radar image and the AIS information.

4.7.7 Target data derived from radar and AIS should be clearly distinguishable as such.

4.7.8 The operator may choose to display all or any AIS targets for graphical presentation. The mode of presentation should be indicated.

4.7.9 If the display of AIS symbols is enabled, removing a dangerous target should only be possible temporarily as long as the operator activates the corresponding control.

4.7.10 The AIS symbol of an activated target may be replaced by a scaled ship symbol on a large scale/small range display.

4.7.11 If the COG/SOG vector is shown, its reference point should be either the actual or the virtual position of the antenna.

4.7.12 Means should be provided to select a target or own ship for the display of its AIS data on request. If more than one target is selected, the relevant symbols and the corresponding data should be clearly identified. The source of the data, e.g., AIS, radar, should be clearly indicated.

4.8 PROCESSING OF INFORMATION

4.8.1 If zones or limits for automatic target acquisition are set, these should be the same for automatically activating and presenting any targets regardless of their source.

4.8.2 The vector time set should be adjustable and valid for presentation of any target regardless of its source.

4.8.3 If radar plotting aids are used for the display of AIS information, these should be capable of calculating and displaying collision parameters equivalent to the available radar plotting functions.

4.8.4 If the calculated CPA and TCPA values of an AIS target are less than the set limits,

- a dangerous target symbol should be displayed and
- an alarm should be given.

The pre-set CPA/TCPA limits applied to target data derived from different sensors should be identical**.**

4.8.5 If the signal of a dangerous AIS target is not received for a set time:

- a lost target symbol should appear at the latest position and an alarm be given;
- the lost target symbol should disappear after the alarm has been acknowledged; and
- means to recover the data for a number of last acknowledged lost targets may be provided.

Preferably this function may also be applied to any AIS target within a certain distance.

4.8.6 An automatic display selection function may be provided to avoid the presentation of two target symbols for the same physical target. If target data from AIS and from radar plotting functions are available, then the activated AIS target symbol should be presented, if the automatic selection criteria are fulfilled, otherwise the respective symbols should be displayed separately. The operator should have the option to make reasonable changes to the default parameters of automatic selection criteria.

4.8.7 Means should be provided to display and acknowledge alarm messages from own AIS. Indication should be given if own AIS is out of service or switched off.

4.9 HUMAN INTERFACE

As far as practical, the user interface for operating, displaying and indicating AIS functions should be equivalent to the other relevant functions of the navigational aid.

Note:
AIS uses WGS84 datum. Users should be aware that alternative datums used in electronic aids or referenced on a paper chart may induce positional errors.

Appendix 4-1

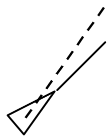
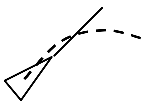
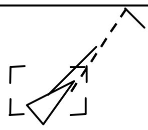
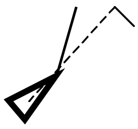
AIS target	Symbol	Description of symbol
AIS target (sleeping)		An isosceles, acute-angled triangle should be used with its centroid representing the target's reference position. The most acute apex of the triangle should be aligned with the heading of the target, or with its COG, if heading information is not available. The symbol of the sleeping target may be smaller than that of the activated target.
Activated AIS target	 	An isosceles, acute-angled triangle should be used with its centroid representing the target's reference position. The most acute apex of the triangle should be aligned with the heading of the target, or with its COG, if heading information is not available. The COG/SOG vector should be displayed as dashed line starting at the centroid of the triangle The heading should be displayed as solid line of fixed length starting at the apex of the triangle A flag on the heading indicates a turn and its direction in order to detect a target manoeuvre without delay A path predictor may also be provided
Selected target		A square indicated by its corners should be drawn around the target symbol.
Dangerous target		A bold line clearly distinguishable from the standard lines should be used to draw the symbol. The size of the symbol may be increased. The target should be displayed with: vector, heading and rate of turn indication. The symbol should flash until acknowledged. The triangle should be red on colour displays.
Lost target		A prominent solid line across the symbol, perpendicular to the last orientation of the symbol should be used. The symbol should flash until acknowledged. The target should be displayed without vector, heading and rate of turn indication.

Table 4-1: **Recommended AIS Target Symbols**

- If colour fill is used no other information should be masked or obscured.
- Base stations may transmit information on targets tracked by other means. If these targets are displayed they should be presented using symbols clearly distinguishable from the symbols above.
- Further symbology for special situations will be developed.

CHAPTER 5

OPERATION IN THE SHIP - SHIP MODE

The AIS is a ship to ship, ship to shore broadcast system. In the ship to ship mode of operations, IMO has provided "Guidelines on Automatic Identification Systems (AIS) Operational Matters of AIS" for the mariner. These were not finalised when this document was issued. IALA has been involved extensively in the development of these guidelines.

The responsibility of IALA is in the Aids to Navigation and VTS areas of the Maritime community. As such IALA is undertaking to provide a definition of an AIS shore station and a unique AIS AtoN station.

This is a major work that will take a considerable amount of time to complete due to the many decisions that will need to be make in order to define these stations.

There is a further definition of an AtoN station in Chapter 14 but it is preliminary work only.

CHAPTER 6

INFORMATION DISSEMINATION

6.1 PRESENTATION OF AIS INFORMATION

The following items have been identified in this document as future item to be addressed. Each is being discussed in many forums and there are no conclusions to be published at the time of printing of this document.

6.1.1 Symbology

6.1.2 Displayed on Radar

6.1.3 Displayed on ECDIS

6.1.4 Dedicated Graphic Display

6.1.5 Integrated Navigation Systems

6.1.6 Use of AIS Information

6.1.7 Navigation Warnings

6.1.8 Meteorological Warnings

6.1.9 Shipping Information

6.1.10 Onboard Operation

6.1.11 Interfaces.

6.1.12 ECDIS

6.1.13 Radar

6.1.14 Independent display

6.1.15 Gyro

6.1.16 Rate of turn

6.1.17 Pitch and roll indicate

6.1.18 VDR

6.1.19 Speed log

6.1.20 GNSS/DGNSS

CHAPTER 7

PILOTAGE

7.1 OVERVIEW

In pilotage areas like ports, harbours, rivers and archipelagos, the need for AIS with high update rates is evident; the AIS will be invaluable for navigation, reporting, and communication purposes.

The limitations of the ARPA radar to track vessels due to target swapping from a vessel to land, beacons, bridges and other vessels makes the ARPA capabilities very limited in narrow and congested waters. AIS used together with ARPA radar enhances its function.

Safety will be improved by using AIS in pilotage waters and the broadcast AIS will achieve this by:

- identifying vessels by name, heading, course over ground (COG), speed over ground (SOG), size, draught and type of vessel.
- detecting and identifying vessels especially in restricted visibility e.g. behind a bend in a channel or behind an island in an archipelago.
- predicting the exact position of a meeting with another vessel(s) in a river, port or in the archipelago. Thus allowing for the correct manoeuvre to be made for collision avoidance purposes.
- identifying which port or harbour a vessel is bound for
- detecting a change in a vessel's heading almost in real time

7.2 SILENT VTS

The AIS allows the silent and automatic exchange of information with other vessels and VTS centres, leaving port operation VHF channels available for safety purposes and emergency situations. Thus AIS reduces the workload on the bridge of the vessel and also in the VTS centre. In ports where the density of the traffic is low, the AIS fitted vessels may form their own "Silent VTS" without any shore station. In busy ports AIS will reduce the VTS operators' workload and allow them to increase their efficiency in traffic management, information services and other tasks.

7.3 SHORE TO VESSEL AIS SERVICES

There are existing international AIS messages designed to facilitate the reception onboard of online and static information from shore such as hydrographical, hydrological, meteorological, Aids to Navigation, and Warning messages. Local specific messages can also be made available to fit local demands.

7.4 POSSIBLE FUTURE USE OF AIS IN PILOTED WATERS

In addition to the use of AIS standard messages there is a need to use special messages created for use in a specific pilotage area because of differing local conditions.

Examples of information that could be exchanged via AIS in piloted waters:

- actual wind direction and speed
- actual current direction and speed
- actual water level
- actual water and air temperature
- floating aids to navigation on station or off station
- fixed aids to navigation as reference targets for radar
- aids to navigation status/identity
- virtual aids to navigation
- local management messages
- locks open/closed
- bridges open/closed
- tension power on tug lines
- orders to tug boats
- traffic information from the VTS

AIS also provides the facility for a VTS centre to broadcast VTS targets to vessels. A VTS target is any target that can be displayed at the VTS centre including radar targets, DF targets and ARPA targets. What this means for the pilot is that he will be able so see all the vessels the VTS operator sees, even if those vessels do not have an AIS onboard.
The creation and use of these special messages to fulfil local requirements will assist both the pilot and the VTS in their respective tasks. For example, the AIS can provide a bird's eye view of a docking operation with tugboats connected or pushing including information such as bollard pull, directions of pull and even issuing the commands to the tugboats through the Pilot Pack.

Special local applications in e.g. rivers, canals, harbours and archipelagos will most certainly be one of the tools for a pilot or a master with pilot exemption to make their job more efficient. The AIS is able to handle both internationally agreed messages and locally designed messages. This makes the AIS one of the major tools for the pilot in the future.

7.5 PORTABLE PILOT PACK

There are two types of portable carry onboard pilot AIS equipment. The first type is a pilot workstation combined with a portable AIS. The second type is a pilot workstation, which connects to the pilot port connector of an onboard AIS.

- A pilot workstation combined with portable AIS is used primarily to provide marine pilots with the capability to carry onboard an AIS station when piloting vessels not fitted with AIS. Such a Pilot Pack contains GNSS/DGNSS, AIS, (optional) heading sensor, and a workstation. The heading sensor is essential if the vessel is using the Pilot Pack for navigating in waters where there are frequent course alterations. Without the heading sensor the AIS will not provide sufficient information to other vessels in the vicinity.

- Most of the vessels that are piloted will be fitted with AIS according to the SOLAS convention. The onboard AIS has a pilot/auxiliary input/output port which provides the facility to forward the own vessel's GNSS/DGNSS information, heading, and (optional) rate of turn continuously, independently of (i.e. faster than) the standard AIS reporting rate. The pilot will receive all other AIS information at the standard rate. This allows pilots to plug in their own pilot portable workstation to the onboard AIS in order to receive more frequent own ship navigation information. In addition the pilot port provides the pilot the facility to forward information to other vessels in the vicinity or to the local VTS.

- When installing the AIS there should be connectivity to the AIS pilot port from those locations at which the pilot would use his workstation (see appendix 12-A). In addition a power supply should be available to the same location(s).

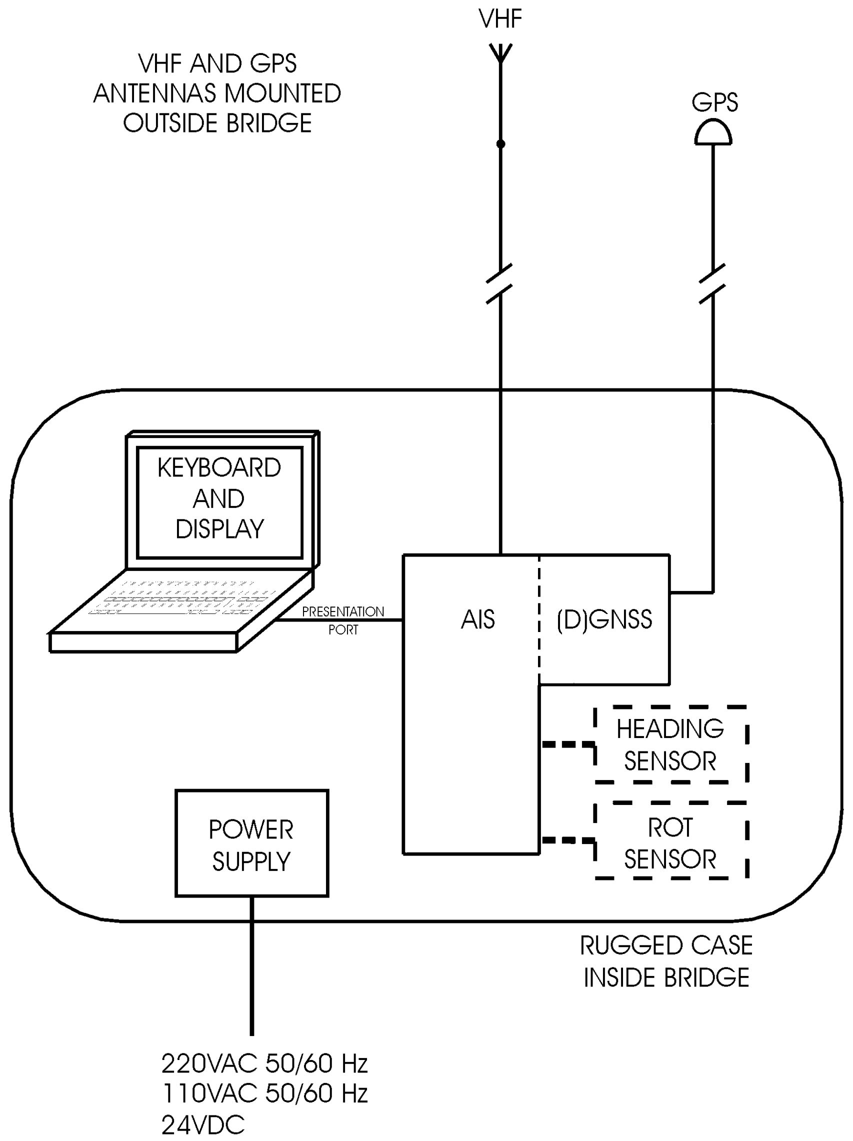


FIGURE 1

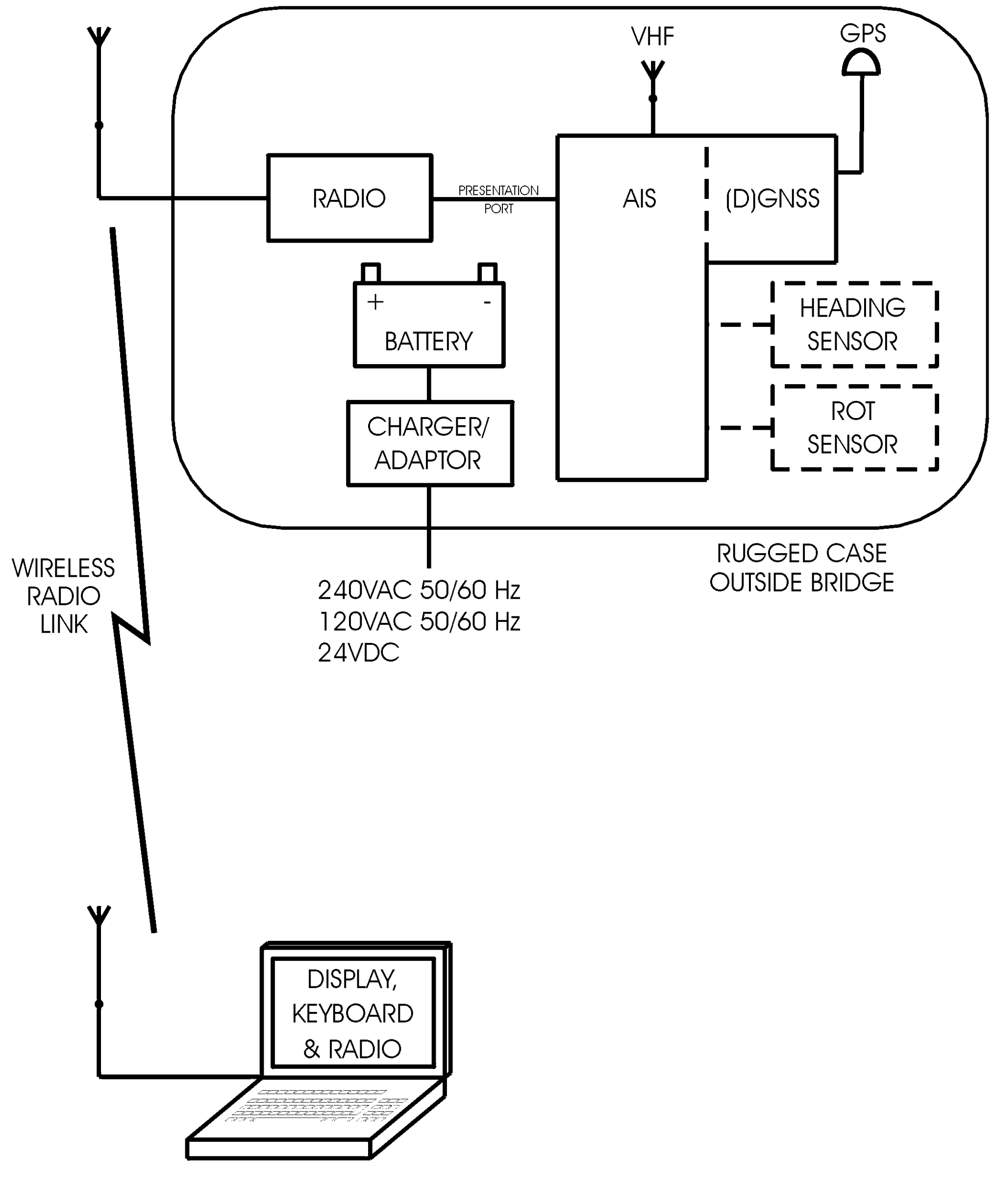

VHF
GPS
RADIO
PRESENTATION PORT
AIS
(D)GNSS
BATTERY
+
-
HEADING SENSOR
ROT SENSOR
CHARGER/ ADAPTOR
RUGGED CASE OUTSIDE BRIDGE
WIRELESS RADIO LINK
240VAC 50/60 Hz
120VAC 50/60 Hz
24VDC
DISPLAY, KEYBOARD & RADIO

FIGURE 2

CHAPTER 8

VESSEL TRAFFIC SERVICES

IMO Assembly Resolution A.857(20), Guidelines for Vessel Traffic Services, establishes the following tasks that should be performed by a VTS:

"*A VTS should at all times be capable of generating a comprehensive overview of the traffic in its service area combined with all traffic influencing factors. The VTS should be able to compile the traffic image, which is the basis for the VTS capability to respond to traffic situations developing in the VTS area. The traffic image allows the VTS operator to evaluate situations and make decisions accordingly. Data should be collected to compile the traffic image. This includes:*

- *Data on the fairway situation, such as meteorological and hydrological conditions and the operational status of aids to navigation;*
- *Data on the traffic situation, such as vessel positions, movements, identities and intentions with respect to manoeuvres, destination and routing;*
- *Data of vessels in accordance with the requirements of ship reporting and, if necessary, any additional data required for the effective operations of VTS.*

This chapter of the IALA Guidelines on AIS seeks to identify, for the benefit of VTS authorities, the ways in which AIS contributes to the achievement of the above tasks.

8.1 BENEFITS OF AIS

8.1.1 Automatic Vessel Identification

AIS brings to the mariner many benefits. Principal amongst these, as the name implies, is the automatic and immediate provision of vessel identity (MMSI, call sign etc), thereby facilitating rapid radio communication where necessary. This benefit is of equal, if not even greater, value to VTS authorities.

Most VTS organisations require vessels to report to the VTS centre when approaching or entering the VTS area. Achieving vessel identity relies on such vessels reporting both identity and location to the VTS centre, and the VTS operator then correlating this information with an unassigned radar track.

The process is time consuming and wholly reliant on the co-operation of participating vessels. It is not uncommon for some vessels to fail to comply with this requirement, thereby creating a potentially dangerous situation, and creating further distraction for the VTS operator. Even where VHF direction finding equipment is fitted, the VTS traffic image is still reliant on vessels reporting identity via VHF thereby permitting the correlation of identity with the radar track identified by DF. AIS will help overcome the safety weaknesses and time consuming procedures, inherent in the present arrangements.

8.1.2 Improved Vessel Tracking

8.1.2.1 Wider geographical coverage.

AIS data will be received by other AIS units, or by base or repeater stations. Thus where a VTS organisation is fitted with such equipment, it will be capable of receiving both identity and precise location of a vessel at the maximum reception range of the VHF radio communications frequency. As a consequence, it will often permit detection of vessel target well outside conventional radar range. Even where this is not possible, due to the need to screen base stations from adjacent VHF interference, extended VTS detection range may be achieved by the installation of additional base or repeater stations connected into a network at much lower cost than radar.

8.1.2.2 Greater positional accuracy.

AIS aims to achieve positional accuracy better than 10 metres when associated with DGNSS correction signals. This compares favourably with radar, which as a function of frequency, pulse repetition rate, and beam width, will often only achieve positional accuracy in the range 30 to 50 metres.

8.1.2.3 Absence of "radar shadow" areas.

In coastal and harbour waters radar tracking of vessels can be masked, or otherwise affected by the proximity of land and buildings. The resultant "shadow" areas can cause a radar based VTS to lose track, thereby denying the VTS centre the ability to monitor accurately vessel movement at what could be a critical time. The loss of tracking will invariably result in the need to reacquire and re-identify lost tracks, thereby increasing the work load within the VTS centre.

Whilst AIS tracks will avoid the great majority of such effects, the very close proximity of buildings and bridges, sometimes known as the "urban canyon" effect, can cause difficulties for AIS transponders in heavily built-up areas. This is a consequence of inhibiting either the reception of the differential GNSS signal by the AIS transponder, or the transmission of the subsequent AIS message.

8.1.2.4 Traffic image accuracy

Vessel tracking can similarly be interrupted when two vessels pass close to one another, with the result that the radar tracking of one contact is confused by the proximity of the other. Importantly, this can result in the identity of one track transferring or "swapping" to the other. Self-evidently, such a situation introduces a potentially dangerous inaccuracy in the vessel traffic image, unless noticed and rectified quickly by VTS operators. Again, the consequence of this phenomenon is further work for the VTS centre. The more precise tracking associated with AIS has been shown to prevent the incidence of "track swap".

8.1.2.5 Real time manoeuvring data.

Radar based VTS systems will typically provide details of a vessel's course and speed over the ground. Of necessity, this information is historical in that it is calculated from the track made good by a vessel. In contrast, AIS will provide all recipients with certain elements of real time manoeuvring data such as Ships Heading and Rate of Turn. These are derived directly from the vessel navigation systems and are included automatically in the Dynamic Message broadcast by the AIS.

8.1.2.6 Weather effects on tracking performance.

Navigational radar performance is often adversely affected by precipitation as a function of the radio frequency on which it operates. In heavy rain or snow, effective radar tracking is sometimes unachievable, even with the use of modern suppression techniques. VHF radio transmissions on the other hand are not so attenuated. As a consequence, a VTS centre is much more likely to maintain an accurate traffic image in adverse weather where that tracking is based on AIS data.

VHF radio transmissions can be affected by atmospheric ducting. In these conditions, VHF reception ranges can be greatly extended. Where such an enhanced reception range brings with it the detection of greatly increased AIS messages, the system will automatically overcome the risk of overloading by ignoring signals originating from vessels at greatest range, and re-using the slots so gained.

8.1.2.7 Provision of more precise navigational advice.

It follows that where a VTS centre is able to receive AIS information from vessels within or adjacent to its area, the quality, accuracy and reliability of vessel tracking will be improved markedly. As a consequence, that VTS centre will be able to provide more precise navigational advice, as and when required, or when deemed necessary. Moreover, the availability of certain real time manoeuvring data within the VTS centre will enable VTS operators to appreciate more rapidly, and in greater detail, actual vessel movement. It should be stressed, however, that this facility alone will not enable a VTS centre to provide detailed manoeuvring advice to a vessel.

8.1.3 Electronic transfer of sailing plan information

Where AIS is integrated into a VTS system, it becomes possible for vessels and the VTS centre to exchange passage information such as intended way points, provided the appropriate software is available.

8.1.4 Electronic transfer of safety messages.

The facility available within AIS for the transmission of short safety messages makes possible the electronic broadcasting from a VTS centre of local navigation warnings, and similar safety related messages.

It is anticipated that VTS centres may have the capability to broadcast, via AIS, local chart corrections to ECDIS fitted ships.

8.1.5 Automatic indication of Voyage Related Information (cargoes, dangerous goods, etc)

Vessels are normally required to report to the VTS authority that dangerous goods are being carried. The AIS voyage related message permits the inclusion and automatic transmission of this information.

8.1.6 Impact on VHF communications

As described earlier, a major benefit of AIS is the consequential reduction of VHF voice messages. This in turn reduces the reliance placed on vessels understanding such messages from a VTS centre and vice versa.

8.1.7 Archiving data

The automatic availability within a VTS centre of AIS data for each vessel facilitates the rapid and comprehensive recording, replay and archiving of data.

8.1.8 System redundancy

By equipping VTS centres with AIS, an alternative method of tracking and monitoring vessel navigation is introduced, thereby improving system redundancy significantly.

8.1.9 Potential for interaction within regional AIS network

Increasing emphasis is being placed on networking VTS centres on a regional basis. Such an arrangement facilitates greater efficiency by making possible the rapid transfer of vessel details between different centres. Adoption of AIS within the relevant VTS centres may contribute toward this process.

8.1.10 Improved SAR management

Many marine and VTS authorities are equipping SAR capable units, including aircraft and helicopters, with AIS. The AIS voyage related message permits a vessel to transmit the number of persons onboard. Whilst this is not mandatory for vessels at sea, it can be made a formal requirement in a VTS area. The provision of such details, and the ready identification and location of SAR units greatly facilitates the management and evaluation of any SAR response.

