AUTOMATIC IDENTIFICATION SYSTEM (AIS)

I. INTRODUCTION

I.1. What is the Automatic Identification System

The Ship-borne Automatic Identification System (AIS) as specified by IMO is a ship and shore based broadcast system operating in the VHF maritime band.

It is capable of sending and receiving ship information such as identity, position, course, speed, ship particulars and cargo information to and from other ships, suitably equipped aircraft and can handle over 2000 reports per minute and updates information as often as every two seconds. It uses Self-Organizing Time Division Multiple Access (SOTDMA) technology to meet this broadcast rate and ensure stable and reliable ship-to-ship and ship-to-shore operation.

When used with an appropriate graphical display, shipboard AIS enables the provisions of fast automatic and accurate information regarding risk of collision by calculating the Closest Point Approach (CPA) and Time to Closest Point Approach (TCPA) from the positional information transmitted by target vessels.

I.1.1 System description

Each AIS station consist of one VHF transmitter, two VHF receivers, one VHF DSC receiver, a standard marine electronic communication link and sensor systems. Timing and positional information is derived from an integral Global Navigation Satellite System (GNSS) receiver.

The AIS provides by VHF radio information such as the ship's identity, type, position, course, speed and navigational status. The requirement states that all passenger ships and ships 300 GRT and above (500 GRT and upwards for cargo ships if not engaged on international voyages) to be fitted in a phased program starting in July 2002 and to be completed by 2008. The AIS continuously transmits burst of information at a rate of between 12 and 2 seconds which is determined by the speed of the ship and whether it is turning.

For port VTS, the AIS provides precise position information. And since it also signals the dimension of the ship, it allows an accurate plot of a ship to be displayed on an electronic chart to assist the VTS operators. This type of information will be invaluable in future circumstances such that of the Sea Empress which ran aground in Milford Haven causing extensive oil spill.

For coastal and off-shore surveillance, the AIS gives knowledge on the whereabouts of a ship together with its name and identity numbers. At the Dover Strait, where Coast Guard Stations run the Channel Navigation Information Service, the AIS will eventually replace the need to report their identity by voice as radar targets are automatically tagged with their identities.

Cases:

In 1991, the fishing vessel "Ocean Hound" was run down in the Strait of Dover. And despite radar evidence, it was not possible to find the identity of the ship's involved.

In 1993, MT Braer was wrecked on the Shetland Islands after being off the coast for many hours due to engine failure.

These incidents led to the recommendation that Governments enact laws that will press for a world wide identification system for of vessels.

I.1.2 How does the AIS work

The AIS transponder will normally operate in an autonomous and continuous mode, regardless of whether the fitted vessel is operating on the high seas, in coastal waters or inland waterways. As VHF reports are essentially short range, require a substantial data rate and must not suffer from interference, two VHF frequencies in the maritime mobile band are utilized. These channels are VHF channels 87B (AIS1) and 88B (AIS2), in the maritime mobile band.

Messages are packed in slots that are accurately synchronized using GNSS timing information. Each station determines its own schedule (slot), based upon data link traffic history and knowledge of future actions by other stations. A position report from one AIS station fits into one of 2250 time slots established every 60 seconds.

AIS must be able to operate in "ship-to-ship" and "ship-to-shore" mode everywhere at all times. Thus the ship borne AIS is required to simultaneously support both "ship-to-ship" and "ship-to-shore" modes on two separate channels in a Vessel Traffic Services (VTS) area. To meet this requirement and mitigate the effects of radio frequency interference of radio frequency interference (since one channel may be jammed due to interference) ship borne AIS transponders 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 devices) and for duplex as well as simplex channels.

Position and timing information is normally derived from an integral or external global navigation satellite system (e.g. GPS) receiver, including a medium frequency differential GNSS receiver for precise position in coastal and inland waters. Other information broadcast by the AIS, if available, is electronically obtained from shipboard equipment through standard marine data connections. Heading information and course and speed over ground would normally be provided by all AIS-equipped ships. Other information such as rate of turn, angle of heel, pitch and roll, and destination and ETA could also be provided.

The AIS transponder normally works in an autonomous and continuous mode, regardless of whether it is operating in the open seas or coastal or inland areas. Transmissions use 9.6 kb GMSK FM over 25 or 12.5 kHz channels using HDLC packet protocols. Although only one radio channel is necessary, each station transmits and receives over two radio channels to avoid interference problems and allow channels to be shifted without communications loss from other ships. The system provides for automatic contention resolution between itself and other stations and communications integrity is maintained even in overload situations.

Each station determines its own transmissions schedule (slot), based upon data link traffic history and knowledge of future actions by other stations. A position report from one AIS station fits into one of 2250 time slots established every 60 seconds. AIS stations continuously synchronize themselves to each other to avoid overlap of slot transmissions. Slot selection by an AIS station is randomized within a defined interval and tagged with a random timeout of between 0 and 8 frames. When a station changes its slot assignment, it pre-announces both the new location and the timeout for that location. In this way, new stations, including those stations which suddenly come within radio range close to other vessels, will always be received by those vessels.

The required ship reporting capacity according to the IMO performance standard amounts to a minimum of 2000 time slots per minute though the system provides 4500 time slots per minute. The SOTDMA broadcast mode allows the system to be overloaded by 400 to 500% through sharing of slots, and still provide nearly 100% throughout for ships closer than 8 to 10 NM to each other in a ship to ship mode. In the event of system overload, only targets further away will be subject to drop out in order to give preference to nearer targets that are a primary concern to ship operators. In practice, the capacity of the system is nearly unlimited, allowing for a greater number of ships to be accommodated at the same time.

The system coverage range is similar to other VHF applications, essentially depending on the height of the antenna. Its propagation is slightly better than that of radar due to longer wavelength, so it's possible to "see" around bends and behind islands if the land masses are not too big.

I.2 Historical Background

I.2.1 IALA's Role in the Development of AIS Standards

The International Association of Lighthouse Authorities (IALA) has been the primary organization sponsoring and coordinating the development of the Automatic Identification System (AIS).

In 1996, the Vessel Traffic Services (VTS) and Radio Navigation Committee of IALA prepared a draft recommendation that, with further refinement within IMO, 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 administrators 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.

