Automatic Identification System (AIS) for Vessels

by David Hide (*Gilliat*)

"Vessel at 49° 34'•10N 2° 30'•30W, travelling at 20 knots on 235°, this is Joburg Traffic calling on Channel 16 for identification."

The days of this type of VHF exchange are hopefully numbered, as with AIS fully operational, it will provide Vessel Traffic Services (VTS) with all the information required for monitoring the commercial traffic up and down Channel automatically. However, yet another acronym is added to the growing list with which the yacht crew must be familiar.

This article covers a brief review of the AIS system with particular regard to its current status, experiences from commercial craft and its potential use for yachtsmen. (The information presented is largely a summary of presentations at two Conferences on the impact of AIS for Mariners held by the Royal Institution for Navigation (RIN) and subsequent reports and articles in the Journal of the RIN, the RIN Navigation News and the Newsletters of the Small Craft section of the RIN).

AIS is a system which provides a comprehensive set of information regarding a vessel, its position and status.

In the original definition there were two systems to be implemented:-

- A Class A system for all GMDSS certificated vessels, SOLAS vessels, all vessels over 300 grt and all passenger ships.
- An optional fit lower cost Class B system for any other vessel, work boats, yachts etc.

Definitions of the features of the two classes of system are given later.

What was the rationale for AIS?

The mariners' original concept of AIS was an anti-collision monitoring system supplementing radar. AIS was not intended to replace radar as radar would still be needed to identify non-AIS enabled objects, i.e. Class A exempt craft, Class B small craft and leisure vessels, etc. as well as navigational aids (racons), icebergs, etc.

Under pressure from official government organisations (not necessarily mariners) AIS was then extended to provide automatically the various authorities (Vessel Traffic Services, Pilots, Port Authorities, Customs, Coast Guards and Vessel Operators) with information on all vessels transiting their shores. In the past some of this information has not been automatically provided by existing radar or voice operated VHF systems or other formal reporting systems, such as AMVER etc.

After 9/11, the main driving impetus came when government authorities considered that AIS might be a potentially useful anti-terrorist aid. This pressure forced a common consensus on the means to implement the system technically, via VHF. The original objective of acting as an aid to collision avoidance almost got lost along the way.

Since then a number of official bodies have seen the advantages of AIS, as the result of which AIS is being extended to cover:-

- Aids to Navigation (AtN), for the Lighthouse Authorities (IALA).
- Safety Notices, i.e. to supplement the Notices to Mariners, for Hydrographic Offices and Port Authorities, etc.
- Long Range tracking of vessels (LRT), for Government anti-terrorist authorities. This latter system is likely to be restricted to Class A commercial vessels.

Current Status of AIS

There are two implementations currently available and operational; a Class A VHF-based transponder system (to receive and transmit AIS information) and for other vessels, a number of Class A VHF-based receive only systems.

As yet there are no operational Class B systems (transponder or receive only) as the Class B system is still in specification but limited trials are in progress to validate the technology. However, both Class A and Class B systems should be able to display all the information for any vessel of either Class.

Specifications for AIS for Aids to Navigation, Safety Notices and Long Range Tracking are also not yet finalised. Whilst AIS for AtN and Safety Notices can be VHF based, the requirements for LRT will generally involve another transmission mechanism, based probably on satellite technology.

What is the current status for vessels?

1 GMDSS certificated Commercial Vessels, i.e. over 300 grt.

All GMDSS certificated vessels (including all non-GMDSS certificated tankers and passenger carrying vessels) should have been fitted with an operational AIS Class A transponder system by the beginning of 2005. (The UK Coast guard plan to have all the necessary AIS Class A shore stations installed and operational by the end of 2005).

For US waters, all US-registered vessels over 20m (65 foot) should have been fitted with an operational AIS Class A transponder system by the end of 2004, as should all vessels over 20m visiting US waters, which are GMDSS certified or "equipped with the equivalent satellite technology".

2 Class A Exempt Vessels

It should be noted that the following categories of vessels over 300 grt can be exempt:

- Warships.
- Naval Auxiliaries.
- Government owned or operated vessels.