8.2 INSTALLATION OF AIS INTO A VTS - ISSUES TO BE CONSIDERED

8.2.1 Number/location of base stations/repeaters

In deciding the size, and thus cost, of integrating AIS into a VTS system, a careful study needs to be undertaken to establish practically the number and location of base and repeater stations required to achieve full and reliable coverage of the expected traffic load. Although VHF reception is greatly influenced by antenna location and height, operation in a noise electronic environment may necessitate the installation of additional base stations in order to reduce susceptibility to interference.

8.2.2 Interoperability with adjacent VTS

Where it proves necessary to use more than one centre, or where a VTS authority involves more than one VTS centre, the method of connecting the component elements into a local network needs to be given careful consideration. In particular, the existence of, or plans for a regional network may necessitate using a local networking solution, which is compatible with national and international networks.

8.2.3 Availability of VHF Communication channels.

Two maritime VHF Channels have been allocated by the ITU for the international use of AIS in its primary ship-to-ship mode. What is not yet certain, is whether additional local channels will need to be allocated to support the operation of VTS within certain congested VTS port environments. The need for such additional channels will be at its most acute where large numbers of vessels navigate within a VTS area, and where the VTS centre has a particular interest in deriving vessel identity at maximum range. As has been described previously, AIS in an overload situation will discount AIS signals received from the extremity of an area, before those emanating from vessels or craft close to the receiving station.

8.2.4 Availability of national/regional/local DGNSS corrections

In order to monitor vessel navigation with the 10 metre accuracy potentially possible, a reliable DGNSS correction signals will need to be made available to all vessels throughout the VTS area. Such services are provided nationally or regionally in some areas. Where such a service does not exist, a VTS authority may consider providing these corrections itself. It is technically possible to transmit the relevant corrections using the AIS itself.

8.3 OTHER ISSUES TO BE TAKEN INTO CONSIDERATION

8.3.1 Integration of AIS into existing radar based systems

Radar based VTS systems often differ in the way radar video is handled and processed, prior to presentation of the traffic image. System design and age are thus likely to influence the options for successfully integrating AIS. A full appreciation of those options, together with any consequences, will normally only be possible after consultation with the relevant manufacturers.

In many VTS areas, vessel traffic is varied and includes both SOLAS and non-SOLAS vessels. In these circumstances, radar will remain the primary sensor for detecting vessels not fitted with AIS. Economies in infrastructure are therefore unlikely.

AIS data is transmitted at variable rates depending upon vessel speed and manoeuvre. In contrast, radar data is generated at a constant rate as defined by the antenna rotation speed. The integration of AIS into a radar based VTS system thus needs to be capable of achieving and maintaining the correlation of AIS and radar data originating from the same vessel, despite unpredictable variations in data rates. The potential benefits of AIS would be quickly reduced, should the process of integration result in the generation of numerous false tracks.

8.3.2 Use of electronic charts

VTS systems have traditionally used a schematic representation of the geographical and hydrographic features of the relevant area as the background to the traffic image. The accuracy of such representations, however, is not suitable for precise navigation. With the advent of electronic charts, there are clear benefits to be gained from using such charts as the background to the traffic image. By so doing, vessel navigation may be monitored, and advised, in relation to precise charted features. In VTS systems not fitted with electronic charts, such advice can only be given in relation to radar detectable features, such as coastline or navigational buoys, or as depicted on existing VTS display diagrams.

Where reliance is to be placed on electronic charts for this purpose, it is important that they are issued by an approved hydrographic office, accurate, and up to date. It is anticipated that VTS authorities will be able to broadcast local chart corrections to suitably equipped (ECDIS/ECS) vessels and to issue navigational warnings electronically using AIS.

In confined waters, it is likely that VTS operators in monitoring vessel manoeuvres will occasionally have need to reduce the scale of their displays. In such circumstances, it will be important that the electronic chart acting as the background to the traffic image, is capable of showing increasing levels of survey detail, as operators reduce the scale on their displays. This will only be possible where the electronic chart is compiled from source survey data, rather than from an existing paper chart. In these circumstances, it will also be important that the charted location of radar sites is accurate to a maximum of 10 metres, if errors between radar and AIS generated tracks, which will be all the more obvious at reduced range scales, are to be avoided.

IHO standard S52 defines the standards for symbols and colours on official electronic charts. Four variations of the basic colour scheme are available. These colour schemes, whilst optimised for navigation in varying light conditions on the bridge of a vessel, may not be suitable for VTS purposes ashore, particularly where operators are required to study a display constantly for long periods.

8.3.3 Choice of VTS Symbols

Appendix 12-A shows the choice of AIS symbols allocated for use onboard vessels.

These symbols may be found to be unsuitable for VTS purposes, for two reasons. Firstly, those selected to represent AIS tracks may need to be accommodated logically within an existing framework of symbols. Secondly, VTS centres will often have need to represent visually on the traffic image, a much wider range of information than is necessary onboard a vessel. For example, traffic management may necessitate the use of symbols which depict different types and sizes of vessels. Alternatively, it may be necessary to show which vessels have pilots embarked, and which do not.

Where it is required for a VTS to transmit a pseudo-AIS target to an AIS/ECDIS fitted vessel, it will be necessary for that information to be transmitted in terms which will be recognised by the vessel, however, it is represented internally within a VTS centre.

8.4 AIS AND AIDS TO NAVIGATION (ATON)

A further application of AIS is as an AtoN (refer to paragraph 1.7).

The remote control and monitoring of aids to navigation has been developed primarily to enable service providers to ensure that aids and supporting systems are functioning correctly and where required to organise maintenance.

Until now, there has been no simple and universal method of communicating such information. The introduction of AIS presents an opportunity to provide such information to service providers and mariners, using internationally standardised and recognised equipment, message protocols and frequencies.

The operation and performance of aids to navigation can be monitored or controlled using an AIS data link as the interface with the service provider. It is possible to have an aid transmit its identity, operational status and other information such as real time wave height, tidal stream and local weather to ships nearby or to the service provider. Buoys that can transmit an accurate position, perhaps based on DGNSS, can be monitored to ensure that they are on station. Performance monitoring, remotely changing operating parameters, and activating back-up equipment are also made possible by the use of AIS.

8.5 AIS FOR METEOROLOGICAL AND HYDROLOGICAL INFORMATION

Another application, which is expected to be widely used, is the transmission of meteorological and/or hydrological data. Where such an application is intended for international use, the message format will be registered by IALA prior to being made available to system manufacturers. This will facilitate the correct presentation of the information on systems from different manufacturers.

Options for implementing this application include:

- Connecting a sensor directly to a local AIS-unit, which then broadcasts the relevant information.

- Several sensors can be connected to a shore station network via a data communication system. Information can then be broadcast as required.

- A sensor can be co-located with an AtoN equipped with AIS. The AIS-unit can then be used to broadcast both the AtoN information and meteorological and/or hydrological information using separate messages.

The information to be broadcast will depend on the operational requirement and the availability of measuring and processing equipment. Examples include:

- Wind speed, average and gust values
- Wind direction
- Water level
- Water temperature
- Air temperature
- Current speed and direction on different depths
- Tide information

Such data permits the presentation of real time information at receiving stations, including onboard ships within VHF range.

8.6 PERSONNEL AND TRAINING

For information on personnel and training, refer to IALA Model Courses V103-1, V103-2, V103-3 and its associated task book and V103-4.

8.7 SHORT TERM ACTION BY VTS AUTHORITIES

AIS equipment is to be implemented as a mandatory carriage requirement under SOLAS Chapter V for newly constructed vessels from 1 July 2002 and progressively thereafter to other vessels by 1 July 2008.

VTS authorities therefore need to consider, as a matter of priority, whether they intend integrating AIS into their VTS system. As the previous paragraphs will have demonstrated, the inclusion of AIS into a VTS system significantly enhances the precision and reliability with which AIS equipped vessels may be monitored, and thus enhances safety.

AIS also has the potential to improve efficiency in vessel traffic and port management. The degree to which this potential may be realised will vary depending on the operational circumstances. It is for each VTS authority to make that assessment.

8.8 CAUTIONARY NOTE

In order to avoid a situation whereby AIS fitted vessels incorrectly believe that a VTS authority is receiving data being transmitted via the AIS, all VTS authorities will need to publish by appropriate means their status in respect of AIS. Where applicable, the date on which they intend to incorporate AIS should also be promulgated well in advance.

GUIDELINES

ON

UNIVERSAL SHIPBORNE

AUTOMATIC IDENTIFICATION SYSTEM (AIS)

PART 2

TECHNICAL ASPECTS OF AIS

CHAPTER 9

DESCRIPTION OF SYSTEM ARCHITECTURE OF THE AIS

9.1 INTRODUCTION TO THE TECHNICAL PART OF THE IALA AIS GUIDELINES

Previous chapters have concentrated on the operational aspects of the AIS, i.e. on the description of what the AIS is supposed to do under what circumstances in operational terms. This chapter introduces a set of chapters that will deal with the technical aspects of the AIS.

This part of the IALA AIS Guidelines intends to satisfy the information need of

- anyone, in particular an interested user, who wishes to gain a better understanding of the technical aspects of the AIS: While a user of the AIS may feel that knowing the operation of AIS is sufficient he/she will discover that understanding the technical principles of AIS will lead to a greater appreciation of the benefits of AIS but also its limitations. Hence the overall effectiveness of the application can be optimised.
- integrators and application designers, both operational and technical, when seeking both a comprehensive and an accurate description of the basic services which the AIS delivers, without wishing to go into the highly technical reference documents. It should be noted, that this description was drafted from a shore-side point of view, i.e. it focuses on AIS services delivered at the shore-side interface of an AIS base station. However, many fundamental descriptions may also be of value for the AIS services delivered at the interfaces of the mobile AIS stations.
- competent authorities who wish to deploy a shore-based AIS infrastructure and seek well structured guidance in the planning and the procurement of that shore-base AIS infrastructure.

The large and still expanding volume of relevant international documents and standards has created the need for a reference guide. This part of the IALA AIS Guidelines refers the reader to the paragraph or section of the appropriate international document relating to the AIS function under consideration.

The purpose of this chapter is to give a broad introductory overview of the system "AIS" as a whole. It introduces the layered structure of the AIS and the applications using the AIS derived information. This chapter also indicates where the different kind of AIS stations fit into the layered concept of the AIS as a whole, i.e. it maps the AIS stations to the layers of the ISO/OSI-layer model.

The purpose and functions of the AIS can be expressed in terms of services provided. The most fundamental services of the AIS are called Basic AIS Services (BAS). They make use of the diverse features of the AIS VHF Data Link (as described in Recommendation ITU-R M.1371-1 in connection with the IALA Recommendation on Technical Clarifications of Recommendation ITU-R M.1371-1) and the diverse features of the different AIS stations (as described e.g. in the appropriate IEC standards and the before mentioned IALA Recommendation). They can be described in a common format. All available BAS are described in Chapter 10.

This description of the BAS does not make redundant the referenced documents, i.e. the appropriate international standards or introduce new system features. However, this description of the BAS binds together - in a comprehensive and highly accurate manner - all information items from various sources that are essential to understand what is being delivered in functional terms on a given interface on the recipient's side. It is also the basis for an assessment of the usefulness of a particular AIS service for a particular intended application in terms of accuracy, frequency, reliability etc.

The AIS frequency management was given a separate chapter as both a very powerful and very complex BAS, which should be carefully considered before using it. Competent authorities are responsible both for the decision to implement AIS frequency management - thus drawing away from the global default AIS frequency management - and to manage the regional AIS frequencies. In that region, this service affects the AIS as a whole - for good and for worse. Therefore, detailed guidance for competent authorities that have identified a need for AIS frequency management is given in Chapter 11.

While Chapters 9, 10, and 11 deal with the AIS as a whole, Chapters 12 to 15 turn to specific AIS stations. Shipborne mobile AIS stations (Chapter 12), AIS base and repeater stations (Chapter 13), Aids-to-Navigation AIS stations (Chapter 14), and Search-and-Rescue Aircraft AIS stations (Chapter 15), all exhibit some special features.

After the introduction of the individual varieties of AIS stations, coastal-wide issues of an AIS shore infrastructure are considered, Planning of coastal AIS VDL coverage (Chapter 16), configuration management of AIS shore infrastructure (Chapter 17), processing AIS data from multiple base stations (Chapter 18), and AIS shore networking (Chapter 19). Chapters 16 - 19 also reference Annex 4 where concrete guidance is given to administrations with regard to what requirements are advised to be included in any call for tender for a shore based AIS infrastructure in order to procure a functioning, flexible and future-proof shore-based AIS infrastructure.

Long Range Applications (Chapter 20) addresses the special consideration for long range use of AIS. This does not make use of the AIS VDL but uses appropriate long range communication links to provide a means for ship reporting and tracking systems which cannot use AIS VHF coverage due to the distance to the next AIS base station ashore.

9.2 SYSTEM ARCHITECTURE

This section describes the framework, which is used in the design of the AIS.

9.2.1 The AIS - a system designed using functional layers

The AIS is designed as a modern electronic system. Modern electronic systems are generally designed by structuring them in stacks of functional layers.

9.2.1.1 Open System Interconnection 7-Layer Model

There is one internationally recognized standard model of how to structure the functionality of a complex system in layers. This layer model consists of 7 layers and was developed by the International Standards Organization (ISO). The AIS has been designed using this model. In order to fully understand the AIS technology it is vital to understand this model.

The model is called the Open Systems Interconnection Reference Model (OSI model, for short). It was originally developed to provide a general structure for understanding and assisting in the development of digital links between computer-based systems. This general structure was developed to help engineers create internationally standardized systems that use a number of different data and communication protocols.

The OSI model is used in the documents, which define the AIS technology, in particular the Recommendation ITU-R M.1371-1 and the IALA Recommendation on Technical Clarifications on Recommendation ITU-R M.1371-1, to help identify, define, and describe features that the AIS must posses. While designed primarily for communications systems, the OSI model was found to be satisfactory as an organizing framework for AIS.

The OSI model partitions the digital computer communications process into seven layers of services. The seven layers interconnect to provide the functions needed to move digital information. Each layer provides a service that ensures that digital information is transferred correctly. Standards and methods can be defined for each layer.

The top three layers of the model are used to describe the application-oriented processes of exchanging AIS-related information and the AIS-related support functions needed. The bottom four layers of the model describe the most fundamental processes needed to connect two or more AIS devices and control information flow without errors, loss of information, or duplication of information. The following briefly describes the services provided by each layer in the OSI model, *Figure 9-1*.

- **Application Layer:** This layer interfaces directly to, and performs common application services for, the application process. It directly supports the exchange of information between application programs at both ends of the data path. This layer is not part of the applications that either generate or use the information, which can be the mariner or a VTS operator using AIS as well as automated applications. Specific applications are external to the OSI model, i. e. the shipboard navigation using AIS and the traffic management processes (performed in a VTS centre) using AIS lies above the OSI model.
- **Presentation Layer**: Provides the process to transform information into a mutually agreed format. It relieves the Application Layer of concern regarding syntactical differences in data representation between the two "end-user" applications.
- **Session Layer:** Responsible for managing the connection between cooperating applications. It manages such things as link termination and restart procedures.
- **Transport Layer:** Manages the connection between the two end nodes in the information exchange. It provides the transparent transfer of information

between the two "end-user" applications, thus relieving the upper layers from any concern with providing reliable and cost-effective data transfer.

- **Network Layer:** Responsible for providing the functional and procedural means of transferring variable length data sequences from a source to a destination. It performs routing, flow control, and segmentation/de-segmentation functions.
- **Data Link Layer:** Provides the reliable transfer of data frames over the physical layer. It can be used to detect and correct some of the errors that occur in the Physical Layer.
- **Physical Layer:** Responsible for the mechanical, electrical, functional, and procedural aspects of the data link between the "end-users". It establishes and terminates the communication medium connection, manages contention resolution and flow control, and converts the representation of digital data in the user equipment and the corresponding signals transmitted over the communications medium. The details of the physical layer design are driven by the characteristics of the communications medium, i. e. by the characteristics of the VHF maritime mobile band. Its characteristics are a significant factor in determining the overall design.

While not actually part of the ISO/OSI model, the VHF maritime mobile band as the transport media of the AIS is introduced here as an "eighth layer" in order to draw attention to signal propagation and electronic interference issues. In the IALA AIS Guidelines the eighth layer will be referred to as the "Propagation Layer".

- **Propagation Layer:** This layer provides the connection between the information source and the destination. The uncontrolled characteristics of the propagation layer have a significant impact on the design and operation of the layers above it and performance of the overall system. Many of the precautions taken in higher layers are designed to combat problems that exist in this layer.

Each layer communicates with the layers above and below it. *Figure 9-1* shows how these layers can be organized into "stacks." Note that each layer exists at both the transmission and reception side. Each layer in the reception stack must be designed with the detailed knowledge of what the corresponding layer in the transmission stack is doing to the information passing through that layer. It is the detail of this type of information that makes it necessary to use clearly agreed upon methods and standards to implement the AIS functionality and AIS-based applications. It is also important to keep in mind that an unlimited number of reception stacks can be simultaneously receiving the signal produced by a single transmission stack, which is the basic feature of the AIS information broadcast.

The layers on the transmission side may attach headers to the messages as they process them and pass them on to the next lower layers. Each lower layer treats the headers from the levels above it as part of the data that it is forwarding. On the receiver side, as a report is passed to successively higher layers, each layer examines the header applied at the corresponding level on the transmitter side to determine how the particular group of data is to be processed and routed and then removes that header before passing the data on to the next higher level.

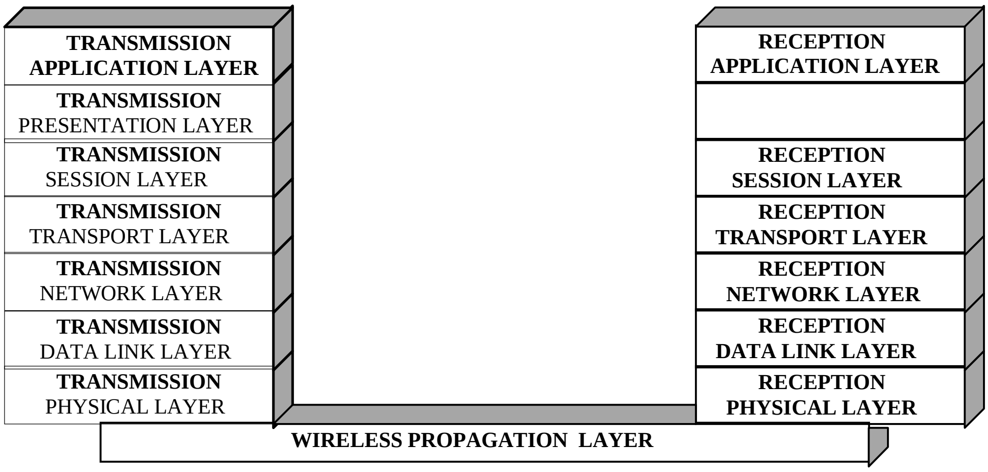


Figure 9-1 - General OSI model stack

9.2.2 The special features of the AIS's "Wireless Propagation Layer" and its impact on the design of the AIS layer stack

In the previous section the bearing of the transport media on the design of the stacks on both transmitting and receiving side has been highlighted. In the case of the AIS the interconnecting radio links operate on two, internationally designated, VHF radio frequencies, AIS1= Channel 87B (161.975 MHz) and AIS2= Channel 88B (162.025 MHz). These frequencies are part of the global maritime mobile radio frequency band (ITU-R Radio Regulations, Appendix S 18) and occupy 25 kHz of bandwidth each.

AIS has been designed to satisfy IMO's requirements for a safety system. Therefore, the AIS must meet high standards in terms of reliability and robustness of the information exchange via the given radio frequencies. On the other hand since a wireless communication means is being used there may be interference on the VHF radio frequencies, both natural and man-made. The characteristics of both the VHF radio propagation and possible interference are well understood due to long standing experience. As a consequence the FM/GMSK (Frequency-Modulation/ Gaussian Minimum Shift Keying) modulation method has been chosen for the AIS radio transmissions because of its robustness, its bandwidth efficiency and its widespread application in mobile digital communications. This compromise between bandwidth efficiency and robustness provides a data transfer rate is of 9600 Bits/s for each frequency utilized.

The safety related information, such as position reports, was required to be available at all receiving stations in the vicinity of the transmitting station simultaneously. The following specific transmission paths were identified:

- Mobile to mobile, e.g. ship to ship or ship to aircraft
- mobile to fixed, e.g. ship to shore
- fixed to mobile, e.g. shore to ship

In order to meet this the requirement for all receivers in the vicinity to receive these messages, the broadcast mode of operation is required.

Additionally, many stations in any given area should be able to access the two available VHF radio frequencies virtually simultaneously without disturbing each other. This required a method for access coordination. There are several access coordination methods to chose from when designing a radio system, in particular frequency division multiple access and time division multiple access. Since there were only a limited number of frequency channels available on a global basis, frequency division multiple access was not an option. Eventually, a Time Division Multiple Access (TDMA) method was selected. The information and control signals that allow the AIS to function as intended are organized in accordance with a highly capable data communications protocol called Self-organizing Time Division Multiplex Access (SOTDMA). The key characteristic of this protocol is that at any one moment only one AIS participant may transmit an information signal (radio transmission burst). This rule is achieved by dividing a minute of time, defined as a frame, into 2250 individual time slots that last only 26.7 m-sec.

While no longer being part of the "Wireless Propagation Layer" but rather of the Physical and Data Link Layers of the OSI model, this mechanism is described here in brief for a better understanding of the technology. Because all AIS stations are continuously synchronized to each other in any given region, they can select, according to certain rules, their own transmission time slots in which they transmit their position reports or other messages as stipulated. Being self-organizing, this rule for accessing (using) the two available AIS frequency channels results in a highly efficient communication medium that can provide a high throughput of information without wasting time for synchronization and reciprocal acknowledgements and confirmation of receipt of transmission. In addition, this protocol has the ability to resolve transmission conflicts (data packet collisions) should these occur as a result of specific circumstances such as high traffic loading conditions. AIS stations continuously synchronize themselves to each other to avoid overlap of slot transmissions. Slot selection by an AIS station is randomised within a defined interval, and tagged with a random time-out of between 3 and 8 minutes. This means that a given AIS station can occupy a given slot for only up to 8 minutes. When an AIS station changes its slot assignment, it pre-announces both the new slot number and the time-out for that slot. In this way AIS stations will always receive new stations, including those AIS stations that relatively quickly come within radio range of other vessels close by. Furthermore, this randomised access scheme prevents a collision situation that may develop from becoming locked-in to a software loop that the AIS itself cannot break from.

Everything which has been said so far results in an actual AIS stack model which slightly differs from the standard OSI model due to the use of two frequencies in parallel: For each of the two frequencies the two lowest layers of the OSI model, the Physical Link Layer and the Data Link Layer, have been implemented in any AIS station as indicated by Figure 9-2.

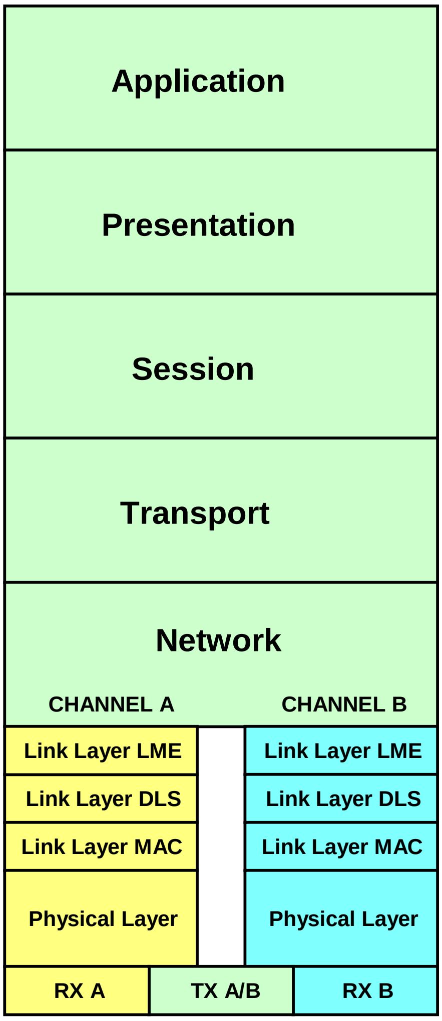


Figure 9-2: AIS stack model
(Please note, that this stack model is in place on every transmitting and receiving side.)

9.2.3 Grouping of AIS-related services and mapping them to the OSI layers

In the introduction section to the OSI model (see above) three different areas of AIS-related services have been identified and have already been grouped together and mapped to certain parts of the OSI model layer stack:
The "application-oriented processes of exchanging AIS-related information" and the "AIS-related support functions" have both been mapped to the top three layers. The "most fundamental processes needed to connect two or more AIS devices and control information flow" have been mapped to the four lowest layers of the layer stack.

For simplicity's sake these three kinds of AIS-related services are named as follows:

- AIS Application Services
- AIS Support Services
- Basic AIS Services.

The different character of the tasks of these AIS-related services can possibly best be understood by analogy with a familiar Personal Computer:

The Basic AIS Services can be compared by analogy with a PC's BIOS.

Upon power-on, the PC boots by virtue of a so-called *Basic Input / Output System (BIOS)*, which normally makes itself visible to the user by a special screen. The BIOS drives the different basic components of the Personal Computer such as the graphical display, the hard disk, the floppy disk etc. The BIOS provides a well defined *logical* interface to the Operating System. The BIOS also hides away from the Operating System the details of the functionality of the basic components and how to access them *physically*. After completion of some initialization tasks the BIOS hands control over to the Operating System and remains at hand for further tasks prompted by the Operating System.

The AIS Support Services can be compared by analogy with a PC's Operating System.