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 the "IALA Guidelines on Ship borne Automatic Identification System (AIS). 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.

I.2.2 ITU's Role in AIS Technical Characteristics Development

The International Telecommunications Union conducted its World Radio Communication Conference (WRC) in Geneva in 1997. On IMO's request, the ITU designated two marine VHF channels for AIS. They are:

1. AIS 1 161.975 MHz
2. AIS 2 162.025 MHz

The ITU R M.1371 was prepared and entitled "Technical Characteristics for a Ship borne Automatic Identification System (AIS) using Time Division Multiple Access in the Maritime Mobile Band." This document was formally approved by ITU in November 1998 and is now adopted as the technical standard for AIS that defines the following:

- Transceiver characteristics

- Modulation
- Data format, message and packaging
- Time Division Multiple Access (TDMA)
- Channel Management

I.2.3 IEC's Role in the AIS Test Standards

The International Electrotechnical Commission (IEC) is the world organization that prepares and publishes international test standards for electrical, electronic and related equipment. It is the same organization that prepares the type approval test specifications for ships mandatory equipment required under SOLAS.

AIS test standards were developed and entitled as IEC 61993 Part 2: Ship borne Automatic Identifications System, Operational and Performance Requirements, Methods of Testing and Required Tests Results." Such standards include the following:

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

I.2.4 Significant Dates for AIS Development

1990 -	First paper presented to IMO at Nav 36.
1991 -	Draft technical requirements presented at Nav 37. It was based on Digital Selective Calling technique, 500 reports/hour.
1995 -	For capacity reasons, the technical requirements focused from DSC to SOTDMA.
1997 -	Draft performance standard for AIS based on SOTDMA existed.
1997 -	ITU WRC allocates two international marine AIS VHF frequencies.
1998 -	IMO performance standards for AIS-MSC 74 (69) Annex 3 adopted.
1998 -	ITU adopts the AIS technical characteristics reviewed October 2000 and adopted April 2001.
1998 -	IMO Maritime Safety Committee includes the AIS within SOLAS Chapter V, Regulation 19
2000 -	IMO MSC 73 ratifies changes of SOLAS chapter V
2001 -	BHS IN Germany performs conformity tests on AIS
2001-	AILA adopts technical guidelines for AIS IN December
2002 -	IMO carriage requirements start for AIS.

The Revision of SOLAS Chapter V Regulation 19

I.3 Carriage requirements for Ship borne Navigational Systems and Equipment

The existing Chapter V was written in 1974 and came into force in 1980. In 1992 it was decided that a thorough revision was appropriate. Some of the carriage requirements for navigational equipments were looking particularly old fashioned. Radio Direction Finders for instance, were a requirement although in practice most ships are using GPS. Reflection Plotters were a required although all modern radars are the daylight viewing raster types. The sub-committee on Safety of Navigation (NAV) was instructed to review and revise the chapter as necessary to bring it up to date. The task was finally completed in 2000 to come to into force on 01 July 2002. The new Chapter has been designated to take better account of the "human factor" and a more functional approach has been adopted for navigation based on an analysis of the basic tasks related to each navigational function.

The existing subparagraphs 4, 5 and 6 of paragraph 2.4.2 are replaced by the following:

"In the case of ships, other than passenger ships and tankers, of 300 gross tonnage and upwards but less than 50,000 gross tonnage, not later than the first safety equipment survey after 01 July 2004 or by 31 December 2004, whichever occurs earlier; and"

The following new sentence is added at the end of the existing subparagraph 7 of paragraph 2.4:

"Ships fitted with AIS shall maintain AIS in operation at all times except where international agreements, rules or standards provide for the protection of navigational information."

I.3.1 IMO Carriage Requirements

The 72nd Session of the IMO's Maritime Safety Committee decided the following ships will be required to carry AIS equipment:

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 AIS, as follows:

- Ships constructed on of after 01 July 2002
- Ships engaged on international voyages constructed before 01 July 2002
- Passenger ships, not less than 1 July 2003
- Tankers, not later than the first survey for safety equipment on or after July1 2003
- Ships, other than passenger ships and tankers, of 50,000 gross tonnage and upwards, not later than 1 July 2004
- Ships, other than passenger ships and tankers, of 10,000 gross tonnage and upwards but not less than 50,000 gross tonnage, not later than 1 July 2005
- Ships, other than passenger ships and tankers, of 30,000 gross tonnage and upwards but less than 3,000 gross tonnage, not later than 1 July 2007.
- Ships not engage to international voyages constructed before 1 July 2002, not later than July 2008;
- The Administration may exempt ships from the application of the requirements of this paragraph when such ships will be taken permanently out of service within two years after the implementation date specified in all the above implementation dates.

II. TECHNICAL ASPECTS OF AIS

II.1 General Description

Initially called the “Ship-Ship, Ship-Shore (4S)” broadcast transponder, this technology formed the basis of what eventually became known as the “Universal Ship- borne Automatic Identification System (AIS).

Putting it simply, AIS is an autonomous and continuous broadcast system, operating in the VHF maritime mobile band. It is capable of exchanging information such as identification, position, course, speed, etc. with ships and shore. It can handle multiple reports at rapid rates and uses Self-Organizing Time Division Multiple Access (SOTDMA) technology to meet this broadcast rates, ensuring reliable and robust operation.

AIS is now defined by an IMO Performance Standard and has carried the name “Universal AIS” in order to set the technologies, and precursor concepts known as AIS.

"Universal" no longer appears as a descriptor or a discriminator, which establishes the term AIS as terminology for only the most current, certified and standardized system equipment.

II.1.1 Objectives of AIS

1. Safety of life at sea
2. Safety and efficiency of navigation
3. Protection of the maritime environment

II.1.2 Purpose of AIS

The purpose of AIS is to help identify vessels, assist in target tracking, simply information, exchange and provide additional information to boost situational awareness. In general, data received via AIS will improve the equality of information to assist situation awareness as well as improve the quality of the information to the OOW.

II.1.3 Principles of AIS

The principle of AIS is to allow automatic exchange of shipboard information from vessel's sensors – inputted static and voyage related data – between one vessel and another or between one vessel and a shore station.