(Masters of all other vessels can switch off AIS but it could be unwise for them to do so in many territorial waters, without a special set of reasons). Approaching the UK, Class A vessels are expected to switch on AIS when within 200 nM of UK territorial waters. However, at the moment this is not mandatory.

3 Other Commercial Vessels over 300 grt

Non-GMDSS commercial craft over 300 grt should have AIS Class A transponder systems installed before 2007, though national rules can vary from country to country, i.e. US rules previously mentioned impose a earlier deadline.

4 Commercial Vessels under 300 grt and Leisure Vessels

No decision has yet been made re commercial vessels under 300 grt but Class B transponder systems were intended to be the voluntary fit. For leisure vessels there are currently no UK plans to make AIS compulsory.

It has to be admitted that if all vessels were fitted with Class B transponders then in areas of high traffic density there may be problems in displaying all the AIS information available.

A voluntary fit of a Class A receive only system is currently possible for all UK vessels in this category, but the situation with other countries may be different.

Costs

Class A transponder equipment costs thousands of pounds, since it requires a number of separate sensors (GPS position, rate of turn, heading etc.). Also some has to be input manually (name of vessel, status, destination etc.) often through a dedicated keyboard or computer.

A review of the costs of Class A receive only systems is given later.

Voluntary fitted vessels will probably opt for the planned cheaper Class B transponder equipment, which may have an integral GPS system to provide some of the necessary information and which will require a minimum of manually inputted information. However, as the specifications are not yet finalised no real indication of cost is available.

AIS for Yachts

Within the UK, AIS Class A transponders can be a voluntary fit, though it is not recommended by the MCA. Any vessel fitting a transponder system should note that it must also be equipped with a DSC VHF system, in order to have an MMSI number, which forms an essential part of the AIS messages.

Trials of AIS for leisure vessels by both the UK and German authorities have indicated that an AIS Class B transponder system potentially generates a much better target than a conventional radar reflector and it could well become a recommended installation in the future.

AIS receive-only systems will not help in respect of other smaller vessels, which will not be AIS enabled, nor will it help for those vessels which have AIS switched off or not obliged to install AIS.

a) Yachts with Radar

Notwithstanding the reservations of commercial vessel mariners, a yacht owner might decide to install an AIS receive-only system as an extra tool for collision avoidance. However, the other features of AIS, apart from positional awareness, will not be of any major advantage currently.

b) Yachts without Radar

An AIS receive-only system could act as a relatively cheap alternative to radar in restricted visibility. In this respect it should be better than a badly tuned radar display, with a power consumption much less than radar.

However, it should be noted that radar is still the only accepted system in the ColRegs to be used in periods of restricted visibility.

Displaying AIS information

The considered opinion of experienced mariners is that the AIS information should be displayed both to supplement radar as well as appear on electronic chart systems, the latter resulting in a possible increase in situational awareness as well as a fuller avoidance of conflicting and confusing information. The simultaneous display of AIS on a chart could be useful as some authorities are considering the replacement of some navigational marks by 'virtual AIS targets', i.e. they would not appear visually to the navigator or appear on radar displays.

Radar (ARPA or mini-ARPA) uncluttered by AIS information should remain the prime means of assessing a risk of collision, especially when vessels are not in sight of one another. Whilst it could be beneficial in the longer term to superimpose AIS information on a radar display, there are considerable technical challenges to be overcome in ensuring that a coherent set of data is presented to the operator. Currently no operational system of overlay of AIS data on a radar screen appears to be available for the leisure market.

Benefits for Yachts Fitted with AIS Receive Only Sets

There are some potential benefits for yachts fitted with a Class A receive only set, in that they will be able to 'see' most if not all the commercial vessels operating in their vicinity. Depending on the set chosen, there may however, be a limit on the number of vessels able to be seen at any one time, which may well affect the effective range in congested waters at which vessels can be detected.

AIS can actually 'see' vessels beyond a radar range, i.e. beyond headlands or breakwaters, which generate an echo, thus an AIS display for yachts can be of benefit to those not fully trained in interpreting radar systems.

The AIS information on vessels' bearing and range may well be of advantage to those vessels fitted with non-ARPA sets, in determining if a collision situation is developing. However, if using speed and course, due allowance must made for the differences between the ground speed and course, which are the parameters reported through AIS, and the normal water speed and course.