The *Operating System* of a PC provides some higher system management functions such as access of the user to specific data files, to the local area network, to the internet, or start / termination of application processes. The Operating System, however, is not an application, although some common Operating Systems are delivered with basic application software, such as simple text editors, simple games, and simple graphic viewers.

The AIS Application Services can be compared by analogy with the application software of a PC.

The *application software* of the PC, such as a sophisticated word processor, a spread sheet program, or a graphic editor, finally provides the actual usefulness the user wants to achieve with the PC.

It should be noted, that the application software does not constitute the application itself: A calculation software, for instance, does not constitute the accounting. It is just a tool for the accountancy department.

The task now is to group all AIS-related services to the different service levels and by doing so to the corresponding layers of the OSI model. This is done in the consecutive chapters as follows:

1. All available BAS are described in Chapter 10.
2. Some AIS Support Services, as far as they are being developed for this edition of the IALA AIS Guidelines, are described in Chapters 17 (Configuration Management of AIS shore infrastructure), 18 (Processing of AIS Data from multiple base / multiple repeater station environment), 19 (AIS networking on shore side using telecommunication network), and 20 (AIS Long Range Applications).
3. So far, only one highly specialized AIS Application Service has been described in technical terms, i. e. "AIS Long Range applications" in Chapter 20.

9.3 MAPPING OF LAYERS TO CONCRETE DEVICES AND ENTITIES

When it comes to concrete planning for deployment and installation of AIS-based applications, the question arises, which concrete devices and entities contribute to what AIS-related services, as described above.

Since the AIS is a co-operative system, no AIS-related service can be provided by one single device. One device in the transmission-side stack and at least one device in the reception-side stack is needed to provide a service of a certain layer or a group of layers.

Figure 9-3 represents a complete high-level system diagram of the key elements of a functional AIS system. It also provides an overview of the most important concrete devices and entities participating in the AIS. Additionally, it indicates the relationship of the international documents related to the AIS.

The following section introduces an overview of the devices or entities that are performing the various AIS-related functions, and layer or group of layers of the AIS stack introduced above.

9.3.1 Actual AIS devices

All actual AIS devices cover the layers 1 to 4 of the OSI model.
The actual AIS devices are:

- Class A Shipborne Mobile AIS devices, intended for use by vessels subject to a mandatory carriage requirement, either by IMO SOLAS Chapter V or by national / regional legislation, and for use by voluntarily fitted vessels
- Class B Shipborne Mobile AIS devices, mainly intended for pleasure craft
- (Regional) Class A Shipborne Mobile AIS device derivatives, intended for users who are not subject to IMO SOLAS Chapter V mandatory carriage requirement and who still want to benefit from the functionality the Class A Shipborne Mobile AIS device provides (which is superior to the functionality, which a Class B Shipborne Mobile AIS device can provide). Additionally, there may be adaptations to regional needs and / or requirements.
- SAR Aircraft AIS devices
- Aids-to-Navigation AIS devices

All these actual AIS devices given above are considered "mobile" from a functional point of view, regardless of whether they are physically mounted on a fixed structure - such as Aids-to-Navigation (e.g. AIS devices on lighthouses) - or not. The following AIS devices proper are considered "fixed" from a functional point of view, although e. g. a base station may physically be mounted on e. g. an floating Aid-to-Navigation.

- AIS Base Station
- AIS Simplex Repeater Station
- AIS Duplex Repeater Station

9.3.2 AIS Shore Network

The AIS Support Services on the shore side are generated in most cases by entities that reside in the AIS shore network. The AIS shore network is understood to comprise all devices and entities:

- that deliver AIS information from the AIS base stations to the AIS Application Services, which may reside e. g. in one or many VTS centres;
- that control the AIS Basic Services, which are available at or are provided by AIS base stations;
- that perform some or all AIS Support Services, as required.

With regard to sophistication of layout every AIS Shore Network can be scaled between the to of the following possibilities:

- simplest AIS Shore Network layout: just direct communication link from the AIS base station to a shore-based data processing computer (with or without display), which might not even be part of a VTS. In this case, this AIS Shore Network comprises just the devices needed to build up the direct communication link, e.g. a local cable or a point-to-point radio link.
- most complex AIS Shore Network layout: This AIS Shore Network connects a plurality of AIS base stations to a plurality of VTS centres of the same competent authority. Therefore, sophisticated routing and filtering processes are being implemented. However, this AIS Shore Network does not comprise VTMIS services, which are understood to network VTS(s) of different competent authorities.

9.3.3 AIS-based VTS applications

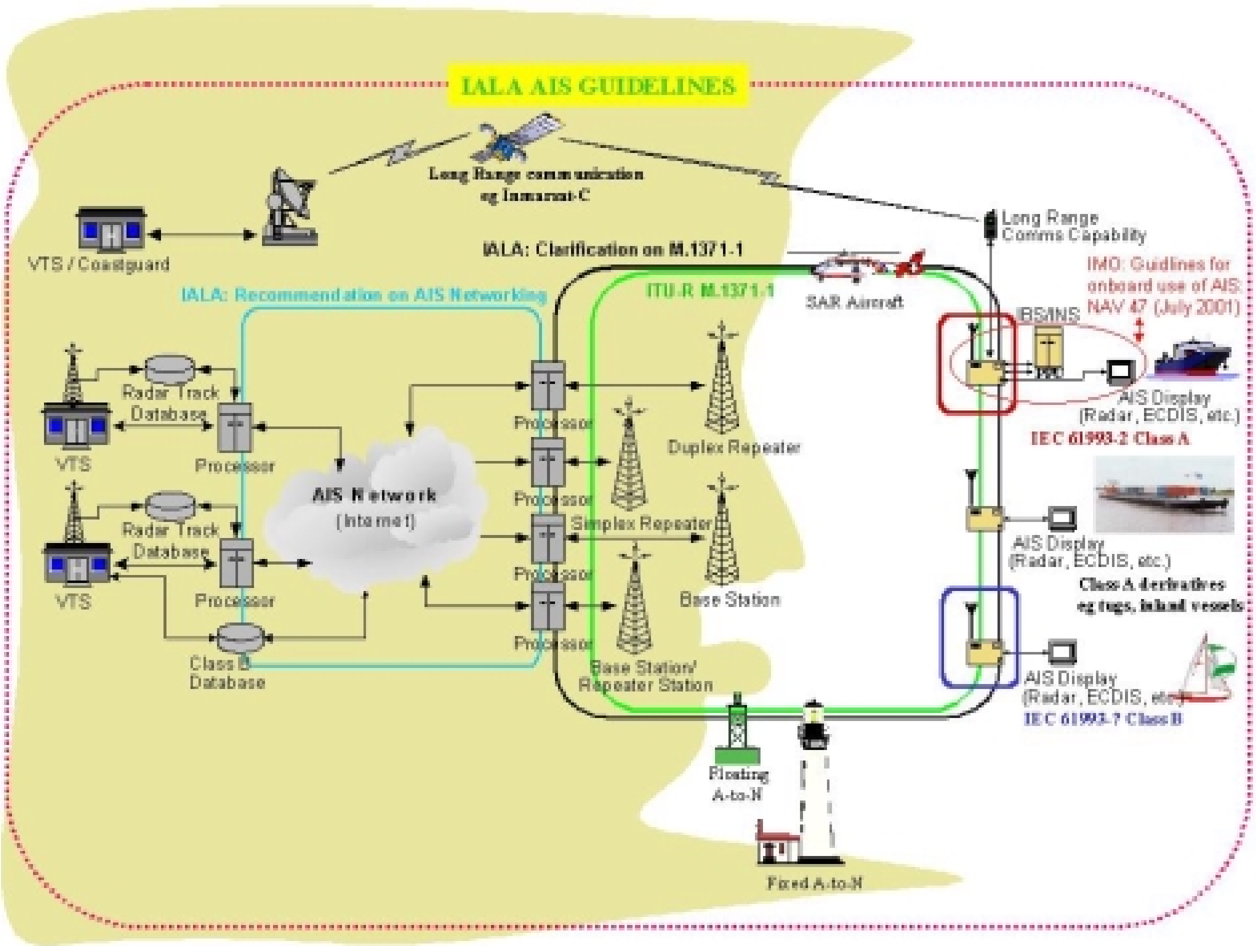


Figure 9-3: High-level system diagram

CHAPTER 10

BASIC AIS SERVICES (BAS)

10.1 INTRODUCTION

The purpose of this chapter is to describe the basic AIS services that support higher levels (in accordance with the ISO/OSI layer model) and applications built using these services. As such, this chapter will be of benefit to manufacturers, system integrators, and users alike. It provides a basic understanding of what services AIS can deliver. What services it cannot deliver, and what are the proper conditions under which the service can be used. It will describe the basic AIS services that support the design of AIS based applications that directly serve the needs of the mariner, vessel traffic service, and littoral state.

To convey this information to the reader, this chapter has been constructed in the following manner:

- List of basic AIS services and
- General service description overview

It should be noted that the details of these Basic AIS Services are located in Annex 3.

10.2 LIST OF BASIC AIS SERVICES

The basic AIS services as shown in List 1 have been derived from the information and recommendations contained in the following documents; IMO MSC.74(69) Annex 3, ITU-R M.1371-1, and IEC 61993-2. To facilitate the description of these services, List 1 is organized with the following sub-headings:

- External Services
- Internal Services
- External and Internal Services
- Recovery Services

External basic services produce, transfer, and accept information to and from higher levels of the ISO/OSI layer model and applications that are not themselves part of the AIS (as explained before the AIS covers the ISO/OSI layers 1 - 4). The functionality of higher level services and AIS applications are built upon the capabilities of these services. Such higher level services and applications are for instance:

- AIS information dissemination
- on-board using automated shipborne information networks
- ashore using AIS shore networking
- integration into shipborne Integrated Navigation System / Integrated Bridge Systems and
- ship and radar data processing of VTS

Internal Services are used by the individual AIS units to support system level operation of the AIS VDL as a whole and coordination between the all AIS units. These services are generally not available external to the AIS.

External and Internal Services are those internal services that are also made available for use by higher levels and external applications.

Recovery Services are internal services that have the specific task of maintaining the integrity of AIS VDL operation.

List 1 - Basic AIS Services

External Basic AIS Services

BAS No. 1: IMO SOLAS Static Information
BAS No. 2: IMO SOLAS Dynamic Information
BAS No. 3: IMO SOLAS Voyage Information
BAS No. 4: IMO Short Safety-related Addressed Messages
BAS No. 5: IMO Safety-related Broadcast Messages
BAS No. 6: Long-range reporting
BAS No. 7: Interface to User and Applications on Ships carrying Class A shipborne mobile AIS device
BAS No. 8: Interrogation via AIS VDL
BAS No. 9: Interrogation via DSC
BAS No. 10: Control slot allocation of one or more AIS stations (not only mobile) via assignment
BAS No. 11: Control reporting rates of one or more AIS stations (not only mobile) via assignment
BAS No. 12: Current vessel status from ships carrying Class B shipborne mobile AIS device
BAS No. 13: Current SAR aircraft status
BAS No. 14: Current AtoN AIS station data
BAS No. 15: Current base station status
BAS No. 16: Determine whether User Display/Keyboard with at least Minimum Keyboard and Display functionality is connected to a/another ship's AIS device (both Class A and Class B shipborne mobile AIS units) using DTE Flag status
BAS No. 17: Broadcast text telegram (IAI FI #0)
BAS No. 18: Addressed text telegram (IAI FI #0)(with and without application acknowledgement)
BAS No. 19: Exchange addressed application specific information with acknowledgement
BAS No. 20: Broadcast of application specific information
BAS No. 21: Exchange higher level and application acknowledgment (IAI FI #1)
BAS No. 22: Interrogate application specific message (IAI FI #2)
BAS No. 23: Capability Negotiation (IAI FI #3+4)
BAS No. 24: Transmit VTS target (IAI FI #16)
BAS No. 25: Advise on waypoints and/or route plan of VTS (IAI FI #18)
BAS No. 26: Provide DGNSS-Corrections via AIS VDL

Internal Basic AIS Services

BAS No. 27: Slot selection and reuse
BAS No. 28: Provide synchronization (UTC Direct, UTC Indirect, and Semaphore)
BAS No. 29: Switch AIS VDL frequencies via AIS VDL
BAS No. 30: Switch AIS VDL frequencies via DSC Channel 70
BAS No. 31: Set transmitter power level of mobile AIS stations
BAS No. 32: Control frequency regions
BAS No. 33: Control transition zone size
BAS No. 34: Use / Evaluate Repeat Indicator
BAS No. 35: Simplex Repeating Process
BAS No. 36: Duplex Repeating Process

BAS No. 37: Pre-processing of multiple report reception from VDL

External and Internal Basic AIS Services

BAS No. 38: Build in Integrity Test (BIIT)
BAS No. 39: Security protection
BAS No. 40: FATDMA slot management

Recovery Basic AIS Services

BAS No. 41: Management of Channel loss
BAS No. 42: Management of VDL capacity

10.3 STRUCTURE OF SERVICE DESCRIPTIONS

To facilitate the uniform description of each of the services identified in List 1 - Basic AIS Services (section 4.2) the following format is used.

Service Description

Service Overview

1. **Service Name:**
2. **Purpose and General Description:**
   "Who, what, where, when, and why? - newspaper like description"
   Early decision, "How do we want to pitch this service?"
   Define and describe the service
   What does the service deliver?
   Why is this service important?
   Brief description of service products/benefits
   When/where is this service used?
   Circumstances under which this service should not be used?
3. **Use:**
   Recommendations concerning exploitation of this service. This service could be used to support the following applications: (missions, operations, surveillance,...)
4. **Risks:**
   What are risks - business, safety, technical,...?
   How significant is their impact?
   Are there measures that can limit the negative effects?
   [when using this service mistakenly or with wrong data.
   Evaluation of these risks.
   Possible measures (on higher levels) that can be used to limit possible negative effects of risks]
5. **Operation and Support:**
   Describe start ("trigger event"), support [dependencies, external, internal, ...], *and end of this service*
   Prior Initialization needed for this BAS
   Time
   Location
   Platform condition change
   Interdependence of this BAS [service] with another [internal service] BAS

Service Details

6. **Operating Characteristics:**
   Timing and behaviour with regard to time
   Queuing delays
   Conditional behaviour
   Time of Generation
   Time elapsed since Transmission *(e.g. aboard) to Reception at point of use (e.g. VTS Centre) =* ***Latency*** *issues*
   Update Interval
7. **Information:**
   - ***Detail of service products and support, Data formats, and Data Content - explicit and / or implicit***
     - *example for <u>explicit</u> information: Latitude in degrees; data format: integer value between ...*
     - *example for <u>implicit</u> information: Use of Message #3 instead of Message #1 indicates that the source AIS now operates in assigned mode = implicit acknowledgement of Assigned Mode Command from Base Station*
   - ***Shipboard generation of data item:*** *Automatic generation using sources internal to the shipborne AIS; automatic generation using sources external to the shipborne AIS; manual input at installation; manual input during voyage, etc.*
   - ***Resolution and / or accuracy of Data Content*** *(e.g. +/- ... m; binary; etc.)*
   - ***Default Value of Data Item***
   - ***Messages of M.1371-1 used*** *to realise this BAS*
   - ***Integrity precautions taken when generated automatically***
   - ***Estimated reliability of information with regard to generation of that data item:*** *high, low, etc. (from the recipient's point of view)*
   - ***Implicit or explicit integrity information transmitted***
8. **Consequential fault conditions:**
   technical
9. **Shipboard/shore prerequisites for use:**
   - ***Technical***
     [examples: DTE (date terminal equipment), AIS unit revision, AIS class A/B/base, external application specific capabilities,...]
   - ***Regulatory***
     [examples: ...?]
10. **Side effects:**
    - *positive*
    - *negative*
11. **Fall back arrangements to other AIS services**
    List in a priority scheme
12. **Possibilities / necessity to indicate to higher level state of BAS performance**

13. **Logging possibilities:**

CHAPTER 11

CHANNEL MANAGEMENT

11.1 OVERVIEW OF CHAPTER LAYOUT

Every aspect of channel management is not well understood at this stage of the development of the AIS. This chapter provides an *introduction* to Channel Management for competent authorities. Some recommendations will be derived at the end of the chapter.

A section introducing most fundamental definitions and concepts is presented first, This introduction starts with the mobile AIS station and assumes that it is this station has to operate in accordance with regional operating settings that are different from the default operating settings. It then moves on to the consequential requirements for the shore infrastructure set up by the competent authority.

11.2 INTRODUCTION AND FUNDAMENTAL CONCEPTS

In response to a request from IMO seeking global channels for AIS, the ITU designated two worldwide channels from the VHF maritime mobile band for this purpose (refer to ITU-R Radio Regulations (RR) Appendix S18). The channels are AIS1 – No. 2087 (161.975 MHz) and AIS2 – No. 2088 (162.025 MHz) - with 25kHz bandwidth, and in accordance with Recommendation ITU-R M.1084. Two channels were selected to increase capacity and mitigate Radio Frequency (RF) interference. AIS1 is the "primary channel" and AIS2 the "secondary channel" in "high seas" areas. This distinction will become relevant when considering some details of the transition between regions.

By default every mobile AIS station operates on these two channels, AIS 1 and AIS 2, as defined in Recommendation ITU-R M1371-1. A mobile AIS station is thus capable of receiving two messages, from two different stations concurrently, provided that it does not transmit at the same time. Every mobile AIS station transmits at its "*nominal reporting rate*". This nominal reporting rate is given in tables for the respective class of mobile AIS station (refer to the appropriate chapters of these AIS Guidelines). *Each of the two channels by default is used to transmit scheduled transmissions*, such as autonomous and continuous position reports, *at half of the "nominal reporting rate."* E. g. a Class A shipborne mobile AIS station moving at a speed of more than 14 knots is supposed to report its position in intervals of 2 seconds. Therefore the nominal reporting rate would be once per two seconds. This means, that each of the two channels AIS1 and AIS2 will receive a scheduled position report from this mobile AIS station once every four seconds, i. e. at half the rate of the nominal reporting rate. To understand this fact is crucial for the understanding of the impact of channel management on reporting rates. This behaviour is called dual channel operation.

11.2.1 Reasons for Channel Management

The ITU also provided for administrations to designate "regional frequency channels for AIS" *where channels 2087 and 2088 are unavailable* and, if necessary, to derive new S18 channels using Recommendation ITU-R M.1084 (simplex use of duplex channels and/or 12.5 kHz narrow-band channels).

In addition channel management may be used to mitigate throughput breakdown caused by (local) RF interference on or blocking of one or both of the default operating channels by locally switching over to alternate operating channels.

A channel management scheme is also required when duplex AIS repeaters are used. The justification for duplex repeating may be derived from local unavailability of the default operating channels.

11.2.2 Parameters subject to channel management and their default settings

The following operating parameters (of any mobile AIS station) may be changed by channel management. Also their default setting and range of possible settings are given (see Recommendation ITU-R M.1371-1, Annex 2, §4.1):

- frequency / nominal bandwidth of the primary operating channel = channel A (as expressed by channel number in accordance with Recommendation ITU-R M.1084).
  Default: channel number 2087 = AIS1, 25 kHz bandwidth
  Possible range: all channels of 25kHz or 12.5kHz nominal bandwidth which can be identified by a channel number given in Recommendation ITU-R M.1084. Local possibilities may be depending on regulatory considerations.
- frequency / nominal bandwidth of the secondary operating channel = channel B.
  Default: channel number 2088 = AIS2, 25 kHz bandwidth
  Possible range: refer to primary operating channel
- Transmitter power level setting
  Default: high power level setting
  Possible range: low power level setting = 2W; high power level settings = 12.5W
- Transmit/Receive mode:
  Default: Dual channel operation (receive on both channels A and B simultaneously; transmit on channels A and B alternately, using half the nominal reporting rate on both channels A and B. Assigned mode may change the reporting rate of a mobile station without affecting the use of dual channels alternately.) = TxA/TxB; RxA/RxB
  Possible range:
  (TxA/TxB, RxA/RxB);
  (TxA, RxA/RxB) = transmit only on primary operating channel (channel A) and receive on both channels simultaneously (while not transmitting);
  (TxB, RxA/RxB) = transmit only on secondary operating channel (channel B) and receive on both channels simultaneously (while not transmitting);
- Narrow-band mode for primary channel A:
  Default: nominal bandwidth as specified by channel number (see above)
  Possible range: nominal bandwidth as specified by channel number; reduced to 12.5 kHz (when channel number designates a channel with 25kHz nominal bandwidth)
  Note: It should be observed that the optional use of 12.5 kHz bandwidth reduces somewhat the receiver sensitivity and FM discrimination (slot sharing capability), but still gives the required transmission rate of 9600 bits per second.
- Narrow-band mode for secondary channel B: refer to Narrow-band mode for primary channel A
- Transition zone size:

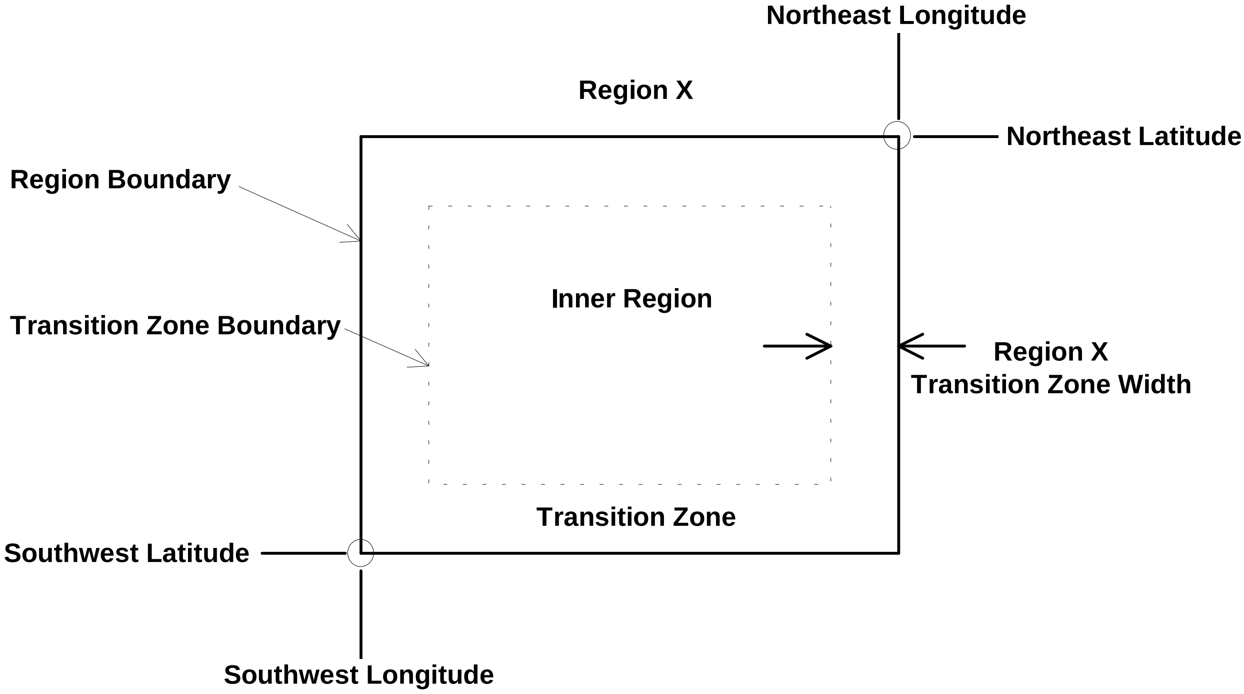


Figure 11-1 - Rectangular representation of a region and its components.

Default: 5 nautical miles
Possible range: 1 to 8 nautical miles in steps of 1 nautical mile

- <u>Addressed mode:</u> A base station can command specific channel management behaviour, using the above parameters, to an individual mobile AIS station.
- <u>Geographical region:</u> Region defining latitudes and longitudes - not only do these values establish the location and size of the region, they are also used to identify the region and the station characteristics data for that region. See below.

Channel management is performed, when mobile AIS stations are switched from their default operating settings to any different operating setting, which may only differ in one parameter.

The whole set of channel management settings and region specification is called *"regional operating settings"*.

The above list highlights that channel management is not just about changing operating frequencies. *Channel management should rather be understood as a walk in a multi-dimensional channel parameter space*. The complexity of channel management results from the many inter-dependencies between these parameters.

11.2.3 The definition of a region and its transitional zone

Depending upon the geographic location of the station and the regional operating settings stored in memory, a mobile AIS station is supposed to automatically change several fundamental operating characteristics from their default values. This feature is designed into the operation of every mobile AIS station. This feature allows local authorities to automatically manage mobile AIS stations' use of the VHF marine band.

Channel management data is organised by geographic regions. This section describes how these geographic regions are defined. In fact, channel management in effect is *only* possible within *precisely defined geographical regions*. This means, that any channel management operation applies to the specified region, only. Mobile stations outside all regions, to which channel management settings apply, will stay in or return to the default settings.

The regional operating areas are designated by a Mercator projection rectangle with two reference points using WGS84 datum. The first reference point is the geographical co-ordinate address of the north-eastern corner (to the nearest tenth of a minute) and the second point is the geographical co-ordinate address of the south-western corner (to the nearest tenth of a minute) of the rectangle. Since it is an area on the curved surface of the earth, a region is not a true rectangle in shape. The sides of the region follow either constant latitude or longitude lines. A rectangular representation of this area is shown in Figure 11-1.

Inside every region's boundary there exists a "transition zone." The width of the transition zone is also part of the data that defines the region. The transition zone for a region is the area between the "Transition Zone Boundary" and "Region Boundary" as shown in Figure 11-1. The transition zone width is specified in increments of one nautical mile and range of one to eight nautical miles. If no value is given in the region's definition, the default width is five nautical miles. The zone size is the same on the 4 inside boarders of a region.