Its principal functions are to facilitate:

1. Information exchange between vessels within VHF range of each other, increasing situational awareness.
2. Information exchange between a vessel and shore station, such as VTS, to improve traffic management in congested waterways.
3. Automatic reporting in areas of mandatory and voluntary reporting.
4. Exchange of safety related information between vessels and between vessels and shore station.

II.2 AIS Standards

Standards set of AIS are guided by the criteria and corresponding references listed on this table. These criteria were originated from IEC, ITU & IMO.

The AIS should be capable of:

1. Providing information automatically and continuously to a competent authority and other ships, without involvement of ship's personnel;
2. Receiving and processing information from other sources including that from a competent authority and from other ships;
3. Responding to high priority and safety related calls with a minimum delay; and
4. Providing positional and maneuvering information at a data rate adequate to facilitate accurate tracking by a competent authority and other ships.

II.3 IMO Performance Standard – IMO Resolution MSC.74 (69) 1998

Annex 3 – Recommendation on Performance Standards for a Universal Ship borne Automatic Identification System

These performance standards specify the requirements for the universal AIS. The AIS should improve the safety of navigation by assisting in the efficient navigation of ships, protection of the environment and operation of Vessel Traffic Services (VTS) by satisfying the following functional requirements:

1. In a ship-to-ship for collision avoidance;
2. As a means for littoral states to obtain information about a ship and its cargo; and
3. As a VTS tool, i.e. ship-to-shore (traffic management).

The AIS should be capable of providing to ships and to competent authorities, information from the ship, automatically and with the required accuracy and frequency to facilitate accurate tracking. Transmission of the data should be with the minimum involvement of ship's personnel and with a high level of availability. The installation, in addition to meeting the requirements of the Radio Regulations, applicable ITU-R Recommendations and the general requirements as set out in resolution A.694 (17) should comply with the following performance standards:

II.3.1 Functionality

The system should be capable of operating in a number of modes:

1. An autonomous and continuous mode for all operation in all areas. This mode should be capable of being switched to/from one of the following alternate modes by a competent authority;

2. 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

3. A polling or controlled mode where the data transfer occur in response to interrogation from a ship or competent authority.

II.3.2 Capability

The AIS should comprise of:

A communication processor, capable of operating over a range of maritime frequencies, with an appropriate channel selecting and switching method, in support of both short and long range applications;

A means of processing data from an electronic position fixing system which provides a resolution of one ten thousandth of a minute of arc and uses the WGS-84 datum;

A means to automatically input data from other sensors meeting the provisions as specified, regarding "information update rates for autonomous mode."

A means to input and retrieve data manually;

A means of error checking the transmitted and received data; and

Built in Test Equipment (BITE)

II.3.3 User Interface

To enable a user to access, select and display the information on a separate system, the AIS should be provided with an interface conforming to an appropriate international marine interface standard.

II.3.4 Identification

For the purpose of ship and message identification, the appropriate Maritime Mobile Service Identity (MMSI) number should be used.

II.3.5 Information

The information provided by AIS should include:

a. Static

- IMO Number
- Vessel's name and call sign
- Length and beam
- Type of ship
- Location of position fixing antenna on the ship

b. Dynamic

- Ship's position with accuracy indication and integrity status
- Time in UTC
- Course over ground
- Speed over ground
- Heading
- Navigational status (anchor, NUC, etc…to be manually inputted)
- Rate of turn

c. Voyage related

- Ship's draft
- Hazardous cargo
- Destination and ETA (at Master's discretion)
- Optional – route plans (way points)

d. Short safety-related messages

II.3.6 Information update for Auto Mode

The different information types are valid for a different period and thus need a different update rate:

Static information every 6 minutes and on request
Dynamic information: Dependent on speed and course alteration according to the Table of Dynamic Information Update Rates in this handbook.
Voyage related information: Every 6 minutes when data has been amended and on request.
Safety related messages: As required.

II.3.7 Table of Dynamic Information Update Rates

Type of Ship	Reporting Interval
At anchor	Every 3 mins
0-14 knots	Every 12 secs
0-14 knots and changing course	Every 4 secs
14-23 knots	Every 6 secs
14-23 knots and changing course	Every 2 secs
> 23 knots	Every 3 secs
> 23 knots and changing course	Every 2 secs

II.3.8 Ship Reporting Capacity

The system should be able to handle a minimum of 2000 reports per minute to adequately provide for all operational scenarios envisioned.

II.3.9 Security

A security mechanism should be provided to detect disabling and to prevent unauthorized alteration of input or transmitted data. To protect the unauthorized dissemination of data, the IMO guidelines (Guidelines and Criteria for Ship Reporting System) should be followed.

II.3.10 Permissible Initialization Period

The installation period should be operational within 2 minutes of switching "on".

II.3.11 Power Supply

The AIS and associated sensors should be powered from the ship's main source of electrical energy. In addition, it should be possible to operate the AIS and associated sensors from an alternative source of electrical energy.

II.3.12 Technical Characteristics

The technical characteristics of the AIS such as variable transmitter output power, operating frequencies (dedicated internationally and selected regionally), modulation, and antenna system should comply with the appropriate ITU-R Recommendations.

II.3.13 AIS Stand Alone Capability

With the integral minimal display and keyboard unit, the AIS would be able to operate as a stand alone unit.

II.4 AIS Classification

In recognition of this requirement, allowance has been made in the AIS Technical Standards (ITU-R M.1371-1) for both Class A and B Ship-borne Mobile Equipment. Class A Equipment complies with the IMO AIS carriage requirement while the Class B provides capabilities not necessarily fully compliant with IMO requirements, but necessarily system compatible to perform satisfactorily on the VDL.

Class A Equipment

Shipborne mobile equipment intended for vessels meeting the requirements of IMO & SOLAS AIS carriage requirement.