However, like commercial vessels, in restricted visibility conditions, the prime source of information should remain the radar.

AIS Demonstration

AIS can be 'seen' via the internet on www.aislive.com. Whilst this is now a commercial fee-paying service, covering the world, it is possible to sign up for the free demonstration version, which does not show live information but shows only some of the AIS information several hours old.

Other live sites are also now coming online covering the US and Australasia areas. An internet search for 'live AIS' should reveal any new sites, however, generally a very small subset of the AIS information is shown (for security reasons this data is also several hours old).

Future Developments of AIS

The AIS system will undoubtedly be supplemented for commercial shipping in order to overcome the range limitations of VHF, i.e. around 20 - 60 nM. This extension is primarily considered necessary for anti-terrorist considerations.

The US Coast Guard was given the mandate in 2002 to "be able to detect, identify and track all vessels entering or transiting their waters within 2000 nM of the US coastline as well as to obtain and archive global vessel movements and port visit histories, in order to document shipping patterns and identify non-normal behaviour." This mandate is in many respects equivalent to the European Traffic Monitoring Directive.

The system for long range reporting is sometimes given the acronym LRT (Long Range Reporting and Tracking). With AIS, LRT it is planned to vary the reporting frequency as a function of the distance offshore, i.e. perhaps 4 hourly between the 300 nM and 2000 nM offshore but these details are currently under discussion through the relevant IMO and related committees.

Conclusions

Like radar, AIS is nothing more than one of several useful tools designed to enable mariners to fulfil their obligations under the ColRegs.

An AIS display should be viewable at the same time as the radar display, in order to cross compare the two disparate sets of information. Display of AIS on charts is also desirable but should be of secondary importance.

With suitable analysing software AIS may be a tool for collision avoidance comparable to the facilities provided by ARPA or mini-ARPA on radar displays.

In the longer term, leisure craft may find a Class B AIS transponder system to be a better indication of their presence in restricted visibility rather than the use of an inactive radar reflector.

Finally a comment made in the Admiralty Court in 1967 is very apposite - "It is on people that safety at sea depends and they cannot make a greater mistake than to suppose that machines can do it for them." The judge could have usefully have added - "Never, ever, rely on only one source of information."

Problems identified with new AIS transponder installations

A number of problems have already been identified with commercial vessels' AIS installations. Some of these are detailed in the following sections.

Position Integrity and related issues

The Panama Authorities inspecting their own registered vessels have found that up to 40% of AIS installations are unsatisfactory, the following points requiring action:

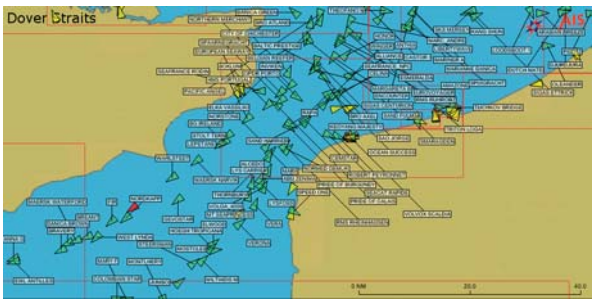
- Ship's position errors, due in part to changes from WGS84 to a different chart datum, when using an external GPS source. Also there can be unrecorded errors in the GPS position, from loss of GPS signal, etc. which can go unnoticed.
- Absence of integrity monitoring with integrated ship's gyro, generating significant errors in the reported ship's heading information.
- Use of different IEC standards.
- Unsatisfactory bridge installation positions.
- Data entry errors.
- Use by untrained personnel.

Man-Machine interface problems

Whilst the data is defined well, the display in a standard useful form for the bridge staff has not yet been finalised. The current crop of installations runs between a simple textual display to more sophisticated displays superimposed on radar or electronic charts. All of these systems have limitations in that there is a significant increase in workload for the current minimal manned watch, especially when the AIS display is not at the normal watch keeper's position on the bridge!