While the transition zone is expressively defined in ITU-R M.1371-1, the portion of the region that is not inside the transition zone is not given a special name. In order to simplify the discussion below, the term "Inner Region" will be used to refer to the portion of a region that is not the transition zone. This means that the area of a region can be described as being equal to the area of the transition zone plus the area of the inner region.

When the mobile AIS station receives different channel management commands for the same geographical region, the information received latest will be used in accordance with an algorithm described below.

Any Class A shipborne mobile AIS station can internally store information for eight different regions. This gives the possibility to “download” to Class A shipborne mobile AIS stations information for several regions (for example covering inland waterways) from one shore station.

The AIS automatically changes to a transitional mode of operation when it is within the specified transitional zone which surrounds the region boundaries. In this zone ships transmit and receive on one of the channels for the area it is leaving and one of the channels for the area it is entering. Within the transitional zone, the reporting rate will be the nominal reporting rate for *both* channels (as opposed to just half the nominal reporting rate in each individual channel during default dual channel operation).

Within the transitional zone, Class A shipborne mobile AIS stations will ignore any assignment of higher nominal reporting rates by shore stations. This guarantees that the broadcasts of mobile AIS stations operating in the transition zone will be received at nominal reporting rate for the benefit of other mobile stations in the immediate vicinity of that station.

The precise details of the behaviour of a mobile AIS station within a transition zone are described below.

11.2.4 A Region's relationship to the high seas (or default) region

The "high seas" or default region has the primary channel of AIS1, and the secondary channel of AIS2 with a bandwidth of 25kHz on both channels. The size of the transition zone is 5 nautical miles. The power level is "high power" and all of the mobile AIS station‘s receivers and the frequency-agile transmitter are used. Figure 11-2 shows the relationship of the Figure 11-1, Region X, and the high seas region.

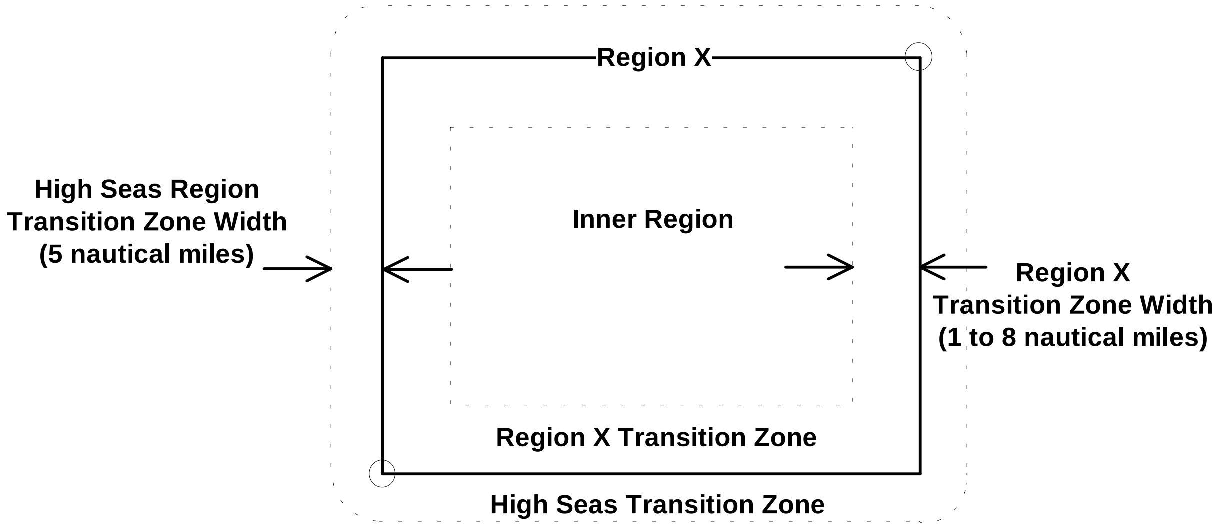


Figure 11-2 - Relationship of region X to the High Seas Region.

The high seas region's regional operating settings are all equal to the default values. They cannot be changed by channel management. Channel management data can only create additional regions that exist within the high seas region. Wherever a defined region is created, if not adjacent to another defined region, this relationship with the high seas region is automatically created.[5]

11.2.5 Two Regions' relationship including the High Seas Region

If two regions are defined with either a latitude or longitude boundary exactly the same, to 1/10 minute, the two regions exist adjacent to each other, see the common side of Region X and Region Y in Figure 11-3. If the boundary of a region falls inside the boundary of another region, the regions conflict and a decision about which to region to use must be made by the mobile AIS station. Recommendation ITU-R M.1371-1, § 4.1.8, states, "*The most current and applicable commands received should override previous channel management commands."* Applying this rule would mean the more current regional definition would apply and the older definition ignored. This also implies that the data and time that a region's data is received should be retained along with the region's data.

Figure 11-3 shows two adjacent regions, Region X and Region Y, surrounded by the high seas region. The Region X transition zone is further broken down into zone 1 and zone 2. Zone 1 is the portion of the Region X transition zone nearest to the boundary in common with Region Y. Zone 2 is the portion of the Region X transition zone nearest to the boundary in common with the high seas region. Recognition, that the transition zone may be sub-divided depending on the relationship it has with adjacent regions, is key to understanding how a mobile AIS station will safely operate as it travels between and among regions that use different radio frequencies, signal bandwidths, power, etc. In a similar fashion, the Region Y transition zone is broken down into zone 3 and zone 4; and the high seas region's transition zone is broken down into zone 5 and zone 6.

[5] Note: There is a slight ambiguity at the corners of the High Seas Transition Zone Boundary. Figure 11-2 is drawn using the 5 nautical mile distance from the region X boundary. Some equipment designers may use lines of constant latitude and longitude that are 5 nautical miles from the region X boundary. This would result in 90 degree corners rather than constant radius corners. These optional interpretations do not represent a significant operational safety issue. Because accurate curved lines are difficult to draw, the remaining diagrams will use "square" corners on the high seas transition zone boundary - with this ambiguity implied.

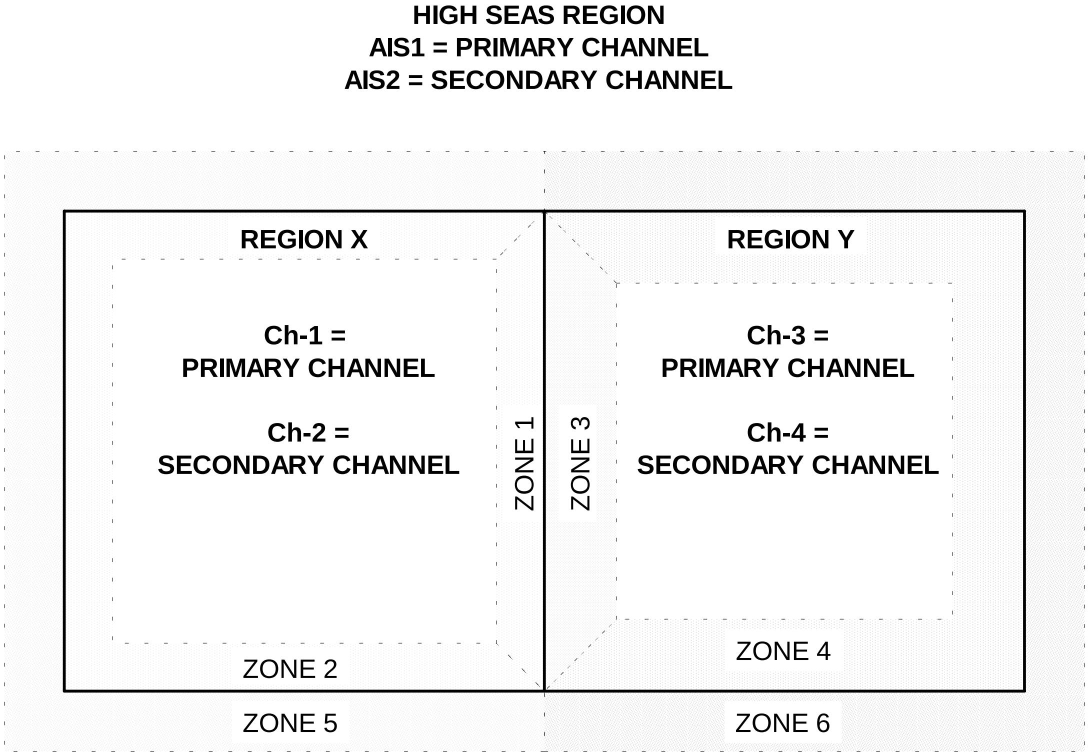


Figure 11-3 - Breakdown of operating zones for two adjacent regions.

How a mobile AIS station will safely operate as it travels between and among regions will be described in detail below, using the above definitions.

11.2.6 IMO requires maximum extent of automated channel management

The AIS is designed as an automatic system. Accordingly, even operating conditions that differ from the default, *such as channel management should be automated as much as possible*. This is in full accordance with the appropriate IMO guidance (refer to IMO/NAV47 "Draft Liaison Statement to ITU-R Working Party 8B", which is Annex 15 of document NAV47/13, 26 July 2001, paragraph 1.2):

> "IMO notes that there may be areas where alternative frequencies are in use but where no base stations exist. This should be an unusual situation, however where it exists, information should be available to all ships sailing in these areas. Therefore, IMO requests that all Administrations notify IMO of these areas for the circulation by the appropriate IMO circulars as well as promulgate this information to shipping in these areas by a suitable means. Also IMO recognises that from the viewpoint of avoiding accidents due to human error, automatic switching should be the normal procedure and manual switching should be limited to specific purposes such as maintenance for the equipment."

This statement clearly applies to both shipboard and shore side.

11.2.7 Overview on means for automatic and manual channel management

Automatic switching of regional operating settings for mobile AIS stations can be done by one of the three means described below. Automatic switching is considered a safer way than manual switching. Among the automatic means, there are two ways to switch regional operating settings from the shore by the competent authority and one automated way to switch regional operating settings on board the ship.

A competent authority may set up AIS shore stations utilising Basic AIS Service "Switch AIS VDL channels via AIS VDL", that uses Message 22 ("Channel Management message") and that gives information of region boundaries, channels and other parameters to be used within the region. The Basic AIS Service “Switch AIS VDL channels via DSC Channel 70” can also be used for this purpose.

In addition, a shipborne information system, which may be connected to the AIS, may input regional operating settings to the AIS. This information may be derived automatically from i.e. a database or from a manual input to this shipborne information system.

Manual channel switching by the AIS operator on the ship can be performed via any suitable interface. The Class A shipborne mobile AIS station provides for manual inputs via the Minimum Keyboard and Display.

Manual channel switching should be avoided if possible in normal operation and should only be based on information issued by the competent authority of that region (compare IMO statement).

The database of the shipborne information system may not fully reflect the current regional operating settings required for the particular region, or the manual input may be flawed. Therefore, regional operating settings received from a shipborne information system or by manual input, will not be accepted by a Class A shipborne mobile AIS station, if a regional operating setting was received for the same region from a shore station recently.

11.2.8 Channel management as a privilege and as a responsibility for competent authorities

Since the exchange of navigational data between ships and between ship and shore can only be done when both the transmitting and the receiving station use the same channel with compatible operating settings, *a wrong operating setting in just one mobile AIS station may result in it being “invisible” as far as the AIS is concerned*. This may be a safety issue. Therefore, *ITU only allowed competent authorities to do channel management.*

Since channel management is one of the most complex functionality of the whole of the AIS and since channel management, when done wrongly, thus can be potential hazardous to safety, it is strongly recommend that every competent authority should consider the use of channel management carefully before implementing it: *Careful planning is required before a Competent Authority implements a Channel Management scheme.*

11.3 CHANNEL MANAGEMENT COMMANDS TO A CLASS A SHIPBORNE MOBILE AIS STATION

All Class A shipborne mobile AIS stations are using the following algorithm to keep the internal eight store memory up to date and to accept new regional operating settings. This algorithm, in general, has three different stages:

1. continuous checking of store regional operating settings, and possibly automatic erasure of remote or old settings.
2. checking of input before accepting it as new regional operating settings. It should be noted, that this is an exception from one fundamental concept of shipborne equipment design, i. e. that the receiving device normally does not check the data it is receiving. For example, the mobile AIS station does not check the sensor data it receives for reporting.

3. operations performed after a new regional operating setting has been accepted.

In detail the Class A shipborne mobile AIS station will perform the following steps (in the following order, if applicable):

1. All stored regional operating settings will be time/date-tagged and they will be tagged with information by what input means this regional operating setting was received onboard (via AIS VDL, DSC telecommand, Manual input via Minimum Keyboard and Display (MKD), input via Presentation Interface).
2. The Class A shipborne mobile AIS station constantly checks, if the nearest boundary of the region of any stored regional operating setting is more than 500 miles away from the current position of its own position, or if any stored regional operating setting was older than five weeks. Any stored regional operating setting which fulfils any one of these conditions will be erased from the memory. This means, that the AIS station automatically “forgets”.
3. Any regional operating settings will be handled as a whole, i. e. a change requested for any parameter of the regional operating settings will be interpreted as a new regional operating setting input to the device.
4. When the mariner requests to manually input a regional operating setting via the MKD, the regional operating settings in use, which may be the default operating settings, will be presented to the user on the MKD. The mariner will then be allowed to edit these settings partly or in full. The Class A shipborne mobile AIS station will ensure, that a region is always input and that it conforms to the most fundamental rules for regions. After completion of input of an acceptable regional operating settings set, the Class A shipborne AIS station will require the mariner to confirm a second time that the input data shall be stored and possibly used instantaneously.
5. Regardless of means of input, automatic or manual, the Class A shipborne AIS station will not accept, i. e. ignore, any new regional operating setting which includes a region, which does not conform to the most fundamental rules for regions. In addition, it will not accept a new regional operating setting, which was input to it via its Presentation Interface (interface to other shipboard equipment; see following chapters), if the region of this new regional operating setting partly or totally overlaps or matches the regions of any of the stored regional operating settings, which were received from a base station via AIS VDL or by DSC telecommand within the last two hours.
6. An channel management command or a DSC telecommand addressed to one individual Class A shipborne mobile AIS station will be accepted only if the Class A shipborne mobile AIS station is in a region defined by one of the stored regional operating settings. In this case the set of regional operating settings will be composed by combining the received parameters with the region in use. An channel management command addressed to an individual Class A shipborne mobile AIS station will not be accepted for the high seas area.
7. If the region of the new, accepted regional operating setting overlaps in part or in total or matches the region of one or more older regional operating settings, this or these older regions will be erased instantaneously from the memory (“overlap” rule). The region of the new, accepted regional operating setting may be neighbouring tightly and may thus have the same boundaries as older regional

operating settings. This will not lead to the erasure of the older regional operating settings.

8. Subsequently the Class A shipborne mobile AIS station will store a new, accepted regional operating setting in one free memory location of the eight memories for regional operating settings. If there is no free memory location, the oldest regional operating setting will be replaced by the new, accepted one.
9. No means other then defined herein are allowed to clear any or all of the stored regional operating settings of the Class A shipborne AIS station. In particular, it is not possible to solely clear any or all of the stored regional operating settings by a manual input via the MKD or by an input via the Presentation Interface without input of a new regional operating setting.

There is not yet a similar algorithm developed for other classes of mobile equipment, except the most fundamental rules in Recommendation ITU-R M.1371-1. The IEC has begun work on Class B standardisation, however. IALA will begin work on A-to-N AIS stations in 2002.

11.4 BEHAVIOUR OF A SHIPBORNE MOBILE AIS STATION ENTERING OR MOVING IN A CHANNEL MANAGEMENT SCHEME

When a mobile AIS station enters a transition zone, it changes operation to the "two-channel transitional operating mode." How the mobile AIS station operates among zones and regions will now be discussed. In particular, how the mobile AIS station schedules periodic repeated messages.

"Two-channel transitional operating mode" is entered when there is a change of either operating frequency or bandwidth, or both, from one region to the next. This mode of operation begins when a transition zone is entered. There are three exceptions to this rule:

1. If the regional operating settings in both regions use the same channels and bandwidths, operation in the "two-channel transitional operating mode" is not necessary. However, when the region boundaries are crossed, there may be an internal "virtual switch" of the primary and secondary channel designations within the mobile AIS station2. If the primary channel is the same in both regions, the mobile AIS station should use only that single primary channel at nominal reporting rate while operating in the "two-channel transitional operating mode."3. If the primary channel in one region is the same as the secondary channel in the other region and that secondary channel is a simplex channel, the mobile AIS station should use only that channel at the nominal reporting rate while operating in the "two-channel transitional operating mode."

11.4.1 Description of mobile AIS station operation in the "two-channel transitional operating mode"

The following describes the operation of a mobile AIS station as it moves between Regions X and Y through zones 1 and 3 of Figure 11-3. The possible movements of the station are shown in Figure 11-4 with notes describing changes to the stations operation.

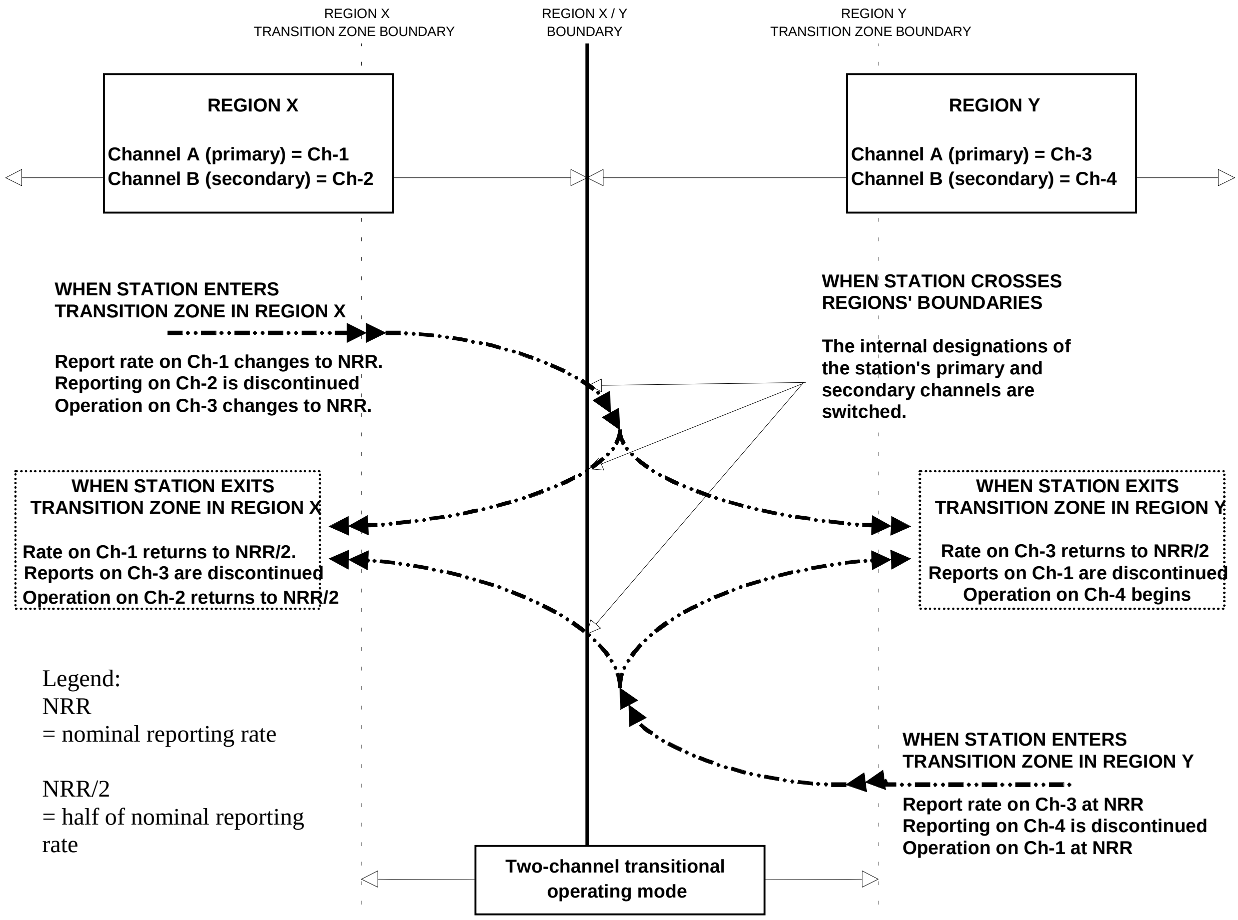


Figure 11-4 - Expected operation of a mobile AIS station in "two-channel transitional operating mode"

Upon entering the transition zones between two regions, the mobile AIS station should switch to the "two-channel transitional operating mode" by:

1. Switching the secondary receiver channel to the primary channel of the adjacent region and begin initialisation phase, while
2. Continuing to broadcast and receive on the primary channel (channel A) for the occupied region for one minute, and broadcast on the secondary channel (channel B) for one minute closing out the previously reserved slots,
3. Increasing the reporting rate on channel A to the nominal reporting rate after the first minute,
4. Beginning broadcasts on the adjacent region's primary channel - at the nominal reporting rate.

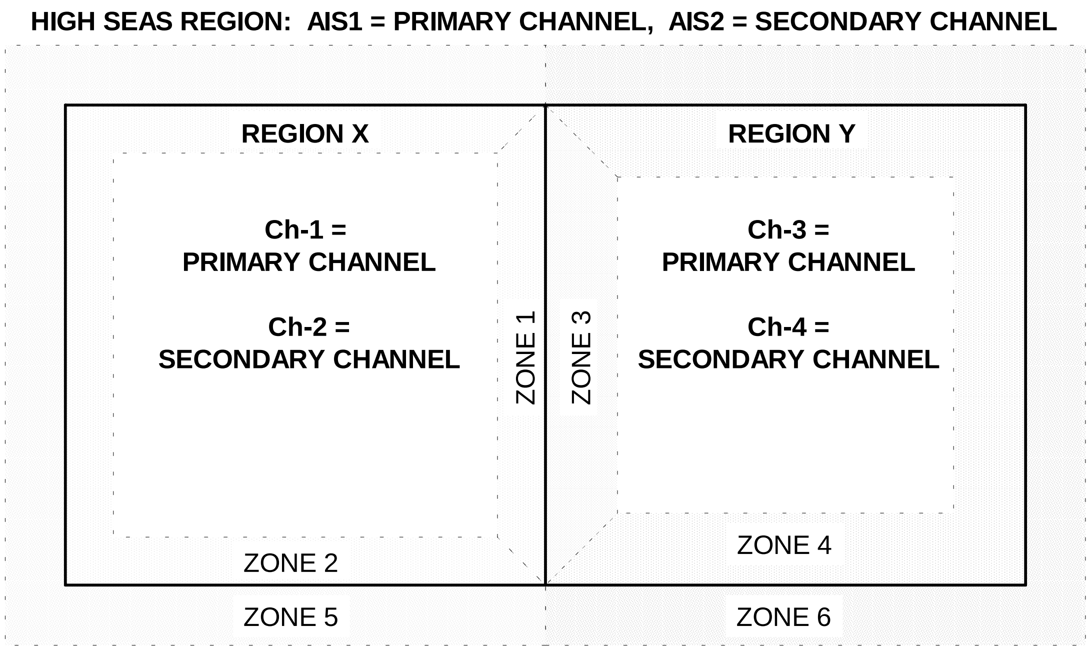
Note: While inside the transition zones, the mobile AIS station's primary channel (channel A) is defined as the primary channel for the region that the mobile AIS station is inside at any given moment. The mobile AIS station should use this rule to change the primary channel, as needed, while it is in the "two-channel transitional operating mode." While inside the transition zones, the mobile AIS station's secondary channel (channel B) is defined to be the primary channel (channel A) of the nearest adjacent region. This rule should be used, as needed, to change the secondary channel while the mobile AIS station is in the "two-channel transitional operating mode."

Upon exit of the transition zones, the mobile AIS station should discontinue "two-channel transitional operating mode" by:

5. Switching the secondary receiver channel to the secondary channel of the occupied region and begin initialisation phase,
6. Decreasing the reporting rate on the primary channel (channel A) for the occupied region to half of the normal channel reporting rate (This will take about one minute.), and broadcast on the secondary channel (channel B) for one minute closing out the previously reserved slots,
7. Beginning broadcast on the secondary channel - at half of the nominal reporting rate.

11.4.2 Operation of a mobile AIS station moving between and among three regions

The description of mobile AIS station operation during movement between two regions can be used to describe more complex relationships. As described above, once a mobile AIS station enters the transition zone, it operates at nominal reporting rate on both the primary channel for the region it is in, and the primary channel for the next closest region. This is the rule used to draw the zones of Figure 11-5. Figure 11-5 contains both Figure 11-3 and a table indicating the proper operating channels for each of the zones in the figure.



Location of mobile AIS station	Double rate primary channel	Double rate secondary channel
ZONE 1	Ch-1	Ch-3
ZONE 2	Ch-1	AIS1
ZONE 3	Ch-3	Ch-1
ZONE 4	Ch-3	AIS1
ZONE 5	AIS1	Ch-1
ZONE 6	AIS1	Ch-3

Figure 11-5 - Channel selection for transition zone operation.