Class B

Ship borne mobile equipment provides facilities not necessarily in full accord with IMO AIS carriage requirements. IEC has begun work on a Class B certification standard, which should be completed by 2004-2005. The Class B is nearly identical to Class A, except that Class B:

- Has reporting rate less than a Class A.
- Does not transmit the vessel's IMO number or call sign.
- Does not transmit ETA or destination.
- Does not transmit navigational status.
- Is only required to receive, not transmit, text safety messages.
- Is only required to receive, not transmit, application identifiers (binary messages).
- Does not transmit rate of turn information.
- Does not transmit maximum present static draft.

II.5 Features of the AIS

II.5.1 AIS in Inland Waterways

As an example of a regional inland approach to use AIS, modified AIS carriage is contemplated for certain European Waterways where the mix of ocean and inland vessels causes great complication and congestion.

Multinational river commissions will regulate policy and practice, setting precedent for other Administrations and regions to follow in similar inland scenarios where radio frequency availability permits.

For such inland applications, development of “Class A derivative” AIS equipment has been considered, providing full SOTDMA functionality, but not involving DSC components to achieve radio frequency agility. As the AIS position sensor may also be the inland vessel’s only position fixing device, new regionalized procedures may be necessary for display interface. The messaging process may also need regionalized adjustment.

II.5.2 AIS Use in Marine Rescue and Coordination

For coordinating resources on scene of marine search and rescue operation, it is important to know the position and navigation status of ships in the vicinity of the ship or person in distress. It can provide additional information and awareness of the resources for on scene operation, even though AIS range is limited to VHF radio range.

AIS may be used in search and rescue operations, especially in combined helicopter and surface searches.

Marine Rescue and Coordination Center’s (MRCC) operation would be much more efficient if they had every rescue craft fitted with AIS, quickly determine which ships is closest to a distress situation. During a search, all crafts could be tracked, enabling the Marine Rescue Coordinating Center to monitor their progress, to direct available resources efficiently and determine whether search coverage is without gaps. AIS follows direct presentation of the position of the vessel in distress on other displays such as RADAR or ECDIS, which facilitates the task of search and rescue crafts. For ships in distress not equipped with AIS, the On Scene Coordinator (OSC) could create a pseudo AIS target.

II.5.3 Aid to Navigation

In addition to primary role, an AIS station can be used as an aid to navigation. It 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."

II.5.4 Three ways of implementing AIS to Navigational Aids

a. Install an actual AIS mobile unit on a real aid to navigation and use the AIS Mobile Message Format to broadcast information related to the Aid to Navigation, or such other data as the competent authority may deem appropriate.

b. Create synthetic AIS Aid to Navigation.

2.1 Validated Data – the aid exist and its position can be validated from the aid, but the transmission is coming from another location (either from the shore or another aid)
2.2 Unvalidated data- the aid exists, but its position cannot be validated. In this case, it may be off-station and, hence, the IAS transmission is coming from shore or another aid. An "unvalidated" Synthetic AIS may lead to potential navigation problems if used with a floating AID to Navigation.

c. Create virtual AIS where the AIS message is an to navigation message, but no aid exist at the location. Virtual AIS may be useful for short-term temporary marks, but they should not seen as permanent AtoN solution at this stage.

II.5.5 AIS and Shore/ VTS Station

Shore-based station with AIS is capable of providing text messages, time synchronization, meteorological or hydrological or information, navigation information, or position of other vessels. Normally reports every ten seconds.

At present, radar is the main sensor of the VTS for detecting ship. The VTS radar has almost the same error in range and bearing resolution as all other radars, although it has known position and is North oriented without the errors of a compass involved.

The limitations of the ARPA radar to track ships due to target swap to land, beacons, bridges and other ships makes the tracking facility in the ARPA/ VTS rather limit ed. Vessels traffic services are currently limited to tracking ships in a bay area or on approaches from the sea to a harbor. There is a requirement for improving the VTS so that it will be to:

- Cover areas where radar coverage is almost impossible to achieve.
- Identify radar echoes on the VTS radar automatically.
- Interrogate ships for information regarding type of cargo.
- Track with high update rate.
- Know which port a ship is bound for.
- Know the size and draft of ships in the vicinity.
- Detect a change in ship's heading almost in real time.

AIS use in managing VTS (Vessel Traffic System)

For port VTS, the AIS provides precise position information. And since it also signals the dimension of the ship, it allows an accurate plot of a ship to be displayed on an electronic chart to assist the VTS operators. This type of information will be invaluable in future circumstances such that of the Sea Empress which ran aground in Milford Haven causing extensive oil spill.

For coastal and off-shore surveillance, the AIS gives knowledge on the whereabouts of a ship together with its name and identity numbers. At the Dover Strait, where Coast Guard Stations run the Channel Navigation Information Service, the AIS will eventually replace the need to report their identity by voice as radar targets are automatically tagged with their identities.

II.5.6 Safety Related Messages (SRM)

AIS is capable of exchanging Safety Related Messages (SRMs) between stations

II.5.7 Global AIS

The establishment of global AIS in general or a land-based AIS reception network in particular, may actually mitigate the need for VTS in many areas. The cost of installing and maintaining an AIS network is negligible compared to that of a VTS radar network.

II.5.8 DGNSS Corrections

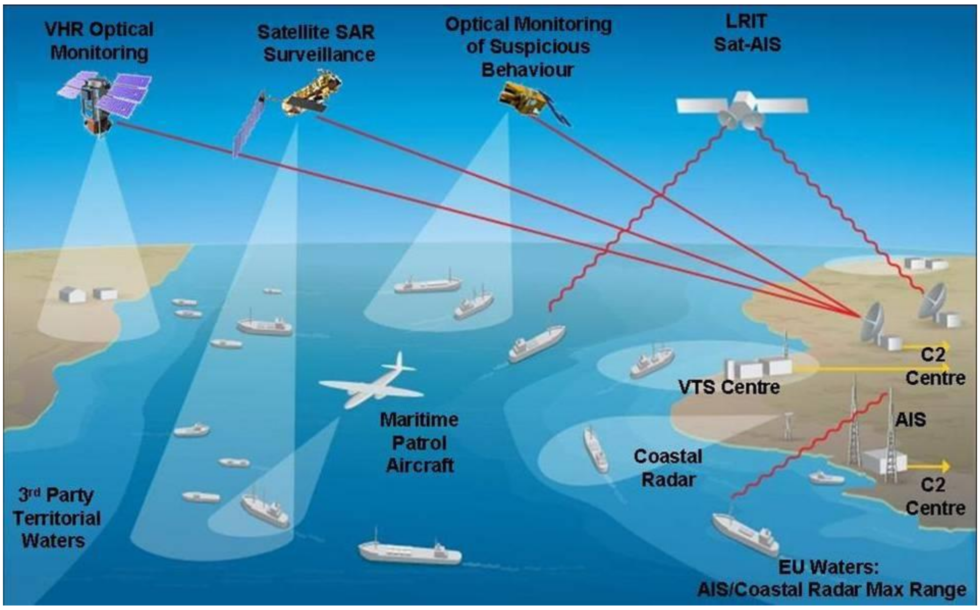
Differential GNSS corrections may be sent by VTS via AIS. This can increase the accuracy of the GPS-derived data on ships within AIS range.