Recent surveys have indicated that many owners have fitted the minimum standards, which consist of Minimum Keyboard Displays (MKDs) as the operator interface. These devices are not at all user friendly. They require considerable extra training and expertise in order to be a useful tool for collision avoidance as there is no automatic indication of time or distance to the closest point of approach.

However, they do satisfy the reporting requirements required by shore-based national authorities, so there is no pressure on vessel owners to fit more appropriate systems for collision avoidance.



ColRegs Problems

Unlike radar, which has a special integration in ColRegs, there is, at the moment, no drive to include AIS specifics in ColRegs. However, the following should be borne in mind:

Rule 2, Responsibilities. Watch keepers are required to be trained in the effective use of equipment, otherwise they are deemed negligent and in breach of good seamanship. However, there is no agreed standard for training watch keepers in AIS as a tool for collision avoidance. In particular for under trained staff the difference between AIS reported speed and course over the ground, rather than water speed and course may well give rise to errors in analysis of a developing situation. There are also the well known interpretation problems of display types, i.e. head-up, North-up etc.

Rule 3, General Definitions. The emphasis is still on visual sight not via electronic or other aids, such as radar, AIS etc.

Rule 5, Lookout. The emphasis is on all available means. Hence AIS if installed must be part of the lookout system, yet it can add another distraction for the watch officer.

Rule 6, Safe Speed. This may need to be modified to include AIS, since it was modified for radar.

Rule 7, Risk of Collision. If AIS is fitted, then it must be used in applying this rule. However, practical experiences have shown that AIS information can often be at conflict with other information to the watch keeper.

Rule 8, Action to Avoid Collisions especially responsibilities between Vessels. The hierarchy of priorities is covered by this set of rules but the definitions of priorities is generally defined by shapes during the day and by lights at night. AIS can supplement this information but since it has to be manually input, it can be subject to human error and/or be infrequently updated. For instance, many people have seen fishing vessels displaying the visual signals that they are engaged fishing, when it is apparent that they are not. At the moment then, AIS information on the status of a vessel is not allowed to be considered, however wrong it apparently is, i.e. a vessel 'at anchor' travelling at 25 knots in mid-Channel!

Rule 17, Stand-on-Vessel. AIS could give extra guidance especially at night or in fog that the 'giveway' vessel has not taken appropriate action, thus avoiding a potential collision. In particular AIS could give earlier information on changes of course, speed and positive action of the 'give-way' vessel.

Rule 19, Restricted Visibility. AIS could well give a better detection at greater distance than radar since it is not subject to the effects of rain clutter or sea state but at the moment only radar is allowed for under this Rule.

Other Considerations

- There appears to be little 'ownership' of AIS information by watch officers, since its main benefit is undoubtedly for shore based operations. Hence the AIS data may not be as correct as it should be.
- Unnecessarily close passing is reported to be on the increase, due to reluctance to stray from an electronically pre-determined path.
- There has been a reported increase in VHF chatter due to the increased use of negotiated manoeuvres contrary to Colregs.
- At long range and open waters AIS may be a useful additional aid but in congested waters and close range, such as the Dover Straits (with up to GMDSS 700 ships/day), it is deemed to be of questionable value by professional mariners.
- AIS will probably reduce the perceived need for lookouts, e.g. few commercial vessels in fog have lookouts outside the bridge to listen for fog signals, sound fog signals or significantly reduce speed. An example has been quoted of a AIS-equipped Dover Ferry travelling at 23 knots in thick fog, in a F5 with 1.5m waves. It didn't slow down, sound fog signals or have lookouts!
- Watch officers will probably increasingly ignore small radar targets not on AIS, so small craft will need to be more vigilant in close quarters situations, as a watch officer on an AIS-equipped vessel has warned.

As a consequence and until Class B transponders become available, improving the efficiency of one's radar target should be seriously considered. The use of a radar target enhancers (RTEs), such as the Sea-Me system, is preferable to the standard radar reflector (as many reflectors do not now reach the SOLAS required standards, which came into force in June 2005).