Using the table in Figure 11-5 and the concepts described in Figure 11-4, the operation of a mobile AIS station can be described for any of the possible tracks between and among the three regions of Figure 11-5. For example, if the station enters zone 1, crosses into zone 3, travels down zone 3 and crosses into zone 4, continues into zone 6, and exits into the high seas region, the following channel combinations well be used (first channel is "primary" / second is "secondary"):

1. Start in Region X, Ch-1 / Ch-2,
2. Enter zone 1, nominal reporting rate on Ch-1 / Ch-2 replaced by Ch-3 at nominal reporting rate,
3. Cross into zone 3, nominal reporting rate on Ch-3 / nominal reporting rate on Ch-1; a virtual switch of channel designations,
4. Cross into zone 4, nominal reporting rate on Ch-3 / Ch-1 replaced by nominal reporting rate AIS1,
5. Cross into zone 6, nominal reporting rate AIS1 / nominal reporting rate Ch-3; a virtual switch of channel designations,
6. Exit into high seas, half of the nominal reporting rate AIS1 / Ch-3 replaced by half the nominal reporting rate AIS2.

Other examples can be similarly constructed and analyzed. Under all combinations and circumstances, the station must have one channel in common with nearby stations.

11.4.3 Single-channel operation

The possibility of single-channel AIS operation is briefly addressed under the parameter Tx/Rx Mode. Little, if any, information is given elsewhere in the ITU recommendations. Conditions that may warrant single-channel operation include limited, continued operation after a duplex repeater failure, areas with severe spectrum limitations, and remote waterways with little marine traffic.

If the Region Y secondary channel (Ch-4) is not defined, Figure 11-5 can be used to describe how the mobile AIS station should operate as it moves from any location in Figure 11-5 into the inner region of Region Y. For example, if the mobile AIS station moved from Region X to Region Y, the sequence of channels used might be the following (first channel is "primary" / second is "secondary"):

1. Start in Region X, Ch-1 / Ch-2,
2. Enter zone 1, nominal reporting rate on Ch-1 / Ch-2 replaced by Ch-3 on nominal reporting rate,
3. Cross into zone 3, nominal reporting rate on Ch-3 / nominal reporting rate on Ch-1; virtual switch of channel designations,
4. Exit into Region Y's inner region, continue nominal reporting rate Ch-3 / discontinue Ch-1.

11.5 REQUIREMENTS AND RECOMMENDATIONS FOR COMPETENT AUTHORITIES WITH REGARD TO CHANNEL MANAGEMENT

After this description on how the mobile stations operate within a given frequency management scheme, it becomes obvious, that *the regional operating settings should be set up by the competent authority in such a way that the transition between the different regions is safe. The onus for a safe and proper channel management is on the competent authority.*

11.5.1 Fundamental layout rules for when planning regions

In order to fulfil this requirement the competent authority should make sure that the following conditions are met (requirements taken directly from Recommendation ITU-R M.1371-1 or inferred from description above):

1. Regions should be *as large as possible*. For practical reasons, in order to provide safe transitions between regions, these should not be smaller than 20 nautical miles but not larger than 200 nautical miles on any boundary side. (from ITU-R M.1371-1)

2. The boundaries of each region, *which are meant to be adjacent to each other in the strict sense of the word, should be identical*. A “small” gap between “adjacent” regions, however small, will be interpreted by mobile AIS stations as a combination of three regions in total: two regions with regional operating settings different from default separated by “high sea”, i. e. by a region with default settings. Therefore, the mobile station will enter the transition zone behaviour of

three different regions when moving from one region to the other through the alleged region with default settings.

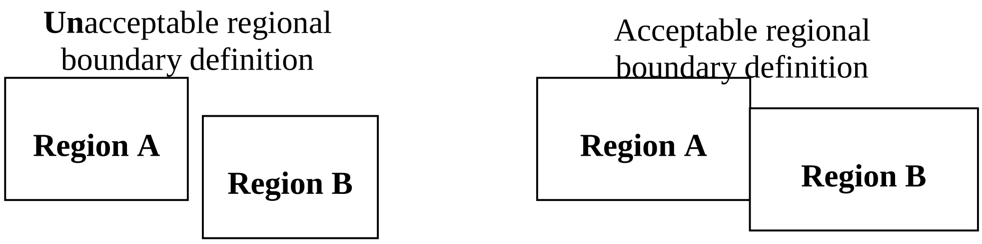


Figure 11-6

3. The distance between regions, *which are meant to be neighbouring, but not to be strictly adjacent*, should be at least the sum of the size of the transition zones of the two regions plus one nautical mile.

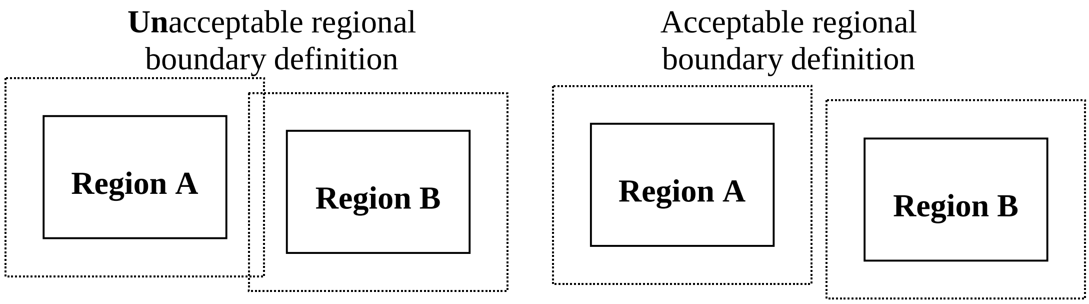


Figure 11-7

4. Having more than three adjacent regions at any regional boundary intersection must be avoided. In this context, the high seas area should be considered to be a region where default operating settings apply. When there are three or more adjacent regions, the minimum distance between the first and the second adjacent corners on one side and any other corner should be at least 8 nautical miles (which is the maximum size of a transition zone). This 8-miles-distance rule will be checked by the Class A shipborne mobile station before accepting a new regional operating setting.

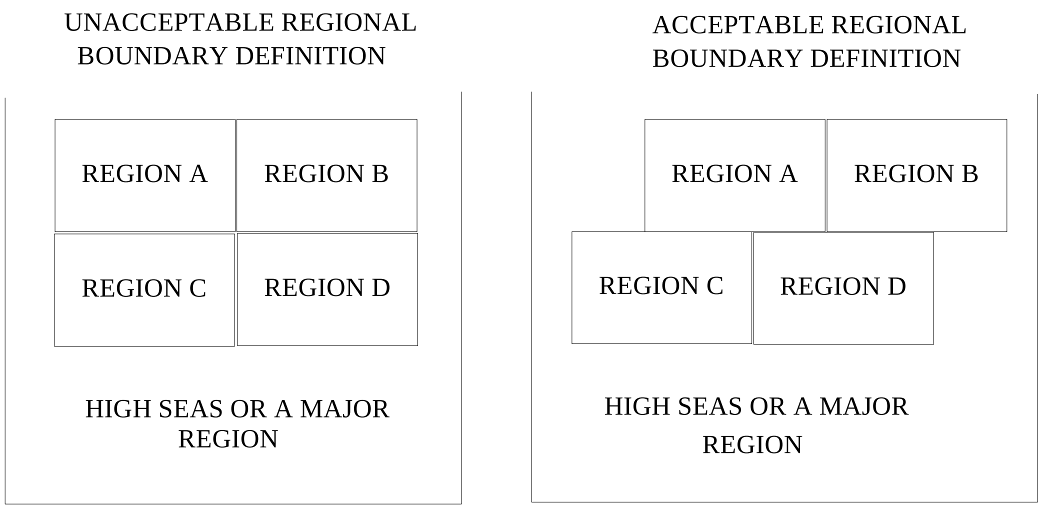


Figure 11-8

The region rules and general operation of the mobile AIS station are designed to successfully operate under the "worse case" conditions where every channel in every region is different. Although the AIS technology and methods adequately deal with these possible conditions, the actual application of channel management should recognise that AIS channel management is the safest when the primary channel of the regions is either AIS1 or AIS2.

11.5.2 Channel management by automatic means, i. e. by base stations

It is strongly recommended – in full accordance with the IMO guidance cited above - *that all areas where the default operating settings does not apply should be covered by AIS shore stations* utilising Basic AIS Service “Switch AIS VDL channels via AIS VDL”, that uses Message 22 (“Channel Management message”), and that gives information of region boundaries, channels and other parameters to be used within the region. The Basic AIS Service “Switch AIS VDL channels via DSC Channel 70” can also be used for this purpose.

Base Stations that provide service in regional operating areas should use one of the above Basic AIS Services *also for all regions surrounding the actual regional areas.*

It is recommended that Basic AIS Service “Switch AIS VDL channels via AIS VDL” should be used by a competent authority for all regions *at least every 10 minutes*. The actual rate should *depend upon the speed of vessels within regional transition zones*.

With regard to the Basic AIS Service “Switch AIS VDL channels via DSC Channel 70” similar considerations should take place. It should be noted, however, that the ITU restricts the use of DSC Channel 70 for AIS related purposes, such as channel management, to 0.0375 Erlang in total (refer to Annex 3 of Recommendation ITU-R M.1371-1, §1.3). Therefore, this Basic AIS Service may not be adequate for all situations where channel management is required.

11.5.3 Change of regional operating settings over time

The change of regional operating settings over time may be required in some situations. Although this potential of the AIS needs much more investigation, some fundamental principles can be stated already.

11.5.3.1Fundamental rules

Since the Class A mobile AIS station stores regional operating settings for up to five weeks, *carefully planned overwriting of the older, stored regional operating settings is needed when there are changes required for the same area over time.*

Channel management regions should only be changed – for safety reasons - *over a longer period of time, i. e. in the order of half-hours instead of minutes*.

The steps should be carefully planned beforehand, and the effects of any change should be well understood before implementing it. After one change step the system should be allowed to return to a stationary mode, i. e. all transitional states should have had time to subside. When there is a need to change operating frequencies within a region, there should be a minimum time period of 9 minutes after the first operating frequency has been changed before the second operating frequency is changed (refer to Recommendation ITU-R M.1371-1, Annex 2, §4.1.9).

Base stations should never change two channels (A and B) simultaneously within any region.

11.5.3.2 Preliminary procedures to change regions over time: Changes in region boundaries

Two possible changes of regional boundaries apply:

- **A region will be deleted, i. e. operation is intended to return to default**
  If the competent authority determines, that a region should no longer exist as a defined region, and the settings of that region should be changed to the default settings, the procedure as described as follows should be applied for that particular region: A channel management command must be transmitted by a base station to change the first operational frequency and all other parameters except the second operating frequency set to the default values, followed by a second channel management message after at least 9 minutes to change the second operational frequency. The region (geographical area) should be identical in size and location as the region to be deleted. If all AIS stations in that region are using the new operational frequencies, periodical channel management messages are no longer needed if the new operational settings are all equal to the default settings. The regional operating settings, which are stored in the memory of the Class A shipborne mobile AIS stations, will then be deleted in accordance with the algorithm given above, i. e. after five weeks latest.

- **A region will be moved or a new region will overlap the current region.**

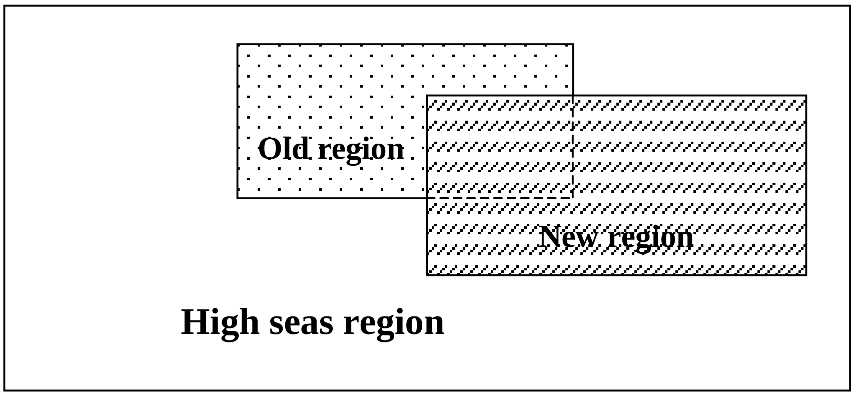


Figure 11-9

The picture illustrates the possible movement of a region from the old position to the new position. The same applies if a new region overlaps the old region. Any new region overwrites the stored old region as a whole immediately (refer to description of memory algorithm above). Therefore, the change from old to new could be accomplished in one step, i. e. all mobiles, which have been in an old region and are no longer in any specifically region – because the old region has been overwritten – would automatically be in "high seas" and would thus use default settings for *all* parameters immediately.

While this may be desired with some parameters other than operating frequency or just one operating frequency to be returned to default, this would not be a safe procedure, if more than one operating frequency different from AIS1 and AIS2 would need to return to default. Instead a step-by-step approach should be planned as explained before.

11.6 DUPLEX REPEATERS

A duplex repeater and the use of channel management regions can provide safe passage for ships transiting between adjacent regions where different frequencies are used, since each ship is using at least one of the same frequencies as each other ship in its region or service area plus one of the same frequencies as each

other ship within the adjacent region. It is essential that one channel (channel A, or the primary channel) always be designated as a simplex ship-ship channel in every region.

If duplex repeaters are used, base stations should ensure that the same simplex channel is always selected as the primary channel (channel A) in every regional area.

11.7 FUTURE WORK TO BE ADDED AT A LATER DATE

Further work is needed in particular in the following areas:

- More elaborate planning criteria for reasons to go into channel management, at all
- Introduce measures for safe behaviour of other classes of mobile stations in channel management environments.
- Change of regional operating settings over time by competent authorities: elaborate procedures
- Criteria for real-time decision making for changing operating frequencies due to e. g. RF interference / blocking

Use and effect of duplex repeating on channel management szenanios.

CHAPTER 12

SHIPBORNE MOBILE AIS STATIONS

12.1 INTRODUCTION

Two types of AIS mobile stations for vessels have been defined in ITU-R M.1371-1:
Class A Shipborne Mobile Equipment will comply with relevant IMO AIS carriage requirements
Class B Shipborne Mobile Equipment will provide facilities not necessarily in full accordance with IMO AIS carriage requirements. This type is mainly intended for pleasure craft.

There is another class of users that has not yet been defined. This group of mobile AIS stations concerns professional users, needing the Class A functionality. This AIS mobile equipment is called 'Class A-Derivatives'.

12.2 DEFINITIONS OF AIS STATIONS

The most important issue is that all categories of mobile AIS stations must be fully compliant on the VDL level. They must recognise all different types of messages, only the processing of the messages can be different. The interfaces to external display systems and sensor system may vary between different types of AIS stations. The definition of the different categories of shipborne mobile AIS stations are as follows:

Class A Shipborne Mobile Station must be 100% compliant with the IMO performance standard and the IEC 61993-2 standard.
Class A-Derivatives have full functionality on the VDL level but may have differences at the level of the Presentation Interface (PI), the use of external sensors, and the use of the internal AIS GNSS system for position determination. Class B Shipborne mobile stations have a different functionality on VDL-message level. The position and static information reports are transmitted with their own VDL messages and with different reporting rate.
For both Class A Shipborne mobile station Derivatives and Class B Shipborne mobile stations the DSC functionality may be omitted depending on the regional regulations.

12.3 COMMON FEATURES FOR ALL SHIPBORNE MOBILE AIS STATIONS

The operating principles of a shipborne mobile AIS device can be described as follows. A ship determines its geographical position with an Electronic Position Fixing Device (EPFD). The AIS station transmits this position, combined with ship identity and other ship data via the VHF radio link to other AIS equipped ships and AIS base stations that are within radio range. In a similar fashion, the ship, when not transmitting, receives corresponding information from all ships and base stations that are within radio range.

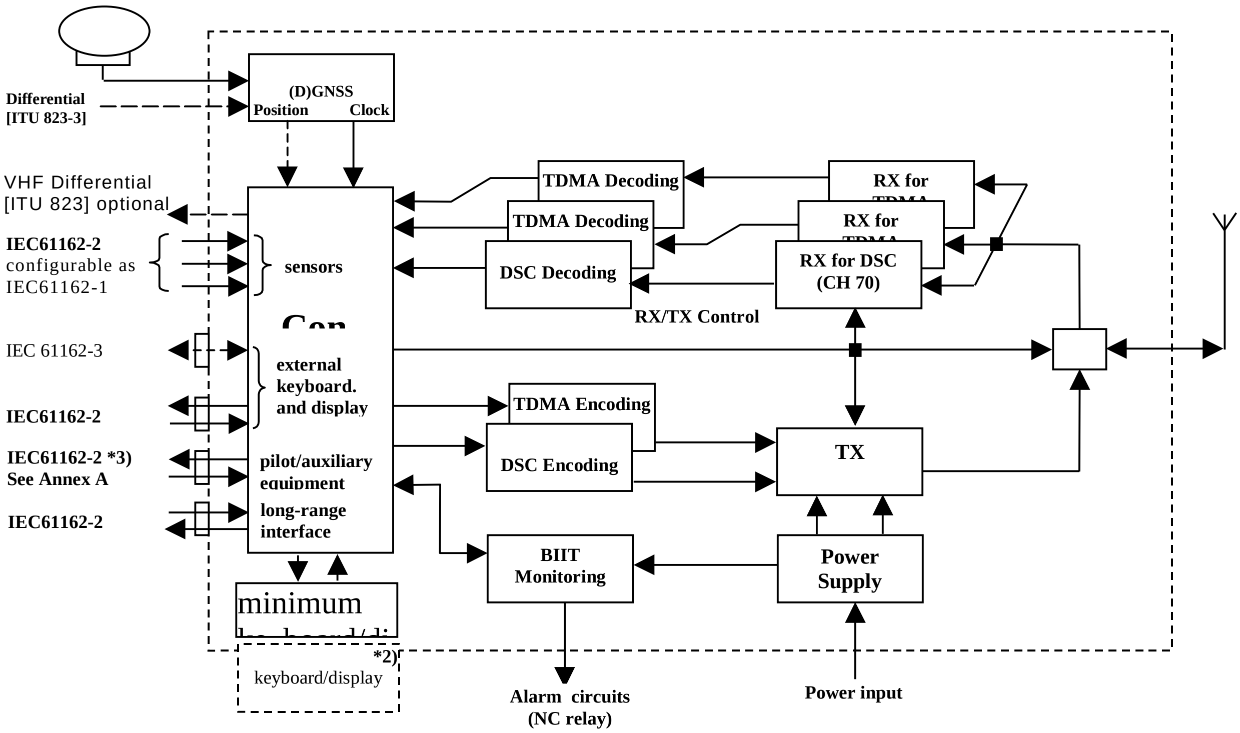
12.4 SPECIFIC ISSUES FOR CLASS A SHIPBORNE MOBILE AIS STATIONS

Class A description is based on the IMO Performance Standards, ITU-R M.1371-1 and the IEC 61193-2 standard.

12.4.1 Functional Block Diagram

Figure 12.1 shows the principal component parts of a Class A shipborne mobile AIS station. Components for Class A are:

- GNSS receiver: The GNSS receiver supplies the time reference to the AIS station and ensure that all transmissions are properly time sequenced such that there are no collisions or overlaps which would destroy the information at all of the receiving stations.
  - The internal (D)GNSS receiver may be used as a back-up source for ships positioning , SOG and COG determination.
- VHF transmitter/receiver: There is one VHF transmitter and two receivers for TDMA operation. The VHF transceiver transmit and receive the radio signals that form the data links that interconnect the AIS stations to each other. The individually assigned transmission time slots are short (26.6 ms) the VHF transmitter has to have a very fast switching capability (1 ms) from zero power output to full power and vice versa. In the block diagrams (fig 12-1) the receivers are functionally shown as a receiver part (RX for TDMA) and a TDMA decoding part. In the same way, the transmitter consists of TDMA Encoding and TX as parts of the transmitter.
- Controller: The Control unit is the central intelligence of the AIS station. It manages the time slot selection process, the operation of the transmitters and receivers, the processing of the various input signals and the subsequent distribution of all of the output and input signals to the various interface plugs and sockets, and the processing of messages into suitable transmission packets.
- Built-in-Integrity-test (BIIT) controls continuously integrity and the operation of the unit.
- Power Supply
- Signal interface connectors: In order to be able to transmit all the information that a position report includes, the AIS station has to collect information from various ship sensors. There are also interfaces for connection to external display systems and Long-Range equipment.
- DSC receiver : The DSC receiver is fixed tuned to channel 70 to receive channel management commands for regional area designation. The DSC receiver can also be used for limited DSC operation. When replying DSC interrogations the common VHF transmitter will be used.



*1) The external keyboard/display may be e.g. radar, ECDIS or dedicated devices.
*2) The internal keyboard/display may optionally be remote.
*3) ANNEX A describes the installation of the "pilot plug".

Figure 12-1: Block diagram of a Class A

12.4.2 Presentation Interface Description

The Presentation Interface (PI) connects the AIS mobile station to external equipment such as:

- EPFD
- Gyro giving heading and/or ROT
- Display systems (ECDIS, ARPA, INS, etc.)
- Pilot Unit
- Long Range communication means e.g. Inmarsat-C

The PI will consist at a minimum of the following ports:

- 3 sensor input ports: EPFD, Gyro and ROT (Ch 1, 2 and 3 in the following diagram)
- 1 bi-directional high speed interfaces to external display systems (Ch 4)
- 1 bi-directional high speed interfaces to external auxiliary equipment or pilot carry on board display systems (Ch 5)
- 1 bi-directional high-speed interface to operate Long Range functions (Ch 8)

Optional ports can be added i.e. for DGNSS correction data (in and out) (Ch 9) and an IEC 61162-3 compliant port (Ch 6).

The following information isoutput via PI ports to display systems, auxiliary or pilot carry on board systems:

- All received data from other AIS stations (base and other mobiles)
  - Position reports
  - Static and voyage related data
  - Binary and safety related messages
  - VDL related messages (e.g. channel management)
- Own ship information when it is transmitted
- Long Range interrogation information
- Ships sensor data and status, which is connected to the AIS station, every second
- Alarm and status messages generated by the BIIT

The following information can be input via the PI from the display systems:

- Voyage related data
- Station static data
- Long Range confirmation
- Binary and safety related messages
- Alarm confirmations
- Channel management actions

Long Range messages will be input to and output from external long range communication system, e.g. Inmarsat-C via the Long Range port on the PI.

A dedicated connector for BIIT alarm status is available on Ch 10.

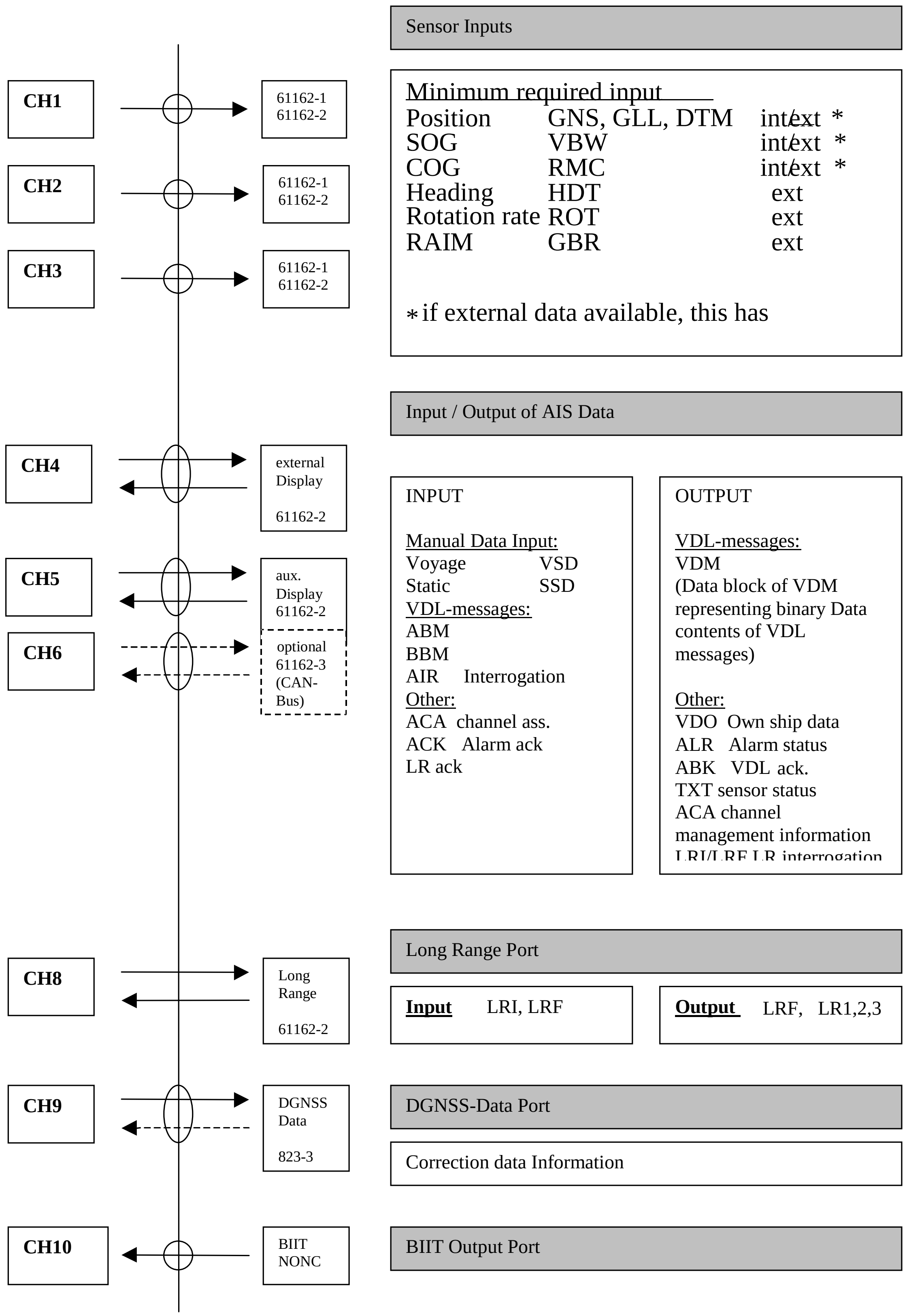


Figure 12-2: Presentation interfaces for Class A Shipborne Mobile Stations

12.4.3 Built-in-Integrity-Test (BIIT)

AIS mobile stations are equipped with a built-in integrity test unit (BIIT). This runs continuously or in appropriate intervals simultaneously with all other functions of the station.
If any failure or malfunction is detected that will significantly reduce integrity or stop operation of the AIS, an **alarm** is initiated. In this case the alarm is displayed on the minimum keyboard and display unit and the alarm relay is set “active”.
An appropriate alarm message shall be output via the Presentation Interface and repeated every 30 sec.