II.5.9 Text Messages

VTS may send short messages either to one ship or all ships within a certain range or in a special area such as:

- Navigational warnings
- Traffic management information
- Port management information

II.5.10 Long Range Feature



The AIS data is compressed and broadcasted in very small data radio packets to any and all vessels within the coverage range of the vessel. The coverage range is limited and to a large extent depends on the height of the antenna.

II.5.11 Long Range Technologies

Various technologies exist that could satisfy the long range requirements being discussed by various maritime authorities. These include the following:

1. Satellite Systems

Satellite systems fall mainly into two primary service groups:

a. Real time communication
b. Store and forward communication systems

2. High Frequency (HF) and Medium Frequency (MF) Radio Systems

This system use 3MHz – 30 MHz radio band. Radio signals in this band have an ability to travel for long distances and as such are often used by the maritime industry for low cost inter-continental communications.

3. Meteor Scatter Radio System

Meteor Scatter Radio Systems use the ionized trails that result from when meteors enter the Earth's atmosphere. These ionized meteor trails act as temporary radio frequency mirrors and allow for reliable packet data communications for distances up to +/- 1500 km and thus with a limited number of meteor scatter radio base stations, a large area can be covered.

II.5.12 AIS Long Range Applications

Sensitive Area Reporting

Inmarsat-C is used as a long range data collection tool whereby the vessel is polled every few hours to provide its current position. This is then automatically logged in a database along with the voice reporting system data and thus allow having a view of all vessels in area covered.

II.5.13 Ship Operation Reporting

The primary application of this service are in operational planning and ship security application. Such service is normally offered on a subscription basis to the vessel owners and operators. The ability to interface this to shore-based AIS networks and applications is immediately apparent.

II.6 Other Features of AIS

II.6.1 Allocated VHF Channels

AIS operate primarily on two dedicated VHF channels: AIS1 at 161.975 MHz and AIS2 at 162.025 MHz. Where these channels are not available regionally, the AIS is capable of automatically switching to alternate designated channels.

II.6.2 Built In Integrity Test (BIIT)

The technical status of the AIS is automatically checked by the Built In Integrity Test (BIIT), but the quality and accuracy of the ship sensor data input to the AIS is not checked by the BIIT before being transmitted to other ships and shore stations. The OOW should carry out regular routine checks during the voyage to validate the accuracy of the information being transmitted. The AIS requires an alarm output to be connected to an audible alarm device or to the ship's alarm system if available.

II.6.3 The MKD Display

The IMO display requirement of AIS is Minimum Keyboard and Display, that is, presentation of target information in alphanumeric format only. For most operators this type of information is probably of very limited value. Since this type of display is likely to still remain the cheapest for some years ahead, it is reasonable to assume that most ships will be equipped with this type of AIS display.

II.6.4 Minimum Graphical Information

When AIS information is made available for graphical display, the following information should be displayed:

- Position
- Course Over Ground
- Speed Over Ground
- Heading
- Rate of Turn, or direction of turn

II.6.5 Priority of AIS Target Symbols

The presentation of AIS target symbols, except for sleeping or lost target, should have priority over other target presentations within the display area, including targets from Electronic Plotting Aid (EPA), Automatic Tracking Aid (ATA) or ARPA.

If such target is marked for data display, the existence of some other source of target data may be indicated, and the related data may be available for display upon operator command.

II.6.6 Suppressing Dangerous Targets

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

II.6.7 Course and Speed Over Ground Vector

If the Course Over Ground (COG) and Speed Over Ground (SOG) vector is shown, its reference point should be either the actual or the virtual position of the antenna. The vector time should be adjustable and valid for the presentation of any target, regardless of its source.

If the zones, guard rings or search area for automatic acquisition are specified and activated, these should be the same for all targets, regardless of their source

II.6.8 Warning Limits

Whenever the calculated CPA and TCPA values of an AIS target fall below set limits, a dangerous target should be displayed and an alarm should sound off. The preset CPA and TCPA limits applied for target data derived from different sensors should be identical.

III. USE OF AIS IN COLLISION AVOIDANCE AND MARITIME SECURITY

III.1 AIS and Maritime Security

Maritime security - AIS ship data

At its79th session in December 2004, the Maritime Safety Committee (MSC) agreed that, in relation to the issue of freely available automatic information system (AIS)-generated ship data on the world-wide web, the publication on the world-wide web or elsewhere of AIS data transmitted by ships could be detrimental to the safety and security of ships and port facilities and was undermining the efforts of the Organization and its Member States to enhance the safety of navigation and security in the international maritime transport sector.

The Committee condemned the regrettable publication on the world-wide web, or elsewhere, of AIS data transmitted by ships and urged Member Governments, subject to the provisions of their national laws, to discourage those who make available AIS data to others for publication on the world-wide web, or elsewhere from doing so.

In addition, the Committee condemned those who irresponsibly publish AIS data transmitted by ships on the world-wide web, or elsewhere, particularly if they offer services to the shipping and port industries.

After the September 11th attacks, authorities in the US and EU envisioned an important role for AIS in the field of higher security systems.

The AIS is an important tool for coastal states to monitor ship traffic and to detect possible threats. The new International Ship and Port Facility Security Code (ISPS Code) which is the outcome of the SOLAS amendment Chapter XI-2 (Special Measures to Enhance Maritime Security) shortens the above listed implementation periods.