- The currently projected range of a Class B transponder system of around 3 nM to 5 nM will make it less likely that commercial vessels will be in a position to take avoiding action, when the AIS target appears suddenly on their systems. Indeed to many commercial vessels the 3 nM is well within the distance at which they would be expected to have already taken action under ColRegs.
- For commercial vessels, the fact that a relatively cheap receive only Class A set is now available could well increase the risk of acts of piracy, since the details of its exact position, its cargo, dimensions etc. are freely available to all and sundry. The same information is also available for free on the Internet! Some ships' captains have switched off AIS as a result.
- If authorities start using a 'virtual AIS target' to mark wrecks etc. there may well be no equivalent radar target or charted object to be seen. When marking drifting buoys etc. the AIS target will be 'off the charted station'.

Yacht AIS Systems Currently Available in the UK or US

Stand-Alone AIS Class A Receive-only and Combined Display Systems

These generally need a 12V power supply and a new VHF aerial, which needs to be kept well clear of the main VHF aerial as both systems could interfere with each other, especially when transmitting on VHF channel 16 or another VHF channel, such as the DSC channel 70. A minimum VHF aerial separation of 1m is generally recommended.

An input NMEA 0183 or NMEA 2000 signal, running at 4800 or 9600 bps from the boat's primary GPS unit, is also often required to establish the position of the vessel on which the set is installed.

NASA Marine produces a stand-alone display system, called AIS Radar, somewhat similar to a radar display which displays a subset of the overall AIS information available for up to 30 vessels at one time. It can display a number of fixed ranges. Cost £259, see more information on the NASA Marine website www.nasamarine.com.

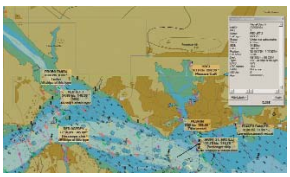
AIS Class A Receive-only Engines

These 'engines' carry out the VHF detection, hence need a power supply and a VHF aerial and generate as an output the NMEA AIS signals (in accordance with the ITU-1371 specification). Due to the potential AIS link traffic, the output signal needs to run at 38,400 bps, in order to cover the necessary maximum possible load. These 'engines' are mainly designed to interface to a ECDIS chart plotter system (Electronic Charting and Display Information System) running on a computer.

Usually a simple display package is provided with these 'engines' to display the AIS data on a computer when no ECDIS computer based chart plotter is available. Some simple chart based display systems, non-ECDIS based, are also available as part of the hardware engine-only package.

NASA Marine produces a stand-alone AIS 'engine' and simple display package. A NMEA 2000 output at 38,400 bps is generated to produce the VDM AIS strings corresponding to ITU-1371. The PC needs a 9 pin serial port or an optional USB convertor can be supplied. Cost £129, see more information on the NASA Marine website www.nasamarine.com.

EuroNav produces a stand-alone AIS 'engine' and simple display package, designated the AI3000 system. The system can be integrated with other AI3000 engines to produce a wide area scheme and is of professional quality, as would be used by harbour authorities etc. Industry standard NMEA 0183 / IEC61162-2 output format is generated for compatibility. The computer needs a 9 pin serial port or an optional non-supplied USB convertor. Cost £675.63, which reflects the increased capabilities of the unit, see more information on the Euronav website www.euronav.co.uk.



Smart Radio produces a stand-alone AIS 'engine' (SR 161). A NMEA 0183 output at 38,400 bps is generated to produce the VDM AIS strings corresponding to ITU-1371. Cost US $288, see more information on the e-BigChina website www.ebigchina.com. Since the system is not integrated with a chart plotter system, the integration may become a DIY job. The supplier is currently seeking European distributors.

ECDIS currently supporting AIS Information

A large number of chart plotter programs running on computers now claim compatibility with AIS data from a number of AIS 'engines'.

As a collision avoidance tool these packages should display the time to closest point of approach (TCPA) and distance to closest point of approach (DCPA). The TCPA and DCPA results should be able to set alarms.

The more sophisticated packages can also use the data contained within the AIS reports (dimension of ship and type) to display a scaled representation of each vessel and its projected short term movement when in restricted waters, such as narrow channels or harbours.

EuroNav: The Sea-Pro Standard and above chart plotting packages support display of some AIS information based on the AI3000 'engine'. This package generates the TCPA and the DCPA, with alarms. Other AIS information can also be logged. Widows only

The EuroNav Sea-Pro Plus package can be expanded to be a full Class A system by the addition of a AIS transmit module, provided the additional Class A VHF transmit hardware has been fitted.