The alarm relay is deactivated upon acknowledgement of the alarm either internally by means of minimum display and keyboard or externally by a corresponding ACK sentence.

If a change of a relevant system status as described below is detected, an **indication** is given to the user. This indication is accessible on the minimum keyboard and display unit.
An appropriate text message (txt) is also output via the Presentation Interface.

12.4.3.1Monitoring of functions and integrity

In case a failure is detected in one or more of the following functions or data, an alarm is triggered and the system reacts as given in **Error! Reference source not found.**12.1.

Alarm's description text	Reaction of the system to the Alarm Condition threshold exceeded
AIS: Tx malfunction	Stop transmission
AIS: Antenna VSWR exceeds limit	Continue operation
AIS: Rx channel 1 malfunction	Stop transmission on affected channel
AIS: Rx channel 2 malfunction	Stop transmission on affected channel
AIS: Rx channel 70 malfunction	Stop transmission on affected channel
AIS: general failure	Stop transmission
AIS: MKD connection lost	continue operation with "DTE" set to "1"
AIS: external EPFS lost	continue operation
AIS: no sensor position in use	continue operation
AIS: no valid SOG information	Continue operation using default data
AIS: no valid COG information	Continue operation using default data
AIS: Heading lost/invalid	Continue operation using default data
AIS: no valid ROT information	Continue operation using default data

Table 12.1 Integrity alarms

12.4.3.2 Sensor data status

In case a sensor data status changes, an indication is given and the system reacts as given in **Error! Reference source not found.**12.2:

Text Message	Reaction of the system
AIS: UTC clock lost	Continue operation using indirect or semaphore synchronisation
AIS: external DGNSS in use	Continue operation
AIS: external GNSS in use	Continue operation
AIS: internal DGNSS in use (beacon)	Continue operation
AIS: internal DGNSS in use (message 17)	Continue operation
AIS: internal GNSS in use	Continue operation
AIS: external SOG / COG in use	Continue operation
AIS: internal SOG / COG in use	Continue operation
AIS: Heading valid	Continue operation
AIS: Rate of Turn Indicator in use	Continue operation
AIS: Other ROT source in use	Continue operation
AIS: Channel management parameters changed	Continue operation

Table 12.2 Sensor status

12.4.4 Minimum Keyboard and Display

A minimum keyboard and display unit (MKD) is mandatory on Class A mobile stations. Non-SOLAS vessels with Class A-derivative mobile stations will conform to the locally issued regulations with respect to the manner in which AIS information is displayed.

The MKD has the following functions:

- Configures and operates the equipment.
- Shows at least three lines of information.
- Inputs all required information via an alpha numerical keyboard with all valid 6-bits ASCII characters available
- Displays all the received vessels' bearing, range and names. The MKD displays at least Range, Bearing and vessel's name on a line-by-line display. Any horizontal scrolling does not remove the range and bearing from the screen. It is possible to scroll up and down to see all the vessels that are currently in the coverage area of the AIS unit.
- Indicates alarm conditions and means to view and acknowledge the alarm. When the AIS unit gives an alarm the display indicates to the user that an alarm is present and provides means to display the alarm. When an alarm is selected for display it is possible to acknowledge the alarm.

- Indicates the state/condition change inside the AIS and provides a means to view the state/condition change message. The MKD may be used to input voyage related information, such as cargo category, maximum present static draught, number of persons on board, destination, ETA, and navigational status.
- The MKD may be used to input static information such as MMSI number, IMO number, Ships Call sign, Ships Name, Length and Beam, Position reference points for GNSS antenna and Type of Ship
- Displays safety related messages. The MKD will indicate to the operator when a safety related message has been received and display it on request
- The MKD may be used to input safety related messages. It is possible to input and send addressed (message 12) and broadcast (message 14) safety related messages from the MKD.
- Change the AIS unit mode of response to Long Range (LR) interrogations.
- It is possible to set the AIS station to respond automatically or manually to LR interrogations. The mode (LR or default) the AIS unit is in will be displayed where appropriate.
- Indicates LR interrogations when in automatic mode and provides a means to acknowledge these indications. In case of automatic reply to LR interrogations, the display will indicate that the system was LR interrogated until the operator acknowledges the indication.
- Indicates LR interrogations when in manual mode and provides a means to initiate a reply or cancel a reply to the interrogation. In case the of a manual reply to LR interrogation, the display will indicate that the system was LR interrogated until the operator has replied to the interrogation or cancelled the reply.
- The MKD may be used to control the AIS channel switching. It is possible to change the AIS operational frequencies and power settings from the MKD.
- Displays GPS position when the internal GNSS receiver is operating as the back-up position source for the AIS reporting. When the AIS is using the internal GPS for position reporting, that position must be continuously displayed. The AIS unit has an option where it uses the internal GPS receiver position information for position reporting. When in this mode, the position that is transmitted by the AIS will be available on the MKD.

Some of the above actions can be password protected.

12.5 SPECIFIC ISSUES FOR CLASS B SHIPBORNE MOBILE AIS STATIONS

Class B operation is identified in the ITU-R M.1371-1 recommendation by defined message types and reporting rates. IALA proposes to develop recommendations for Class B operation and investigate the technical impact of Class B on the VDL. In the absence of mandatory regulations, carriage of class B by leisure craft and other non-SOLAS vessels will be influenced largely by the perceived advantages as seen by each vessel’s owner, however, carriage may be dictated in those waterways where competent authorities choose Class B AIS may be a stand-alone unit, interfaced with existing equipment, or as a combined unit with GNSS/DGNSS. In both cases the requirement to be recognised may be the driving consideration. Due to the ongoing development of the standard, there probably will be changes in the future.

12.5.1 Operation of Class B shipborne mobile stations

Class B stations may primarily be used for pleasure craft and other non-SOLAS vessels that administrations may determine.
Operational situations in relation to traffic loading will have to be investigated. Local conditions and experience of operations will show how this can best be dealt with.

The use of DSC Channel Management depends on the regional regulations in the geographical area where the Class B station is intended to operate. In areas where AIS1 and AIS2 are not available DSC could be used to inform the mobile station which frequencies must be used for AIS.

Long Range functionality is optional for Class B stations.

12.5.2 User interface

The minimum keyboard and display unit, as on Class A stations, may not be required on pleasure craft, they may use the Class B station as a black box (to be seen) or connected to a more or less sophisticated display (e.g. ECS/ECDIS) to see and present own position and other AIS targets in relation to the environment. However, there must be at least one means to program the station with static data during the configuration.

12.5.3 Deviating functions compared with Class A stations

Compared with Class A mobile stations, some function may not be available or are optional for Class B stations. Some options are:

- Variable Power setting
- Channel spacing of 12.5 kHz is optional for Class B dependent on local regulation
- Channel Management is optional for Class B dependent on local regulations
- Class B is not allowed to act as the synchronising semaphore and is not able to synchronise other stations.

The following messages or usage of messages are optional for Class B stations:

- Send and receive binary message
- UTC and date inquiry and response
- Send and receive safety related messages
- Interrogate other vessels

The following messages shall not be sent by Class B stations:

- Message 1,2,3: position reports for Class A
- Message 5: Ship static and voyage related data for Class A

Differential corrections sent out from a base station via AIS VDL (message 17) should be used for position determination

12.6 CLASS A-DERIVATIVES

Class A-Derivatives are not defined in any of the AIS related documents (IMO, ITU, IEC, IALA). Class A-Derivatives may be the result of any local or international development for particular groups of users. Examples are:

- Inland and coastal navigation
- Development of Personal Pilot Units.
- The use of AIS in harbours for service vessels like tugs, buoy tenders, hydrographic ships, pilot vessels, etc.

Class A-Derivatives are intended to use the same functionality and reporting rate as Class A stations on VDL message level. The main difference between Class A and Class A-Derivatives is that not all mandatory components of Class A stations must be included.

The use of DSC Channel Management depends on the geographical situation. In areas where AIS1 and AIS2 are not available DSC may be used to inform the mobile station which frequencies must be used for AIS.
Long Range functionality can be optional but not mandatory for Class A derivative stations.

12.6.1 Presentation interface

There is no mandatory requirement for Class A-Derivative stations to carry the same presentation interfaces as Class A stations. The position information may be derived from the internal (D)GNSS receiver. In this case the position information may be displayed and used outside the AIS station for external applications. There may be other equipment on board of the non-SOLAS vessels with interfaces, which are non-compliant with IEC 61162-1 standard (i.e. RS-232).
The minimum keyboard and display on Class A derivative stations may not be required. Non SOLAS vessels can use the Class A derivative station may be configured as:

- a black box (to allow the vessel to be seen only)
- or connected to a more or less sophisticated display (i.e. ECS/ECDIS)
- or other external system for special applications to see and present own position in relation to the environment.

However, there must be at least one means to program the station with static data.

12.6.2 Deviating functions compared with Class A stations

Compared with Class A mobile stations, some functions may not be available or are optional for Class A derivative stations.

- Power setting
- Channel spacing of 12.5 kHz is dependant on the local regulations and is optional

All used messages are the same as for Class A stations.

In the future it might be possible to develop new functions for AIS, which can be used by Class A derivative stations only. Then additional components would need to be added, like a third receiving channel.

12.6.3 Pilot/Auxiliary port

The pilot plug is not a part of the type approved equipment and the fitting is voluntary for the ships owners. The plug may however be requested by local authorities.

Most of the vessels that are piloted will be fitted with AIS according to the SOLAS convention. The onboard AIS has a pilot/auxiliary input/output port (see Chapter 7) that provides the facility to forward the own vessel's GNSS/DGNSS information, heading, and (optional) rate of turn continuously, independently of (i.e. faster than) the standard AIS reporting rate. The pilot will receive all other AIS information at the standard rate. This allows pilots to plug in their own pilot portable workstation to the onboard AIS in order to receive more frequent own ship navigation information. In addition the pilot port connection provides the pilot the facility to forward information to other vessels in the vicinity or to the local VTS.

The greatest benefit would be achieved if this plug is fitted on every ship that is likely to use pilot services. The pilot plug if fitted should be found close to the pilots conning position and be marked with a label that says "AIS PILOT PLUG". Power for the computer should be available nearby.

The Pilot/Auxiliary input/output port is defined by IEC 61193-2 for connection of ship's pilot equipment, service equipment etc. is terminated on the following receptacle (or a physical and electrical equivalent receptacle).

AMP/Receptacle-Square Flanged, Shell size 13, 9-pin, Std. Sex 206705-1 A1303-ND AMP/Pin 24-20 AWG, Crimp, Gold/Nickel (for 206705-1 Receptacle) 66103-4 A1342-ND

The termination is as follows:

- TX A is connected to Pin 1
- TX B is connected to Pin 3
- RX A is connected to Pin 5
- RX B is connected to Pin7
- Shield is connected to Pin9

The Pilot's plug is (or an equivalent physical and electrical plug):

AMP/Plug, Shell Size 13, 9-pin, Std. Sex 206708-1 A1302-ND
AMP/Socket 24-20 AWG, Crimp, Gold/Nickel (for 206708-1 Plug) 66105-4 A1343-ND
AMP/Cable Clamp-Plastic Shell, Shell Size 13 206070-1 A1332-ND

Note: *IEC 61162-2 defines the electrical interface used. The laptop interface must be equipped with a similar interface to be able to operate to this port.*

CHAPTER 13

AIS BASE STATION

IALA is in the process of developing the content of this chapter. It is anticipated that this work will be completed by September 2002.

CHAPTER 14

AIDS TO NAVIGATION AIS STATION

14.1 INTRODUCTION

The IMO carriage requirements for AIS (from July 2002) raise the possibility of incorporating AIS technology with aids to navigation. Some of the positive features of this include:

- a positive and all-weather means of identifying an aid to navigation site on AIS and ships' radar displays;
- a complement to Racons
- replacement or supplementation of some aids to navigation with pseudo targets
- a means of monitoring of aid to navigation status
- tracking of a drifting floating aid
- identification of ships involved in collisions with pile beacons and floating aids.
- to provide a reference point for Radar (shipborne)

14.2 AIS ON FLOATING AIDS TO NAVIGATION

The position derived from the internal GPS receiver can be used together with a reference position and a 'guard zone' to monitor the position of the buoy and to generate an 'off station' condition. This would be indicated in the AtoN AIS message and also transmitted as a navigational warning message in the form of a "Safety related text message" (Message 14), alerting shipping that the AtoN is not in its correct position.*

14.3 AIS ON FIXED AIDS TO NAVIGATION

AIS on a fixed Aid to Navigation such as a lighthouse could, in addition to transmitting its own identification, local hydrological and meteorological data, also, act as a relay for other AtoNs.

14.4 AIS ON OFFSHORE STRUCTURES

The position of offshore structures is very important for safety and navigational purposes because they are seen as hazardous objects. There are fixed offshore structures including offshore wind farms and floating offshore structures e.g. rigs.

Offshore structures do not fall under Aids to Navigation category. However, Message 21: 'Aids-to-Navigation Report' is the most appropriate message for reporting position and dimensions for offshore structures when they are fitted with an AIS station. Therefore offshore structures, both fixed and floating, are included in the list of AtoN types (Table 14.1). The standard 'Dimension/Reference for Position' field applies for offshore structures with the same restrictions with respect to the missing orientation of the object. If the offshore structure is composed of multiple elements, and only one AIS station is installed, the overall dimensions of the whole structure must be transmitted. It should be noted that:

- The orientation, established by dimension A, should point true north.

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* Note on Aids-to-Navigation within AIS:
The competent international body for Aids-to-Navigation, IALA, defines an Aid-to-Navigation as: "a device or system external to vessels designed and operated to enhance safe and efficient navigation of vessels and/or vessel traffic." (IALA Navguide, Edition 1997, Chapter 7).
The IALA Navguide stipulates: "A floating aid to navigation, which is out of position, adrift or during the night is unlighted, may itself become a danger to navigation. When a floating aid is out of position or malfunctioning, navigational warnings must be given." Therefore, a station, which transmits Message 21, could also transmit Safety Related Broadcast Message (Message 14) upon detecting that the floating Aid-to-Navigation has gone out of position or is malfunctioning, at the competent authority's discretion.

- For floating structures the dimensions of the AtoN should be given approximated by a square. The dimensions should always be as follows A=B and C=D. This is because the orientation of the floating A to N is not given.

14.5 RADAR REFERENCE TARGET

With the ever-increasing requirement for integrated display systems, the problems of aligning two or more systems on one display surface are increased. If two (preferably three) AIS stations can be installed on prominent, fixed radar targets within an area of special interest, such as a harbour or harbour approach, the AIS GNSS positions, radar echoes and chart symbols of each of these targets can be used to align the three displays. This can result in reduced ambiguity and a less cluttered display.

14.6 VIRTUAL AIS AIDS TO NAVIGATION TARGETS

Every Aid to Navigation will not carry an AIS station. Therefore these AtoNs will need to be identified on a receiving AIS station as a virtual/pseudo target, relative to a known position. The targets that will be generated in this mode needs to be determined by a Competent Authority responsible for providing aids to navigation. It is also possible to use a shore AIS to retransmit position, status and supplementary data from AtoNs within the VHF coverage of the shore installation. Where two authorities (AtoN and VTS) are independent and operating in the save coverage area, this is still possible but special arrangements regarding liability may be required.

This has the following advantages:

- Considerable reduction in power requirements on the AtoN
- A Reduction in cost as fewer AIS AtoN stations are required
- Greater control over the slot occupancy
- Greater VHF range for the majority of AtoNs
- Data can more easily be checked for integrity before transmission

There are, however, some disadvantages:

- No significant reduction in actual slot usage
- Additional radio link required between the AtoN and the VTS centre
- Not suitable for AtoNs near the edge or outside the VHF service area of the VTS AIS

14.7 VIRTUAL AtoN

In the same way that a VTS centre can transmit its tracked radar targets, A ‘Pseudo AIS Track’ can be generated and transmitted and be used to place a target on an AIS display where no real target exists. For example:

A pseudo AIS track can be generated and displayed at the position of a new wreck that has not yet been marked on the chart or by a buoy.

A single pseudo AIS track or a series of pseudo AIS tracks could mark a temporary ‘area to be avoided’ or navigation channel.

14.8 AIS AtoN STATION

An AIS AtoN Station is designed for use on an AtoN. The following are some of the characteristics that may be required (This station has not been developed at this point in time):

- Very low power consumption (<1 Wh/day).
- The AIS firmware shall include the necessary code to calculate the distance (and bearing) from the charted position of the aid. The firmware shall compare this derived distance with a

"guard zone" value and set the 'Off Station Indicator' accordingly. It will also generate and transmit the necessary navigation warning messages

- An interface shall be provided for connecting to hydrological and meteorological data gathering platforms

14.9 AtoN BROADCAST MESSAGES

An AtoN uses a predefined Aids-to-Navigation Report that is normally transmitted every three minutes; other times can be set. The message contains the following information:

- Station Identifier (MMSI number)
- Type of Aid to Navigation:
  - Fixed Aid-to-Navigation (15 possible sub-types);
  - Floating Aid-to-Navigation (12 possible sub-types);
  - A "type not available" indicator
- Station Name (up to 34 characters)
- Position Information
  - Latitude
  - Longitude
  - Accuracy
  - Source of position information e.g. GPS
  - On / Off station indicator
  - Time of position information (UTC)
  - "Position not available" indicator
- Dimensions of AtoN
- Real or Pseudo AIS flag

Full details of the message (type 21) content are contained in the technical section of these guidelines.

14.10 METHODS OF BROADCASTING AtoN AIS MESSAGES

The AtoN message can be transmitted by three different means:

- An AIS AtoN station fitted on an AtoN and transmitting information about that particular AtoN.
- An AIS AtoN station fitted on an AtoN (or elsewhere nearby) and transmitting information on behalf of other AtoNs. These AtoNs may be real or virtual.
- An AIS base station with integrated "AtoN functionality" transmitting information from one or more AtoNs, which can be real or virtual.

To ensure a reliable function of the AIS datalink in high load situations it is important that the position of the transmitting AIS station is in a close range of the positions for the AtoNs for which information is transmitted.

The message contains the following information:

- Station Identifier (MMSI Number)
- Type of Aid to Navigation: 32 different codes
  - Fixed Aid-to-Navigation (15 possible sub-types)
  - Floating Aid-to-Navigation (12 possible sub-types)
  - A "type not available" indicator
  - A "reference point" indicator (infinitesimal point)
  - A "RACON" indicator
  - An "Off-Shore Structure" indicator
  - Station Name

14.11 TYPES OF AID TO NAVIGATION

	Code	Definition
	0	Default, Type of AtoN not specified
	1	Reference point
	2	RACON
	3	Off Shore Structure
	4	Spare
Fixed A to N	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 A to N	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

TABLE 14.1: TYPE OF AID TO NAVIGATION

Notes:

- The types of Aids to Navigation listed above are based on the IALA Maritime Buoyage System, where applicable.
- There is potential for confusion when deciding whether an aid is lighted or unlighted. Competent Authorities may wish to use the regional/local section of the message to indicate this.
- The use of a multiple-slot message in identifying an AtoN will:
  - Reduce the range of reception of such a message as opposed to a single-slot message
  - Increase the loading on the VDL

Therefore, multiple-slot messages should be used with caution in areas of heavy AIS traffic to avoid impairing the safety of navigation of vessels in the area.

14.12 NAME OF AtoN

The following priority should be used in assigning this field:

- Charted name
- National/international identification number
- Description of special exhibits

14.13 OFF POSITION INDICATOR

This flag should only be considered valid by the receiving station if the aid is a floating aid and the Time Stamp is less than of equals 59. For a floating AtoN, the guard zone parameters should be set on installation.

14.14 TYPE OF POSITION FIXING DEVICE

For fixed aids and virtual/pseudo aids, the surveyed position is to be used. This accurate position enhances its function as a radar reference target.

All positions must be given in WGS84 coordinates to avoid erroneous information.

Parameter	*Description*
Message ID	*Identifier for this message 21*
Repeat Indicator	*Used by the repeater to indicate how many times a message has been repeated; default = 0; 3 = do not repeat any more.*
ID	*MMSI number*
Type of Aid~~s~~-to-Navigation	*0 = not available = default;* *refer to appropriate IALA definition* (Table 14-1)
Name of Aid~~s~~-to-Navigation	*Maximum 20 characters 6 bit ASCII, "@@@@@@@@@@@@@@@@@@@@" = not available = default.* The name of the Aid-to-Navigation may be extended by the parameter “Name of Aid-to-Navigation Extension” below.
Position accuracy	*1 = high (< 10 m; Differential Mode of e.g. DGNSS receiver) 0 = low (> 10 m; Autonomous Mode of e.g. GNSS receiver or of other Electronic Position Fixing Device); Default = 0*
Longitude	*Longitude in 1/10 000 min of position of Aids-to-Navigation (±180 degrees, East = positive, West = negative. 181 degrees (6791AC0 hex) = not available = default)*
Latitude	*Latitude in 1/10 000 min of Aids-to-Navigation (±90 degrees, North = positive, South = negative, 91 degrees (3412140 hex) = not available = default)*
Dimension/Reference for Position	*Reference point for reported position; also indicates the dimension of Aid-to-Navigation in metres, see figure xxx* (1)
Type of Electronic Position Fixing Device	*0 = Undefined (default);* *1 = GPS,* *2 = GLONASS,* *3 = Combined GPS/GLONASS,* *4 = Loran-C,* *5 = Chayka,* *6 = Integrated Navigation System,* *7 = surveyed.* for fixed AtoNs and virtual/pseudo AtoNs, the surveyed position should be used. The accurate position enhances its function as a radar reference target. *8 – 15 = not used.*
Time Stamp	*UTC second when the report was generated* by the EPFS *(0 –59,* *or 60 if time stamp is not available, which should also be the default value,* *or 61 if positioning system is in manual input mode,* *or 62 if Electronic Position Fixing System operates in estimated (dead*

	reckoning) mode, *or 63 if the positioning system is inoperative)*
Off-Position Indicator	*For floating Aids-to-Navigation, only: 0 = on position; 1 = off position; NOTE – This flag should only be considered valid by receiving station, if the Aid-to-Navigation is a floating aid, and if Time Stamp is equal to or below 59.* For floating AtoN the guard zone parameters should be set on installation.
Reserved for regional or local application	*Reserved for definition by a competent regional or local authority. Should be set to zero, if not used for any regional or local application. Regional applications should not use zero.*
RAIM-Flag	*RAIM (Receiver Autonomous Integrity Monitoring) flag of Electronic Position Fixing Device; 0 = RAIM not in use = default; 1 = RAIM in use)*
Virtual/pseudo AtoN Flag	0 = default = real A to N at indicated position; 1 = virtual/pseudo AtoN, does not physically exist, may only be transmitted from an AIS station nearby under the direction of a competent authority. (2)
Assigned Mode Flag	0 = Station operating in autonomous and continuous mode = default 1 = Station operating in assigned mode
Spare	*Spare. Not used. Should be set to zero.*
Name of Aid-to-Navigation Extension	This parameter of up to 14 additional 6-bit-ASCII characters for a 2-slot message may be combined with the parameter "Name of Aid-to-Navigation" at the end of that parameter, when more than 20 characters are needed for the Name of the Aid-to-Navigation. This parameter should be omitted when no more than 20 characters for the name of the A-to-N are needed in total. Only the required number of characters should be transmitted, i. e. no @-character should be used.
Spare	Spare. Used only when parameter "Name of Aid-to-Navigation Extension" is used. Should be set to zero. The number of spare bits should be adjusted in order to observe byte boundaries.
Number of bits	*Occupies two slots.* This message should not occupy more than two slots.

Table 14.2: Aid-to-Navigation Report Message

Footnotes:

(1) When using 3.3.8.2.3.3 for Aids-to-Navigation the following should be observed:

- For fixed Aids-to-Navigation, virtual and pseudo A-to-Ns, and for offshore structures, the orientation established by the dimension A should point to true north.
- For floating aids larger than 2 m * 2 m the dimensions of the AtoN should always be given approximated to a square, i.e. the dimensions should always be as follows A=B=C=D>1. (This is due to the fact, that the orientation of the floating Aid to Navigation is not transmitted. The reference point for reported position is in the centre of the square.)
- A=B=C=D=1 should indicate objects (fixed or floating) smaller than or equal to 2m * 2m. (The reference point for reported position is in the centre of the square.)

(2) When transmitting virtual/pseudo Aids to Navigation information, i.e. the virtual/pseudo Aids to Navigation Target Flag is set to one (1), the dimensions should be set to A=B=C=D=0 (default). This should also be the case, when transmitting "reference point" information

14.15 DIMENSIONS OF AtoN

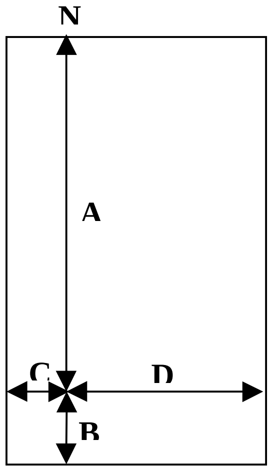
This field should indicate the dimensions of the AtoN object and **not** the dimensions of the area in which a floating aid can move (guard zone) or dimensions of a "dangerous zone" around the AtoN.