III.1.1 US Carriage Requirement

On October 22nd, 2003 the Coast Guard published a Final Rule that amended a previously promulgated Interim Rule, that harmonized the AIS mandates of the Safety of Life at Sea Convention, as amended by the 73rd (MSC 73), and 76th Session (MSC 76), and, the Maritime Transportation Security Act of 2002 (MTSA), which delineates U.S. AIS carriage requirements.

III.2 AIS Impact on Navigational Watchkeeping

The use of AIS on board ship is not intended to have any special impact on the composition of navigational watch keepers, which must continue to be determined in accordance with the STCW.

III.2.1 SOLAS Requirement

The Master shall keep the AIS in operation at all times except when international agreements, rules or standards provide for the protection of navigational information. If the Master decides to switch off the AIS, this should be logged in the ship's logbook. The OOW should periodically check that the information given by the AIS, after it has been switched off, is correct.

III.2.2 COLREG Rule no. 7

"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 must be deemed to exist."

If COLREG obliges all ships to apply all available means to detect the danger of collision and to take preventive measures, one of these means, especially in reduced visibility, is ship-borne radar. Another aid now available is the AIS.

A study by a German Maritime Board showed that so called "radar assisted collision" occurred in restricted visibility when radar provided insufficient, incomplete or ambiguous data.

The study concluded that many of these collisions could have been avoided if the navigators have accessed timely and dynamic information (position, heading, speed, rate of turn, etc.) of the other vessel involved. AIS on ship-to-ship application can now provide such dynamic information accurately and at high update rates when target information is available on the ships involved.

"Early action" is still the best method of collision avoidance.

III.3 Cautions and Limitations in the Use of AIS

Users of AIS should always bear in mind that information given by AIS may not give a complete picture of the shipping traffic within the vicinity. There are many reasons why the AIS may not be able to perform such feature (i.e. malfunction, being switched off, etc.).

The potential of AIS as a collision avoidance equipment is recognized. AIS may soon be recommended for such function. However, care must be taken as AIS may not give a complete traffic overview about some or all of the relevant targets.

When AIS information is used to assist in collision avoidance decision-making, the following cautionary points should be borne in mind:

1. AIS is an additional source of navigational information. It does not replace, but rather augments other navigational equipment and system such as the radar, ARPA and VTS.
2. The use of AIS does not exempt the OOW from complying with COLREG at all times.
3. The user should not rely on the AIS as the sole information system, but user must also make use of relevant safety information available.

III.3.1 Not All Ships are Equipped with AIS

The OOW should always be aware that other ships, in particular yachts and other leisure crafts, fishing boats might not be fitted with AIS

III.3.2 AIS maybe Switched Off

The OOW must always be aware that other ships fitted with AIS as mandatory carriage requirement might have the equipment switched off under special circumstances as assessed by the Master.

III.3.3 AIS Information may not be Complete

Since pleasure crafts and other small vessels are not required to carry AIS, and that the AIS maybe switched off or malfunctioning, the OOW must always be aware that the traffic information provided by AIS may not give a complete overall picture of the traffic around his ship.

III.3.4 Erroneous Information from AIS

The OOW must always be aware that transmission of erroneous information entails a risk to other ships as well as their own. The users remain responsible for all information entered into the system as well as the information added by the sensors. This means to say that operators must check their own ship AIS information at regular intervals and whenever he suspects that something is amiss.

III.3.5 Accuracy of AIS Information

The accuracy of AIS information received is only as accurate as the information transmitted. That is information received by your unit will depend on the quality of information transmitted by each ship.

III.3.6 Special Precautions on Tanker Vessels and Terminals

Restriction on Oil and Gas Tankers:

i)When alongside a terminal or port area where hydrocarbon gases may be present, either the AIS should be switched off or the aerial isolated and the AIS given a dummy load. Isolating the aerial preserves manually input data that may be lost if the AIS was switched off. If necessary, the port authority should be informed. When alongside terminal or port areas where hydrocarbon gases are likely to be present, and if the unit has the facility, the AIS should be switched to low power. If the AIS is switched off or isolated whilst alongside, it shall be reactivated upon leaving the berth. The use of AIS equipment may affect the security of the ship or the terminal at which it is berthed. In such circumstances, the use of AIS may be determined by the port authority, depending on the security level within the port. (ISGOTT 5 4.8.4)

ii) Where either or both ships involved in STS operations are required to have an AIS operating while under way or at anchor, the AIS equipment should remain in use at all times including during STS operations. The AIS equipment used for the AIS broadcasts need not be set to low power output during STS operations. (STS Transfer Guide petroleum 3.5.5.4)

III.4 AIS and Other Navigational Equipment

AIS aim to achieve positional accuracy of better than 10 meters when associated with Differential Global Navigational Satellite System corrections. This compares favorably with radar whose accuracy is a function of frequency, pulse repetition rate and antenna beam width and which often achieves a positional accuracy of 30-50 meters.

Due to higher positional accuracy and less need for plot filtering, the position and changes of course over ground can be presented with less delay than radar.

The AIS provides the supplementary information about other vessels that is not readily available from radar, such as identity, heading course over ground (COG), speed over ground (SOG), rate of turn (ROT) and navigational status.

AIS is also less sensitive than radar to negative weather effects such as heavy rain, snow, etc.

AIS also has the capability to "see" around bends and corners.

III.4.1 ARPA/ATA Performance Standards

The limitations of Automatic Radar Plotting Aid (ARPA) and Automatic Tracking Aid (ATA) are apparent from the IMO Performance Standards. It should be noted that 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.

III.4.2 Comparison of Radar / ARPA and AIS Information

This is clearly manifested in a potential situation shortly after a target vessel has executed a course change to obtain a safe CPA with own ship. The ARPA "time filter" used to stabilize the ARPA vector may cause an offset between ARPA and AIS. This is why it is important for the officer of the watch to remember that ARPA is an early warning equipment for collision avoidance.