For fixed AtoN, and virtual/pseudo offshore structures the orientation established by the dimension A should face true north.

For floating aids larger than 2 m x 2 m the dimensions of the AtoN should always be given approximated to a square, i.e. the dimensions should always be as follows*:* A=B=C=D>1. The reference point for reported position should be in the centre of the square. (This is due to the fact that an orientation of the floating aid is not transmitted.)

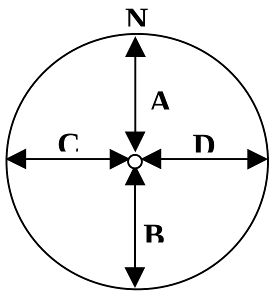
For objects smaller than or equal to 2 m x 2 m the values of the fields should be set to A=B=C=D=1.

When transmitting virtual/pseudo AtoN information, i.e. the virtual Aids to Navigation flag is set to one (1), 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”.



	DISTANCE IN METERS
A	0 - 511
B	0 - 511
C	0 - 63 ; 63 = 63 m or greater
D	0 - 63 ; 63 = 63 m or greater

DIMENSIONS FOR A FIXED ATON



DIMENSIONS FOR A FLOATING ATON:

A+B<=2m	A=B=C=D=0
A+B>2m	A=B=C=D>2

Figure 14-1: Dimensions for AtoNs

14.16 USE OF EIGHT DATA BITS FOR LOCAL/REGIONAL USE

The status of AtoN may be indicated as:

- Light (2 bits)
  - Normal
  - Unreliable
  - Failed
- Racon (1 bit)
  - Normal
  - Failed

14.17 VIRTUAL/PSEUDO AtoN TARGET FLAG

When information is transmitted for a virtual AtoN, this shall be indicated with the Virtual AtoN flag as follows.

0 = default = real AtoN at indicated position;
1 = Pseudo/virtual AtoN, does not physically exist; may only be transmitted from an AIS-station nearby, under the direction of a Competent Authority.

CHAPTER 15

SAR AIRCRAFT AIS STATION

15.1 SCOPE

The search and rescue (SAR) aircraft AIS station is an aircraft-certified AIS system, installed on aircraft used in SAR operations, allowing ships and aircraft involved in a SAR operation and the on-scene coordinator to know each other's position and identity, and to intercommunicate with each other using text or binary messages. Position reports for SAR aircraft are continuously transmitted every ten seconds.

15.2 CERTIFICATION

An AIS system used on aircraft must be designed, tested and certified to appropriate avionics regulatory requirements as determined by responsible aviation authorities. An off-the-shelf AIS system designed to meet shipborne requirements would normally not meet these requirements.

15.2.1 Input/Output

Since aircraft systems do not use the IEC 61162 data interface standard used by shipborne equipment, aircraft AIS equipment must use the data interfaces standards specified by responsible aviation authorities. Interface equipment designed to convert data sentences to and from IEC 61162 may alternatively be used. Since the AIS equipment includes and integral GNSS module for timing, it is possible that position, altitude, speed over ground, and course over ground data can be obtained from that module. The standard SAR aircraft position report (Message #9) also includes provisions for data defined by regional applications. The following data input and output information is required:

15.2.1.1 Input

aircraft GNSS data
altitude (derived from GNSS)
speed over ground
course over ground
GNSS antenna
VHF antenna (transmit/receive)
manual input from pilot
DTE
manual input from maintenance technician
power

15.2.1.2 Output

VHF antenna (transmit/receive)
pilot display
built-in integrity test (similar to that specified in IEC 61193-2)
received position reports to RCCs

15.2.2 Identity

The SAR aircraft AIS equipment uses the same nine-digit maritime mobile service identity (MMSI) used by shipborne, base station, and aids-to-navigation AIS equipment. Since International Telecommunications Union Radio Regulations make no provisions for MMSI use by aircraft, special arrangements would need to be made by national authorities for assigning MMSI use to SAR aircraft. The same MMSI format used by ships (i.e. "MIDNNNNNN", where "MID" is the three-digit country identifier and "NNNNNN" is a six-digit numeric identity assigned by Administrations) should be considered for use by aircraft, pending any ITU amendments. Consequential amendments to the ITU Radio Regulations and ITU-R recommendations should be considered, particularly if SAR aircraft AIS equipment comes into widespread use. Note that a similar problem exists with the use of DSC-equipped radiotelephones on SAR aircraft.

15.2.3 Aircraft pilot interface

The AIS display and interface on a SAR aircraft is not used for navigation, but instead would be used for search and rescue purposes. Therefore if a display is used, it need not be installed at the pilot's position, if other crew positions exist. AIS display integration into most existing aircraft display and control systems, such as weather radar, is probably not feasible. In these cases, if an AIS display and control is required, a dedicated installation may be necessary. Since cockpit space is normally limited, installation at some other location may need to be considered. If the purpose of this AIS installation is solely to allow the on-scene coordinator and other ships to know the identity and location of the aircraft, no aircraft display or control may be needed.

15.2.4 Rescue coordination centre communication

An AIS-equipped SAR aircraft can relay ship information over a wide area to a rescue coordination centre (RCC) using a separate communications link between the aircraft and the RCC. Additionally, the RCC can track its SAR aircraft resources using the long-range option capability of the AIS.

15.2.5 Channel management

Because of the altitude SAR aircraft operate in, AIS propagation ranges would normally far exceed that of shipborne or base station AIS equipment. Aircraft also normally operate at speeds much higher than ships. For these reasons, channel management used for shipborne equipment may affect AIS-equipped SAR aircraft in different ways.

15.2.5.1 Transition zone.

The channel management transition zone size is normally based upon the speed of ships transiting the zone, and the time necessary to for AIS equipment onboard those ships to switch channels without disruption. However, AIS-equipped SAR aircraft would travel through this zone at a much higher speed, which may cause ships and aircraft to lose information for short time. SAR aircraft circling in and out of a boundary of one or more regions may cause significant disruption because of the constant changing of frequencies and the continued transmission for one minute on the old frequency every time a boundary is crossed.

15.2.5.2 Interference.

Channel management regions may be established because AIS 1 or AIS 2 is not available in a particular area, but is instead used for some other service. These channel management regions would be established based upon propagation ranges between ships and these other services. Because of the greater propagation ranges of AIS transmissions from SAR aircraft, interference between the SAR aircraft and these other services may become a problem.

15.2.5.3 Visibility.

Because of the extended propagation distances between AIS-equipped ships and SAR aircraft, ships in a regional operating area may not see a SAR aircraft in a different regional operating area. Similarly, the SAR aircraft may not see the ships in that different regional operating area.

15.2.5.4 Increased probability of slot collisions.

Because the AIS propagation range from SAR aircraft far exceeds that of ships, the probability of slot collisions between the aircraft and ships and among ships seen by the aircraft would be significantly increased. If the number of ships is large, free slots may not be available for the AIS-equipped SAR aircraft, and slot collisions will inevitably result. Intentional slot reuse procedures may cause interference problems with other distant AIS equipment due to high signal strength resulting from lower free space propagation loss. Additionally, propagation delays between the aircraft and ships further away than 100-200 nm will cause garbled transmissions.

CHAPTER 16

CONSIDERATIONS FOR PLANNING OF AIS COVERAGE

When planning AIS coverage, a competent authority should consider the criteria discussed in this chapter. The presented development concept for AIS land infrastructure should enable the acquisition of all AIS users in inland regions, typical territorial waters (12 nautical miles) or in an entire EEZ (Exclusive Economic Zone).

Performance Criteria Considerations:

16.1 RF COVERAGE AREA

AIS VHF operational coverage should encompass the following considerations.
In coastal areas, extending seaward at least 20 nautical miles (NM) from the territorial sea baseline as defined by the competent authority, and including navigable waters within an area extending in-shore to the extent of AIS coverage defined by the competent authority.
For regions along in-land rivers and lakes, including the navigable portion of the rivers and lakes and adjacent land areas, to the extent of AIS coverage defined by the competent authority.
The Basic principles defined by IMO Resolution A.801(19) Provision of Radio Services For The Global Maritime Distress and Safety Service (GMDSS) for establishing Sea Area A1 for GMDSS VHF (156-174 MHz) can be applied for determining the AIS coverage area.

Sea Area A1 is that area which is within a circle of radius A nautical miles over which the radio propagation path lies substantially over water. The radius A is equal to the transmission distance between a ship's VHF antenna at a height of 4 metres above sea level and the antenna of the VHF coast which lied at the centre of the circle.
The following formula should be used to calculate the range A in nautical miles
A=2.5(Square root of H (in metres) + Square root of h (in metres))
H is the height of the coast station VHF receiving antenna and h is the height of the ship's transmitting antenna, which is assumed to be 4 m.
The following table gives the range in nautical miles (nm) for typical values of H:

h	*H→*	*50 m*	*100m*
4 m		*23 nm*	*30nm*

16.2 COVERAGE PERFORMANCE

While operating in the coverage area as defined in Paragraph 16.1, the coastal AIS VHF data link should satisfy the channel performance criteria for the AIS and AIS 2 as specified in ITU-R M.1371. The competent authority may, however, change these frequencies via the AIS channel management function.

16.3 COVERAGE VERIFICATION RECOMMENDATIONS

The competent authority should verify AIS VHF data link operational coverage and channel performance as follows.
Using the results of the initial coverage prediction calculations actual field tests need to be carried out to determine that the objectives of the initial model predictions have been realizes. This field should include a t least one base station inter-operating with several AIS mobile stations and the associated base station's land facilities.

16.4 PLANNING CRITERIA FOR AN AIS LAND-BASED INFRASTRUCTURE

When designing an AIS land-based infrastructure, the competent authority should use the following checklist.

1. How high is traffic volume and where are the points of traffic congestion? What are the traffic statistics in the respective areas? System capacity within the coverage range of a single base station is 4500 time slots per minute

2. Which areas of the coast can be covered with VHF?

3. In view of the traffic volumes to be expected and the ranges needed, what are the shapes of the coverage areas? For example, will coverage areas have to be sectorized?

4. How can garbling effects within coverage areas be minimized? Does this require coverage of the operating area by multiple base stations at different sites or sectorization?

5. What level of redundancy for the operation of the base station is necessary? (Redundancy of devices at a single location, multiple base stations or multiple coverage areas?)

6. How accessible is the base station equipment?

16.5 OPERATIONAL COVERAGE AREA OF A BASE STATION

When determining the size of the operational coverage area (operational cell) of base stations, an important consideration is the traffic load. When the traffic load is high the operational coverage area should be smaller in order to minimize the number of lost data messages due to message collisions (garbling).

The size of the operational coverage area of an AIS station is determined primarily by the height of the transmit/receive antenna. For AIS mobile stations, the height can vary significantly depending on the size of the ship. Generally, the operational coverage area of an AIS base station is larger than that of an AIS mobile station. The reliable reception of data messages depends on the size of the operational coverage area as well as on the operational propagation parameters, the topographical conditions and the traffic density.

Two factors of AIS determine the reception of a base station:

16.5.1 Operation of non-synchronized mobile stations within the coverage area of a base station (hidden user).

One can assume that, depending on the size of the coverage area of a base station, there will be mobile stations within the coverage area of a base station that cannot receive each other and hence will be unable to synchronize themselves. As far as the base station is concerned, these mobile stations access the operational channel at random. Consequently, it is quite possible that two or more mobile stations within the coverage range of a base station, which cannot see each other, will use the same time slot. Consequently, data transmission collisions may occur.

In some cases, the distance between the mobile stations and a base station may result in only the geographically closest mobile station being received (discrimination). When the separation distances are approximately equal the base station will receive neither of the two mobile stations (garbling). The probability of data transmission collisions increases as a function of traffic load i.e. the number of AIS mobile stations inside the coverage range of a base station.

16.5.2 Operation of mobile stations when the operational channel is overloaded:

Mobile stations within VHF operational range organize themselves taking into account the current and future use of time slots by other AIS stations. Consequently mobile stations will only use free time slots. If all time slots within a given VHF operational range are occupied, time slots used by other more distant stations will be intentionally overridden i.e. slot re-use takes place. The range of reception is effectively reduced as a result of the channel overload of the operational range. To avoid losing a target entirely, the transmission of a mobile station will be overridden intentionally only once per minute. Consequently, complete suppression of targets is unlikely. With respect to onboard collision avoidance it is more important to receive mobile stations close by than more distant mobile stations.

The response to overload conditions that works well for AIS shipborne mobile stations presents a problem for AIS base stations. Slot re-use by mobile stations within the coverage range of a base station can result in loss of information at the base station.

16.6 OPTIONS FOR THE BASIC ARCHITECTURE OF AIS BASE STATIONS.

To minimize the probability of garbling within the coverage range of a base station, i.e. several mobile stations using the same time slot, the following options exist:

16.6.1 Adjustment of coverage range to traffic volume

The operational range of base stations must be designed such that the traffic volume remains well below the theoretical system capacity within the coverage range.

This can be achieved as follows:

16.6.1.1 Adjustment of the operational propagation range (operational cell) of a base station:

Conditions of high traffic load lead to reduced range of base stations. Consequently, a relatively large number of sites may be required to ensure an unbroken coverage.

16.6.1.2 Creation of sectorized coverage areas

Sectorization establishes, at a single site, several coverage ranges for base stations that operate independently of each other. Antenna systems with directional properties can be employed to create these sectors. Each coverage sector is assigned to its own base station. In this way coverage areas can be matched specifically to areas of high traffic density.

16.6.2 Use of passive, receive-only base stations

The coverage area of a base station can be subdivided by using several, staggered, receive-only stations with limited range. An active base station with long range provides the operational service for the area; the passive satellite stations utilize the distance to mobile stations to overcome the effect of garbling. The received data messages will then be correlated with each other.

This system option requires relatively many interconnected sites.

16.6.3 Using multiple base stations for a single coverage area.

Two or more base stations may acquire high traffic areas from several directions. The coverage areas of these base stations overlap each other. The constellation of base stations with geographically separated sites can overcome the garbling effect that is always referred to the location of the receiver.

The complete overlap of coverage by several base stations also results in redundancy for any individual base station.

16.6.4 Control of the transmission mode of mobile stations by base stations.

Within its service range, a base station can determine the transmission mode of a mobile station. To do this, the base station switches each mobile station to the assigned mode. Reporting rate and time slots are specified in assigned mode.

In theory, base stations can control the transmission mode of all mobile stations. To do so, every mobile station must be addressed. This process limits the capacity of the system. Correspondingly, adjacent base stations must distribute and correlate the available operational channel capacity. Acquiring a new mobile station entering an operational area for the first time requires the reservation of capacity. Since this control mechanism by itself already results in high channel loading, it can be used only in special circumstances.

16.6.5 Base stations in combination with duplex repeaters to support the self-organizing of mobile stations.

The duplex repeater provides to all participants, within a service area, all data transmissions that originate in a service area. Every participant knows the entire operational traffic in the coverage area of the repeater and, hence, they can be considered during the self-organizing process. The coverage area of a duplex repeater is completely organized. System capacity must be reserved for mobile stations entering the coverage area for the first time. The use of duplex repeaters excludes direct ship-to-ship communications. Land-based duplex repeaters process the entire communication traffic. The use of duplex repeaters requires that all mobile stations be switched to a regional duplex operational channel. The operational channel load in the transition region to the regional channel increases due to additional transmissions from the mobile stations.
Adjacent duplex repeaters require different duplex channels.

16.6.6 Coverage areas arbitrarily defined by a cellular operational network

The assignment of regional operational channels to each base station allows the implementation of a cellular network analogous to the VHF area network. Adjacent base stations are independent of each other. The size of the coverage area can be defined arbitrarily and can be substantially smaller than the actual operational range. In this manner, specially matched coverage areas can be defined.

The use of regional operational cells requires that all mobile stations be switched to a regional operational channel.

Adjacent operational cells require different operational channels. In the transition region, channel load increases as a result of additional transmissions from mobile stations.

The simplex repeater does not constitute an independent option because it is used exclusively to extend the coverage area.

<u>Note</u>
Of the above alternatives only alternatives 1-3 have no effect on technical operation of the mobile stations.

16.7 JOINT OPERATION OF SEVERAL BASE STATIONS

Since coordinated coverage is required, several base stations must be connected to each other. Individual base stations must be networked to combine information and to filter out redundant information. The network, connecting the base stations, will not be discussed here any further since it will be described in detail elsewhere in this report.

The following options for base station coverage areas exist. These may be combined as required:

16.7.1 Coverage of large areas by base stations with long range.

Individual base stations may be arranged such that the largest possible areas are covered. This implies that antenna sites, as high as possible, with clear omnidirectional views (clear view of all the areas to be acquired) be established. This base station design is feasible if a small traffic volume can be assumed such that the system can operate with a low operational channel load. The probability of garbling due to two mobile stations not being able to receive each other is low due to the low channel load.

16.7.2 Coverage of large areas by several base stations with large ranges subdivided into sectors.

In order to avoid overload conditions for long-range base stations (e.g. coverage far out to sea) as a result of too many participants, it is possible to partition the operating area into many sectors. This is achieved technically by using directional antennas that receive signals only from specific directions and transmit respectively only in one direction. By using appropriate layouts it is possible to achieve omnidirectional coverage with several co-located directional antennas. An independently operating base station is assigned to each coverage sector i.e. each directional antenna is connected to its own base station. Since antenna radiation patterns normally overlap, it is necessary to filter redundant data transmissions over the AIS base station network.

16.7.3 Coverage of large areas by several short-range base stations

If large traffic loads are expected, it is reasonable to shorten the coverage ranges of base stations. A smaller coverage area can be achieved by limiting the operational propagation range by, for example, reducing the antenna height. When several short-range AIS base stations are built, their coverage areas include only a small traffic load such that an overload situation can be avoided.

AIS base stations with small coverage areas can also be realized through sectorization.

16.7.4 Coverage of large areas by long-range base stations and several short-range, passive base stations

In order to deal with the garbling effect, an active base stations, which is also responsible for ship-shore communication traffic, can be constructed for a given coverage area. The transmission of this base station will be transmitted over previously reserved and readily available time slots.

Multiple use of time slots by mobile stations, which might still exist, will be resolved through appropriately staggered, passive base stations and the discrimination in favour of the stronger transmitter. Each of the passive base stations receives the transmissions in its immediate vicinity.

It is also feasible to co-locate the passive base stations with the active base station provided they are equipped with receiving sectors.

16.7.5 Multiple coverage of coverage areas of base stations

If the distances between base stations are chosen such that the operational cells overlap significantly, then targets from several base stations will be received simultaneously. This results in a redundancy of reception routes, namely from two or more base stations from different directions. Each of the base station experiences different conditions with respect to the distribution of time slots, such that the probability of garbling for the same time slot in both operational cells is reduced. Interference of reception at one base station could be compensated for by another base station.

The probability of reception in the case of overlapping operational cells is higher.

16.7.6 Increase of coverage areas of base stations by means of simplex repeaters.

The range of AIS base stations can be increased by means of AIS simplex repeater stations. However, this increases the load on the operational channel because all received data telegrams must be send out once again.

Simplex repeaters can be used when the traffic density is low or in areas where the operating range of base stations is limited by shadowing of operational reception due to topography.

The repeater places minimal requirements on the infrastructure because the data messages are simply repeated and are not forwarded over the communication links.

16.8 NETWORKS

In addition to the design criteria for individual base stations as identified in the previous paragraphs, the competent authority needs to consider the requirements for network system design as described in Chapter 19.

16.9 CONCLUDING REMARKS

Planning of AIS coverage areas should consider traffic statistics and the relative importance of the traffic areas to be served, and must be designed keeping in mind future requirements. For example, it has been decided that there will be class B mobile stations available for a significant population of vessels, particularly pleasure craft. This fact could lead to a large number of AIS users in certain areas. This may require that the range of base stations be reduced in order to accommodate this extra traffic and to avoid message collisions.

CHAPTER 17

CONFIGURATION MANAGEMENT OF AIS SHORE INFRASTRUCTURE

17.1 GENERAL

Note:

IALA is in the process of developing the content of this chapter. It is anticipated that this work will be completed by September 2002.

CHAPTER 18

PROCESSING OF AIS DATA FROM MULTIPLE BASE/MULTIPLE REPEATER STATION ENVIRONMENT AS IT AFFECTS THE VDL

18.1 GENERAL

Note:

IALA is in the process of developing the content of this chapter. It is anticipated that this work will be completed by September 2002.

CHAPTER 19

NETWORKING ON SHORE SIDE USING TELECOMMUNICATIONS NETWORK

AIS Shore Side Network Functionality

19.1 INTRODUCTION

Automatic Identification Systems (AIS) were initially viewed as a means for vessels to accurately and automatically communicate to other vessels their position and movements in order to avoid collisions. As the concept evolved, it became clear that similar communications between ships and shore facilities, such as Vessel Traffic Centres, could further enhance the safety of navigation. Further, if the transmitted information were processed and shared with other facilities the port authority could effectively monitor and manage maritime traffic with benefits accruing to safety, commerce and the environment.

The final step in this evolution is the shore side network that makes it possible for the AIS information to be shared among multiple users without additional communication demands on the vessel's pilot or navigation officer. Safety related information, such as position reports, weather reports and hydrographic data can be distributed quickly, accurately and automatically among shore facilities and between shore facilities and other vessels.

An AIS Network is therefore the set of infrastructure that allows for the interconnection of AIS base stations and shore facilities to form one integrated system as illustrated by the red line in figure 9-1.

Several companies offer solutions for AIS networks and can provide more detailed information on AIS Networks. Three documents that illustrate this are:

AIS Network Marine Data Systems 101 De Korte Street Johannesburg 2000 Tel: +27 11 242 4131 Fax: +27 11 242 4341 www.mainedata.co.za	Marine Communications Networks MariTEL 16 East 41st Street, New York NY10017 Tel: +1 212 532 9300 Fax: +1 212 532 2677 www.maritelusa.com	*Saab document name* Saab TransponderTech AB Vretenvägen 12 P.O. Box 4113 SE-171 04 Solna Sweden Tel: +46 1318 80 00 Fax: +46 8627 49 49 www.transpondertech.se

19.2 NETWORK FUNCTIONALITY

In all the structures described in the following section, the network may perform some or all of the following functions:

19.3 ROUTING OF INFORMATION

Due to the fact that an AIS network can have multiple entry and exit points requiring the AIS data, it is necessary that the network route the data to the correct point. There are three possibilities for routing

- From AIS base station to the shore facility
  - An AIS position report from a vessel with in certain VTS service area gets routed to the correct shore facility.

- From a shore facility to a mobile AIS

- o A VTMIS sends an addressed text message to a certain vessel. The network will then route that message from the VTMIS to the base station within which coverage area that vessel currently is located.

- From a mobile unit to another mobile unit using the network
  - o A mobile sends an addressed message to another mobile station that is outside of its coverage area but within the coverage area of the network.

19.3.1.1 Filtering of information

All AIS messages may not be required by all shore facilities. The process of reducing these messages is called data filtering.
One of the distinctions of an AIS network is that in order to get redundant RF coverage the system will have many duplicate messages. These duplicate messages can be used to determine the extent of the RF coverage overlap, but mostly are of no interest to the external applications therefore they should be filtered out as soon as possible to avoid unnecessary use of bandwidth.
The filter criteria can be any data field or combination of data fields in any AIS message type e.g.

- MMSI number
- Destination.
- Position

19.3.1.2 System monitoring and diagnosis

The monitoring function should monitor the status of the network components, identify any failures and give the appropriate alarm. This monitoring function can include system load and link availability.

19.4 FUNCTIONAL STRUCTURE

19.4.1 Basic structure

The most basic form of a network is a single base station connected to a single shore facility like a VTMIS centre or a Coast Guard as illustrated in figure 19-1

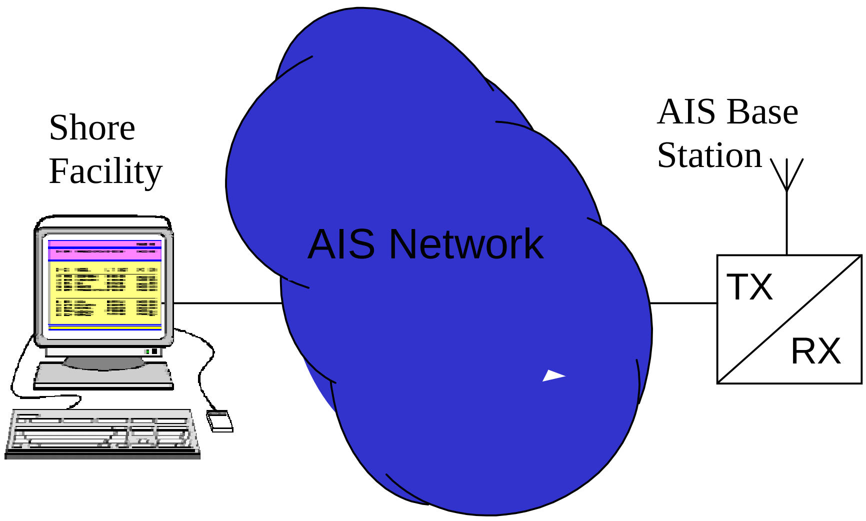


Figure 19-1

This type of network would typically be used in smaller ports where a single VTS centre manages a relative small area and could possibly be as simple as a single data link. Because this network is very basic it does not require routers or filters or extensive network management.

Multiple Base stations connected to a single shore facility
In an area where a single shore facility, like a VTS centre, has to cover a relatively large area or where redundant RF coverage is required a network as illustrated in figure 19-2 would be feasible.

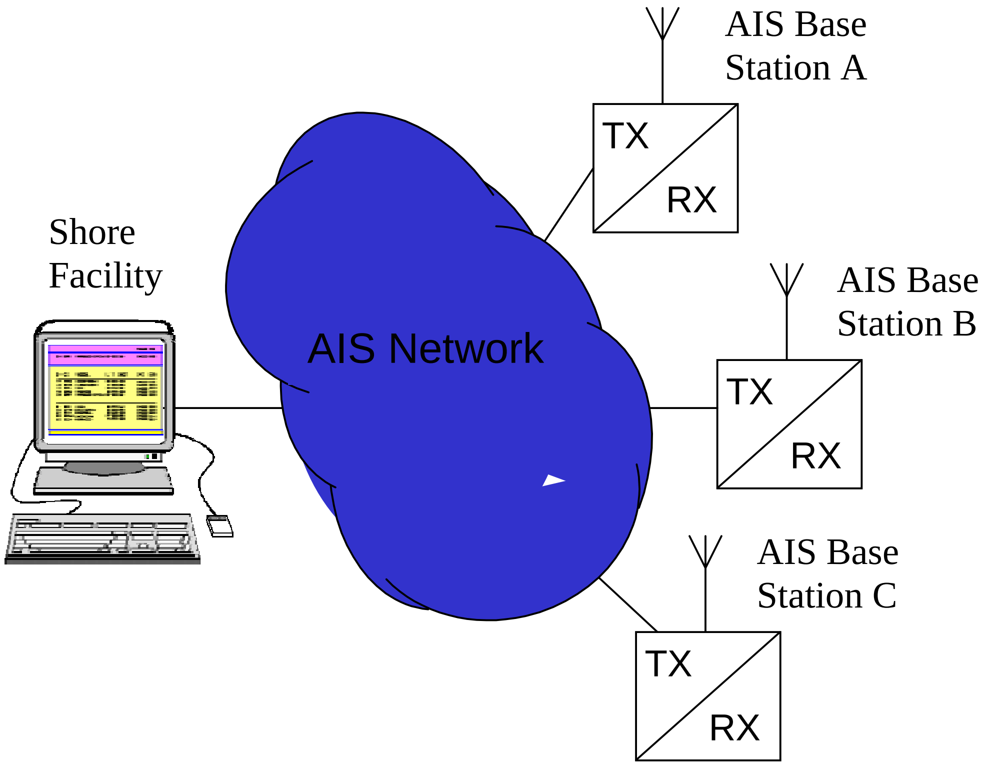


Figure 19-2

Because this type of network has more than one source of information there is a definite possibility of duplicate messages and therefore the filtering functionality as described in **Error! Reference source not found.** above may be required.

Since there is only one shore facility the routing required will be from the shore facility to the correct base station(s) for shore-to-ship messages; or between base stations in the case of ship-to-ship addressed messages.

Unlike the previous functional structure this type of network can be fairly complex and some form of network management would be required.

19.4.2 Multiple base stations connected to multiple shore facilities.

This type of network would be used in a region where more than one shore facility would require access to the AIS network. This is illustrated in figure 19-3

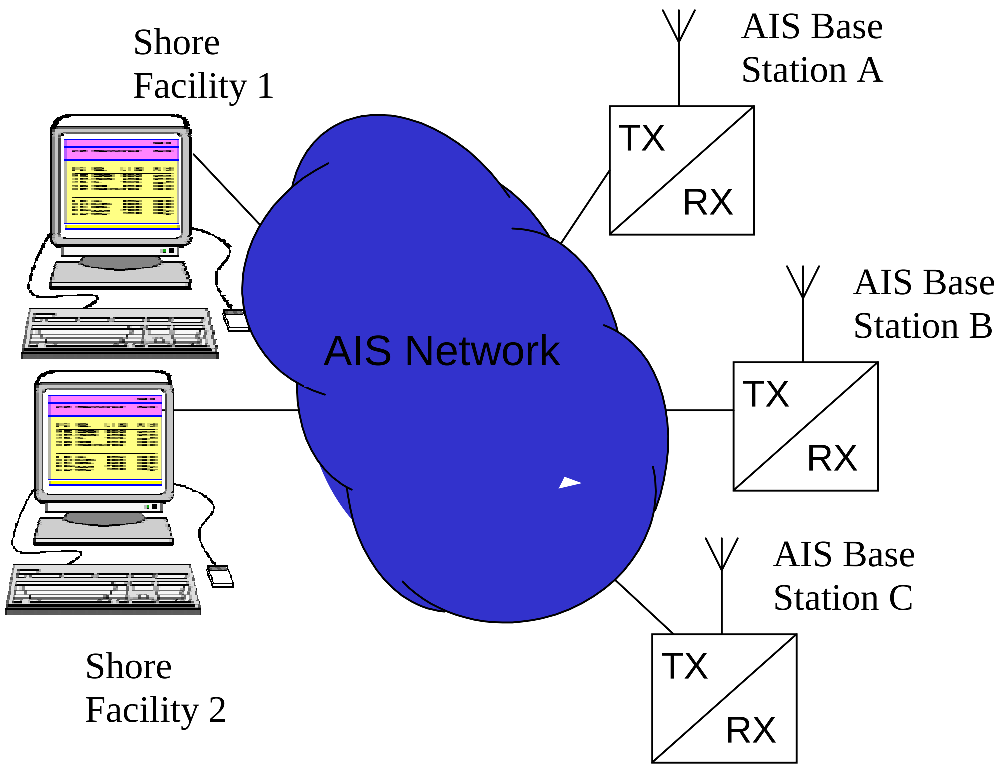


Figure 19-3

This type of network would generally require all the functionalities as described in **Error! Reference source not found.**

19.5 COMMUNICATION LINKS

An AIS network requires digital communication links between the various components and care should be taken that the links have the required bandwidth.

The bandwidth required by the link between the base station and the network is a function of the traffic expected at that base station. The bandwidth required by the links within the network is a function of system traffic.

19.6 SECURITY

The network should provide adequate protection against unauthorized use of the information and the network. A concept of user rights and authorization could be established to ensure that unauthorized users do not have the ability to change or obtain information to which they are not entitled. Likewise unauthorized transmission of data over the network should be prevented.

19.7 OTHER APPLICATIONS USING THE AIS NETWORK

A comprehensive view of the shore side network should include consideration of commercial aspects as well as AIS. While the use of the designated AIS channels for other than safety related communications must be strictly avoided, the network infrastructure can accommodate public correspondence messages if properly designed e.g. for both ship and shore users, the network can provide automated message service.

19.8 MULTIPLE NETWORKS

The design of the network should take into account the possibility that the network may be required to connect to other regional or national AIS networks in order to increase the coverage area for expanded traffic management. For example providing an advance notification to a destination port of a vessel leaving a port in another area.

CHAPTER 20

LONG RANGE APPLICATIONS

Because the communication system for long-range applications to the AIS Class A mobile system (optional for Class B) has not been defined by any IMO requirement, a choice has to be made for long-range data communication means in order to use this service of AIS. In principle every long-range communication system can be used as long as it is suitable for data communication. In the architecture as described in this chapter all examples are given for Inmarsat-C as a practical solution, but also other satellite based systems as well as shore based systems for long-range data communication can be used. From standardisation's point of view a common solution should be preferable. This to avoid re-connecting AIS to different communication systems in different areas. In case of a fully integrated bridge design, where all communication systems, including AIS, are in a common network, it might be possible to use any suitable long-range communication system on request of the 'calling' authority. This is not further developed in this chapter.

20.1. ARCHITECTURE

The functional design of the long-range application can be as follows.

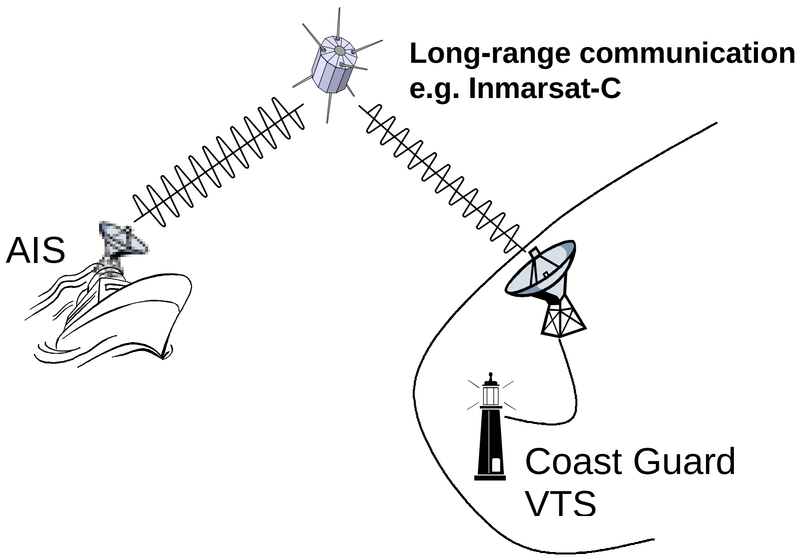


Figure 20-1

As stated above, the long-range mode requires a long-range communication medium. A maritime and/or public service provider will normally operate the long-range communication medium. Long-range AIS information exchange between that service provider and the VTS will be done by telephone lines or other communication means.

The applicable AIS standards do not specify the nature of this long-range communication medium. So an administration is free to choose a long-range communication system that can be easily interfaced to the AIS on board and that provide cost-effective services. For example, Inmarsat-C terminals, which are already carried by many vessels as part of their GMDSS obligations, can be candidates for this application. Also other satellite systems as well as the future UMTS service can take into account. However, most current Inmarsat-C terminals on board, as well as other shipborne long-range communication systems, do not support the IEC 61162-2 interface standard that has been adopted for AIS transponders and all future maritime onboard systems. Consequently, for long-range applications an active interface box is required that translates the long-range AIS 61162-2 messages to the required messages suitable for the chosen communication system and vice versa. This active interface can also gather information that may not be standard to AIS. This could be another information source on board a ship, if installed.

Error! Reference source not found. and **Error! Reference source not found.** are schematic representations of the interface requirement to a long-range communication medium. **Error! Reference source not found.** describes the ideal situation. However, as this ideal situation cannot be realised at this point in time **Error! Reference source not found.** illustrates the recommended interim solution.

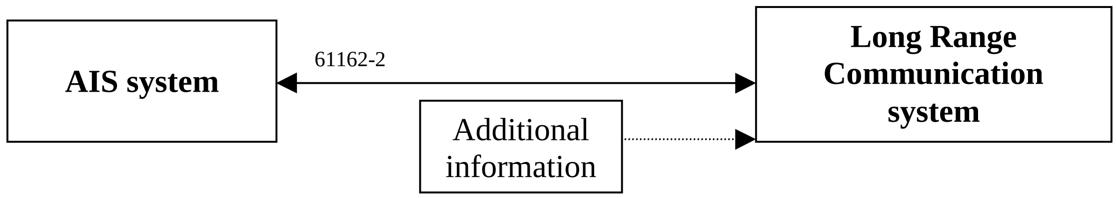


Figure 20-2

If no IEC 61162-2 interfaces exist for long-range communication systems, the following configuration can be used as an interim solution.

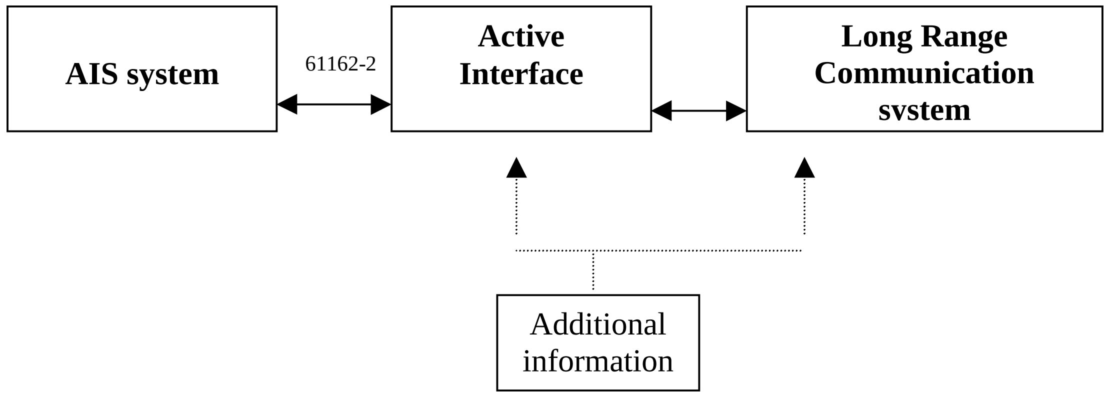


Figure 20-3

20.1 MESSAGES BETWEEN THE AIS AND THE LONG-RANGE COMMUNICATION SYSTEM

Standardised IEC 61162-2 interfaces on the Class A AIS units are defined to communicate with the external long-range communication system.

20.1.1 Interrogation of the AIS

Long-range interrogation of AIS units is accomplished through the use of two IEC 61162-1 sentences - LRI and LRF. This pair of interrogation sentences provides the information needed by the AIS unit to determine if it must construct and provide the reply sentences - LR1, LR2, and LR3. The LRI-sentence contains the information needed to determine if the reply needs to be constructed. The LRF-sentence identifies the information that is being requested.
The information, that can be requested by the LRF-sentence, is shown in **Error! Reference source not found.** (AIS Long-range Communications Input Data and Formats). These information items are the same as those defined in the table in chapter 1.14 of the operational part of this guideline. The letters shown in parenthesises are from IMO Resolution A.851 (20) and are used in the LRF-sentence. Details of these sentences are contained in IEC 61162-1.

AIS Long range Communications Input Data and Formats

Data	IEC 61162-1 Sentences
Long Range Interrogation Type of request Geographic area request AIS unit request	LRI - Long Range Interrogation
Long Range Function identification Requestor MMSI and Name Request for: Ship's name, call sign, and IMO number (A) Date and time of message composition (B) Position (C) Course over ground (E) Speed over ground (F) Destination and ETA (I) Draught (O) Ship / Cargo (P) Ship's length, breadth, and type (U) Number of persons on board (W)	LRF - Long Range Function Identification

Table 20-1

20.1.2 Reply of the AIS

The long-range reply of the AIS unit is accomplished through the use of three IEC 61162-1 sentence formatters - LR1, LR2, and LR3. The AIS unit shall reply with the three sentences, in the order LR1, LR2, and LR3, when responding to an interrogation - even if all the information items in the sentence are ‘null’. The LR1-sentence identifies the destination for the reply and contains the information items requested by the "A" function identification character in the LRF-sentence. The LR2-sentence contains the information items requested by the "B, C, E, and F" function identification characters in the LRF-sentence. The LR3-sentence contains the information items requested by the "I, O, P, U and W" function identification characters in the LRF-sentence.
The individual information items will be ‘null’ if any of the following conditions exist:

- The information item was not requested in the LRF-sentence,
- The information item was requested but is not available, or
- The information item was requested but is not being provided.

The output data shown in **Error! Reference source not found.** shall be provided when specifically requested by function identification characters contained in the preceding LRF-sentence portion of the interrogation. Details of these sentences are contained in IEC 61162-1.

LR Output Data Formats

Data	IEC 61162-1 Sentences
MMSI of Responder MMSI or Requestor Ship's Name Ship's call sign IMO Number	LR1 - Long Range Response, line 1
MMSI of Responder Date and time of message composition Position Course over ground Speed over ground	LR2 - Long Range Response, line 2
MMSI of Responder Destination and ETA Draught Ship / Cargo Ship's length, breadth, and type Number of persons on board	LR3 - Long Range Response, line 3

Table 20-2

20.2 DATA EXCHANGE OVER THE LONG-RANGE COMMUNICATION SYSTEM

Because the long-range communication system is not defined nor standardised, the communication over the long-range link is not defined. To make international use of the long-range application possible, at least the communication requirements and functional design will be described here.

20.2.1 Requirements

The long-range communication system must comply with the following minimal requirements:

- Suitable for data communication.
- Because the long-range mode will be initiated by a general-ships broadcast message directed to a specific geographically defined area, the system must be suitable to receive geographically defined calls or at least general calls. In the last case, the AIS will select the received interrogation message.
- MMSI number will address succeeding long-range interrogations, so the receiving onboard station must be able to select on MMSI number.
- The onboard receiver must be able to distinguish AIS messages to direct them to the AIS designed I/O port.
- If the onboard system is equipped with an IEC 61162-2 interface, the communication system must transfer the long-range data message from the communication link into long-range AIS messages as defined in IEC 61162-1 and vice versa (see **Error! Reference source not found.**).

20.2.2 Functional design

The functional design for long-range communication is strongly dependent of the communication medium in use. The communication system will normally use a shell to transfer the required data messages. Measurements have to be taken for addressing the messages from the sender to the receiver. The following functional diagrams illustrate the long-range communication design.

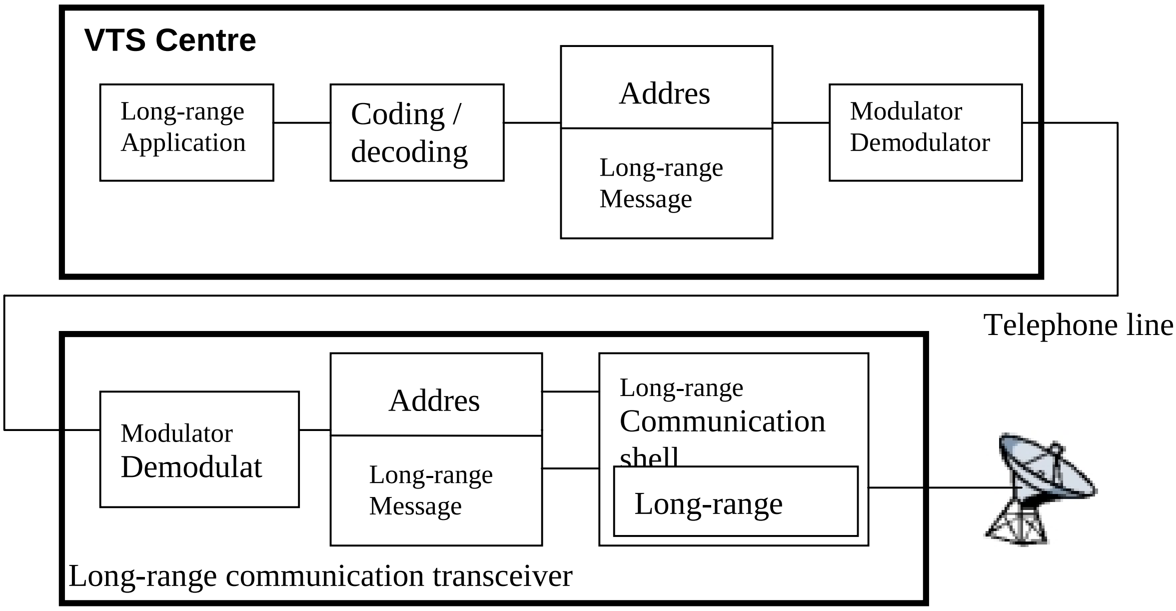


Figure 20-4: Shore based functional set-up

In the VTS station a long-range application will manage the long range AIS communication. Interrogations, geographical as well as addressed, will be coded to long-range messages together with the belonging addresses. Via telephone lines these information will be transferred to a long-range transmitter/receiver station (e.g. an Inmarsat-C earth station). For the air transportation a communication shell will be required, depending of the communication system to be used. The long-range data and the address information are just elements of that shell.

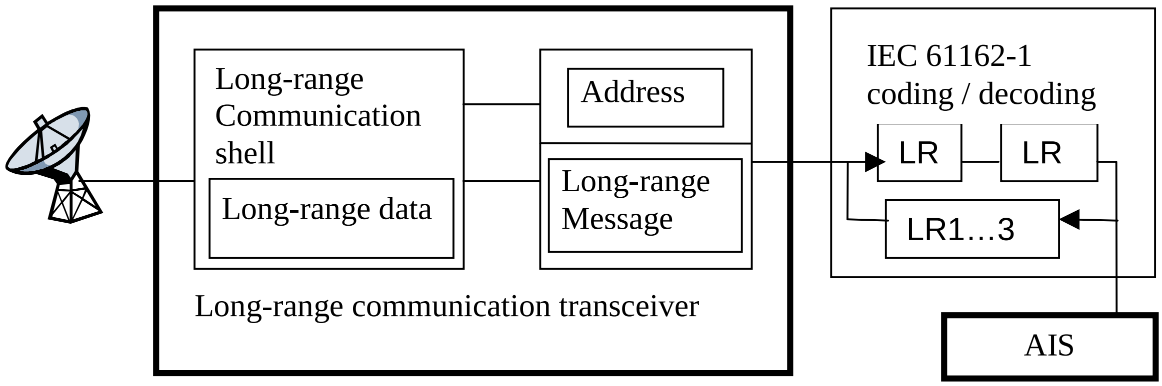


Figure 20-5: Functional set-up onboard

After receiving the message onboard, the long-range message and address information will be decoded from the shell. Now it is clear that the information is addressed to that particular vessel and its AIS system. The coding and decoding to IEC 61162-1 format of the long-range message can be an integral part of the long-range communication transceiver or a separate unit as given in **Error! Reference source not found.**.

ANNEX 1

DEFINITIONS

AIS	Universal Shipborne Automatic Identification System
AIS 1	161.975 MHz (87b – 2087)
AIS 2	162.025 MHz (88b – 2088)
ARPA	Automatic Radar Plotting Aid
ASCII	American Standard Code for Information Interchange
ATA	Automatic Tracking Aid
AtoN	Aid to Navigation
AUSREP	Australian Reporting system
AWP	Advised Waypoints
BAS	Basic AIS Services
BIIT	Built-in Integrity Test
Chayka	
COG	Course over Ground
COLREGS	IMO Collision avoidance Regulations
CPA	Closest Point of Approach
DAC	Designated Area Code
DG	Dangerous Goods
DGNSS	Differential Global Navigation Satellite Service
DSC	Digital Selective Calling
DTE	Data Terminal Equipment
ECDIS	Electronic Chart Display and Information System
ECS	Electronic Chart System
EEZ	Economic Exclusion Zone
EPFD	Electronic Position Fixing Device
EPFS	Electronic Position Fixing System
ETA	Estimated Time of Arrival
EUT	Equipment Under Test
FATDMA	Fixed Access Time Division Multiple Access?
FCC	Federal Communications Commission (USA)
FI	Function Identifier
GLONASS	Global Navigation Satellite Service
GMDSS	Global Maritime Distress and Safety System
GNSS	Global Navigation Satellite Service
GPS	Global Positioning System
Gyro	Gyrocompass
HDG	Heading
Hex	Hexadecimal
HS	Harmful Substances
HSC	High Speed Craft
IAI	International Application Identifier
IBS	Integrated Bridge System
ID	Identification, Identifier
IEC	International Electrotechnical Commission
IFI	International Function Identifier
IFM	International Function Message
IMO	International Maritime Organisation
INS	Integrated Navigation System
ITDMA	Incremental Time Division Multiple Access
ITU	International Telecommunications Union
ITU-R	International Telecommunications Union – Radiocommunications Bureaux
Loran-C	Long Range Navigation (version C)

MF	Medium Frequency
MID	Maritime Identification Digits
MMSI	Maritime Mobile Service Identity
MP	Marine Pollutants
MSC	IMO Maritime Safety Committee
NMEA	National Marine Electronics Association
NUC	Not Under Command
NWP	Next Waypoint
OOW	Officer Of the Watch
PC	Personal Computer
PI	Presentation Interface
RAI	Regional Application Identifier
RAIM	Receiver Autonomous Integrity Monitoring
RCC	Rescue Coordination Centre
REEFREP	Great Barrier Reef & Torres Strait ship reporting system
RIATM	Restricted In Ability To Manoeuvre
ROT	Rate of Turn
Rx	Receiver / receive
SAR	Search And Rescue
SME	Shipborne Mobile Equipment
SOG	Speed Over Ground
SOLAS	Safety Of Life At Sea
SOTDMA	Self Organising Time Division Multiple Access
SRS	Ship Reporting System
TCPA	Time to Closest Point of Approach
TDMA	Time Division Multiple Access
TEZ	Tanker Exclusion Zone
TSS	Traffic Separation Scheme
Tx	Transmitter / transmit
UTC	Universal Time Coordinated
VDL	VHF Data Link
VHF	Very High Frequency
VTS	Vessel Traffic Services
WGS84	World Geodetic Survey 1984
WIG	Wing In Ground
WRC	World Radiocommunication Conference

The following table provides an overview (description) of the types of AIS stations:

<table>
<tr><th colspan="4">Mobiles</th><th colspan="2">Fixed</th></tr>
<tr><td colspan="2">Shipborne</td><td>Airborne</td><td rowspan="2">AtoN</td><td rowspan="2">Base</td><td rowspan="2">Simplex repeater</td></tr>
<tr><td>A*</td><td>B</td><td>SAR</td></tr>
</table>

* including Class A derivatives

Mobiles:
Class A shipborne (mobile) station
Class B shipborne (mobile) station
SAR (airborne) AIS station
AtoN station

Fixed:
AIS base station
AIS simplex repeater

BASIC AIS SERVICES (BAS) DESCRIPTIONS

This section will contain a detailed description of the Basic AIS Services available from AIS. IALA is in the process of developing the content for this section.

ANNEX 2

EXAMPLE OF A PROCURMENT CONTRACT

A procurement document as used by one of the IALA members will be provided here as an example for other members.

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