III.4.3 AIS Compared with Radar

Since AIS provides information different from that provided by the ship borne radar, it is strongly recommended that AIS and radar be used together in order to enhance the available information. AIS can also assist in the identification of targets by name or call sign and by ship type and navigational status. Thus reducing the requirement for verbal information exchange.

III.4.4 AIS Accuracy

As long as AIS provides more accurate and complete information, the passing distance between vessels can be determined with greater accuracy and reliability. From the navigational status information available, any maneuvering restrictions on a vessel become immediately evident and can be taken into account.

IV SYSTEM INSTALLATION AND OPERATION

IV.1 On board AIS Components

In general, AIS consists of the following components:

- Antenna
- One VHF transmitter
- Two multi-channel VHF receivers
- One Channel 70 VHF receiver for channel management
- Central Processing Unit
- An electronic-position fixing system
- Interface to heading and speed devices
- Built-in Integrity Test (BIIT)
- Minimum Keyboard and Display Unit (MKD)

IV.2 Guidelines for the Installation of a Ship borne AIS (IMO.SN.CIRC.227)

The Sub-committee on Safety of Navigation (NAV), at its forty eighth session (July 8-12, 2002) agreed on guidelines for the installation of the AIS and also agreed that they should be issued for use on a voluntary basis. The guidelines describe the ship borne AIS installation matters are meant to be used by manufacturers, installers and surveyors to ensure good installation practices.

The Maritime Safety Committee, at its seventy sixth session (December 2-13, 2002), concurred with the Sub-committee's views, approved the Guidelines as set out and encouraged their use for AIS installation purpose on a voluntary basis.

Member governments are invited to bring the annexed guidelines to the attention of all concerned.

IV.2.1 General

The Automatic Identification System (AIS) Class A is defined by IMO and has been made a carriage requirement by the latest revision of SOLAS Chapter V. AIS provides information that may be used for the navigation of ship. It is therefore essential that the information provided by AIS be reliable.

The AIS itself has been standardized by the International Telecommunications Union (ITU) and the International Electrotechnical Commission (IEC) and is subject to type approval. In order to fulfill the reliability requirements of information exchange, care should be taken to ensure that the AIS is correctly installed.

IV.2.2 Documentation

For installation of AIS, following diagrams are to be submitted:

- Antenna lay-out
- AIS arrangement drawing
- Block diagram

An installation configuration report is required prior to installation and kept on board thereafter.

IV.3 AIS Installation

IV.3.1 Interference to the Ship's VHF Radiotelephone

The AIS ship borne equipment, like any other ship borne transceiver operating in the VHF maritime band, may cause interference to a ship's VHF radiotelephone. Because AIS is a digital system, the interference may occur as a periodic (e.g. every 20 seconds) soft clicking sound on a ship's radio telephone. This effect may become more noticeable when the VHF radiotelephone antenna is located near the AIS VHF antenna and when the radiotelephone is operating near the AIS operating channels (e.g. 27, 28 and 86).

Attention should be paid to the location and installation of different antennas in order to obtain the best possible efficiency. Special attention should be paid to the installation of mandatory antennas like the AIS antennas.

IV.3.2 VHF Antenna Installation

Location of mandatory AIS VHF antenna should be carefully considered. Digital communication is more sensitive than analogue/voice communication to interference created by reflections in obstructions like masts and booms. It may be necessary to relocate the VHF radio telephone antenna to minimize interference effects.

To minimize interference effects, the following guidelines apply:

1. The AIS VHF antenna should have omni-directional vertical polarization.
2. The AIS VHF antenna should be placed in an elevated position that is free as possible with a minimum of 2 meters in horizontal direction from constructions made of conductive materials. The antenna should not be installed close to any large vertical

obstruction. The objective for the AIS VHF antenna to see the horizon freely through 360°.

3. The AIS VHF antenna should be installed safely away from interfering high-power energy sources like radar and other transmitting radio antennas, preferably at least 3 meters away from and out of the transmitting beam.
4. Ideally, there should not be more than one antenna on the same level. The AIS VHF antenna should be mounted directly above or below the ship primary VHF radiotelephone antenna with no horizontal separation and with a minimum of 2 meters vertical separation. If it is located on the same level as other antennas, the distance apart should be at least 10 meters.

Cabling

The cable should be kept as short as possible to minimize the attenuation of the signal. Double screened coaxial cables equal or better than RG214 are recommended. All outdoor installed connectors on the coaxial cables should be water-proof by design to protect against water penetration into the antenna cable. Coaxial cables should be installed in separate signal cable channels/tubes at least 10 cm. away from power supply cables. Crossing of cables should be done at right angles (90°). Coaxial cables should not be exposed to sharp bends, which may lead to change the characteristic impedance of the cable. The minimum bend radius should be 5 times the cable's outside diameter.

IV.3.3 Grounding

Coaxial down leads should be used for all antennas, and the coaxial screen should be connected to ground at one end.

IV.3.4 GNSS

Class A AIS should be connected to a GNSS antenna.

The GNSS antenna should be installed where it has a clear view of the sky. The objective is to see the horizon freely through 360° with a vertical observation of 5-90° above the horizon. Small diameter obstructions, such as masts and booms, do not seriously degrade signal reception, but such objects should not eclipse more than a few degrees of any given bearing. Locate the antenna at least three meters away from and out of the transmitting beam of high-power transmitters (S-Band Radar and/ or Inmarsat systems). This includes the ships own IAS VHF antenna if it is designed and installed separately. If a DGNSS system is included or connected to the AIS system, the installation of the antenna should be in accordance with IEC 61108-4, Ed 1, Annex D.

Cabling

The coaxial cable between the antenna and the AIS ship borne station connector should be routed directly in order to reduce electro-magnetic interference effects. The cable should not be installed close to high power lines such as radar or radio transmitter lines or the AIS VHF antenna cable. A separation of one meter or more is recommended to avoid degradation due to RF coupling.

IV.3.5 Synchronization

After installation, the AIS should be synchronized properly on UTC and that position information, if provided, should be correct and valid.

IV.3.6 Minimum Keyboard and Display

The functionality of the MKD should be available to the mariner at the position from which the ship is normally operated. This can be by means of the AIS internal MKD (integrated or remote) or through the equivalent functionality on a separate display system.

IV.3.7 Pilot Plug

A pilot input/output port is a part of an AIS Class A Station. A plug connected to this port should be installed on the bridge near the pilot's operating position so that a pilot can connect a Personal Pilot Unit (PPU).

IV.3.8 Display System

If there is a navigational equivalent capable of processing and displaying AIS information such as ECDIS, radar or an integrated system available on board the ship, the AIS Class A mobile system may be connected to that system via the AIS Presentation Interface (PI).

IV.3.9 Installation of BIIT

The AIS requires that an alarm output (relay) be connected to an audible alarm device or the ship's alarm system, if available. Alternatively, the BIIT alarm system may use the alarm message output provided on the PI, provided that their alarm systems are compatible.

IV.4 Dynamic Data Input

IV.4.1 External Sensors

The AIS has interfaces (configurable as IEC 61162-1 or 61162-2) for position, heading and rate of turn (ROT) sensors. In general, sensors installed in compliance with other carriage requirements of SOLAS Chapter V should be connected to AIS. The sensor information transmitted by AIS should be the same information being used for navigation of the ship. The interfaces should be configured as given in annex 3. interfacing problems might occur if the existing sensors found on board do not have serial (IEC 61162) outputs.

IV.4.2 Position, COG AND SOG

GNSS sensors normally have IEC 61162 outputs for position, COG and SOG suitable for directly interfacing with the AIS. However, it is important to note that:

The Geodetic Datum of the position data transmitted by the sensor is WGS 84 and that an IEC 61162 DTM sentence is configured.
AIS is able to process two reference points for its antenna position, one for external and one for an internal sensor. If more than one external reference point is used, the appropriate information needs to be inputted to the AIS to adjust reference point information.

IV.4.3 Heading

A compass providing heading information is a mandatory sensor input to the AIS. A converter unit (e.g. stepper to NMEA) will be needed to connect AIS if the ship's compass does not provide an IEC 61162 output. Some Ship of less than 500 gross tonnage may not carry a compass providing heading information.

IV.4.4 Rate of Turn

All ships may not carry a Rate-O-Turn (ROT) indicator according to resolution A.526 (13). However, if a rate-of –turn indicator is available and it includes an IEC 61162 interface, it should be connected to the

AIS. If ROT information is not available from a ROT indicator, the direction of turn may (optional) be derived from heading information through:

- The compass itself;
- An external converter unit
- The AIS itself

Installation of the AIS does not establish a need to install additional sensors above carriage requirements.

IV.4.5 Navigational Status

A simple means shall be provided for the operator to input the ship's navigational status (e.g. making way, at anchor, not under command, restricted in her ability to maneuver, etc.) information into the AIS. The AIS may be connected to the ship's navigational status lights.

IV.4.6 Static Information

The AIS standards require that certain static, voyage-related, and dynamic information be entered manually, normally by means of the MKD, or by means of IEC 61162 sentences "SSD" and "VSD" via the presentation interface if such provisions exist.

IV.5 Entered at Initial Installation of AIS

Information that should be entered at the initial installation of the AIS includes:

- Maritime Mobile Service Identity (MMSI) number
- IMO vessel number
- Radio call sign
- Name of ship
- Type of ship
- Dimension / reference for position of the electronic position fixing device (EPFD) antenna.

Access to MMSI, IMO number and other AIS controls (power and channel settings) will be controlled, e.g. by password. The Call Sign, Name of Ship should be input to the AIS, either manually using the MKD or by means of IEC 61162 sentences "SSD" and "VSD" via the PI. Type of Ship information should be in accordance with the table given in annex 2 (Table 18 from Rec. ITU-R M. 1371-1). For example, a cargo ship not carrying dangerous goods, harmful substances, or marine pollutant; would use identifier "70". Pleasure craft would use identifier "37". Note that those ships whose type identifier begins with a "3" should use the fourth column of the table. Depending on the vessel, cargo and /or the navigation conditions, this information may be voyage related and would therefore need to be change before beginning or at some time during the voyage.

This defined by the "second digit" in the fourth column of the table.

IV.5.1 Reference Point of Position

The AIS stores one "external reference point" for the external GNSS antenna position and one "internal reference point" if an internal GNSS is to be used as fall back for position reporting. The locations of these reference points have to be set using installation values A, B, C and D. The external reference point may also be a calculated common reference position.

Additionally, the content of the Ship Static Data (SSD) sentence on the PI, including the "reference point for position" is being processed by the AIS, and the AIS memory for "external reference point" is set in accordance with the content of this SSD.

IV.5.2 Ship's Dimensions

Ship's dimensions should be entered using the overall length and width of the ship indicated by the values A, B, C and D.

Ship's dimensions (A+B and C+D) should be identical when entering internal and external reference points.

In the rare case of a EPFD antenna installed in the portside corner of a rectangular bow, the values A and C would be zero. Should this be the case, one of these values should be set to 1 in order to avoid misinterpretation as "not available" because A=C=0 is used for that purpose.

IV.5.3 Long Range Function

The AIS long range function needs a compatible long range communication system (i.e. Inmarsat-C or MF/HF radio as part of the GMDSS). If this is available, a connection between that communication system and the Class A mobile unit can be made. This connection is needed to activate the LR function of AIS.

IV.5.4 Rate of Turn

The AIS provides the Rate of Turn (ROT) information to other ships in order to detect early ships maneuvering. There are two possible parameters indicating turning of ships derived from two different sensors.

- Heading from a gyro and
- Rotation rate from a Rate of Turn indicator.

If a Rate of Turn Indicator according to resolution A.526 (13) is connected, the AIS should use this information to broadcast both direction and value of turn on the VDL.

If valid ROT or HDG data is available from external sources (gyro), the AIS should use this information to broadcast the direction of turn on the VDL, if 5° in 30 seconds or 2.5° in 15 seconds.

V. AIS use in Search and Rescue

For coordinating resources on scene of marine search and rescue operation, it is important to know the position and navigation status of ships in the vicinity of the ship or person in distress. Here AIS can provide additional information and awareness of the resources for on scene operation, even though AIS range is limited to VHF radio range.

VI

VII. Assesment