PC Maritime The Navmaster Superyacht chart plotting packages support display of some AIS information. The packages either come as an upgrade to the Superyacht system with a NASA engine at £330 or a complete package with Superyacht software at £600. Windows only

Transas are in the process of developing an AIS display module to be added to their ECDIS system, which is planned for release in 2006. As yet there is no price information available, nor details of any AIS 'engine' to provide the data to the ECDIS package. .

Other packages

There are a number of DIY installations which appear to have been implemented, whereby the user purchases the AIS 'engine' and then gets the system working with a AIS compatible ECDIS system.

NOTE: Users of chart plotting packages not covered by the above are recommended that before they choose the AIS 'engine' to be used, to check specifically with their ECDIS package vendor which format of AIS NMEA input is supported and which AIS data can be displayed.

Not all packages currently appear to offer the automatic calculation of the collision avoidance TCPA and DCPA figures nor can they log AIS related data.

NOTE: For details of AIS compatible Apple Mac OSX based ECDIS packages consult the author.

Hardware Chart Plotter Systems

The commercial SOLAS-compliant market has for some time been well catered for but for the leisure user, no system is yet available which integrates AIS to a hardware chart plotter to display AIS information in addition to the conventional radar display or electronic chart display.

This option for an AIS display appears to offer the potential for the best man-machine interface, namely when a radar plot and an AIS plot can both be overlaid on to a chart, thus providing a single display of all the relevant information for the navigator.

Hardware chart plotters are generally not software upgradeable, though some of the more recent products at the more expensive end of the market have facilities which will allow this. It is thought that these latter more expensive systems will almost certainly be the only ones eligible for any upgrade making them AIS compliant.

There are rumours that at least one manufacturer may announce an AIS upgrade to certain modules of their leisure chart plotter system in 2006 (probably in time for the London Boat Show). At this stage it is not clear whether the announcements will cover both the hardware 'engine' as well as the upgraded hardware chart plotter software.

Other manufacturers may be expected to follow in due course as AIS filters down to the leisure market.

Appendix : Technical Aspects

Class A Systems

On each AIS channel there are 2250 time slots over each 60 second period for the transmission of packets of data. The AIS station determines which free time slot it can use for data transmission and can change time slots dynamically to cater for increased or decreased transmission traffic, in order that vessels do not jam each other and/or fail to detect each other as they come into range or go out of range. The frequency of position reporting can also be changed by the AIS station to suit the traffic load. This system is known as Self Organizing Time Division Multiple Access (SOTDMA).

Unfortunately SOTDMA has been found to be the subject of a Swedish patent and the patent situation has not yet been resolved internationally for the SOLAS ships, even though they are now carrying AIS Class A transponder systems. Patent fees may be applicable to non-SOLAS ships fitting AIS transponder systems. This burden effectively eliminated the possible cost savings for a Class B transponder device.

The situation re receive only systems is that currently they are thought to be free from any patent fees problems, as the patent should only apply to the generation of transmitted signals.

Limitations of Class B systems

Compared with Class A the transmitted power of a Class B system will be limited to 1 watt, giving a range of about 3 miles, its minimum transmission update interval being 30 seconds. The extent of transmitted information is reduced, A Class B system cannot transmit safety messages. In addition the specification currently allows for a shore station to be able to turn off Class B transmissions in exceptional circumstances.

To reduce costs a Class B transponder system will probably have a built-in GPS and will not require a separate compass sensor or rate of turn sensor thus eliminating areas where a NMEA interface has to provide information.

Class Reporting Functions

Class A Position Report

- MMSI Number
- * Navigation Status - "At anchor", "Under way using engine"', "Not under command" etc.
- * Rate of turn left or right, in °/min., max. 720°/min.
- Speed over ground (SOG) in knots, max. 102.0, in 0.1 knot increments.
- Position with an accuracy - Lat. and Long to nearest 0'.0001.
- Course over ground (COG), relative to True N in 0.1° increments.
- True Heading in °, in ° increments.
- Time stamp - when information was generated.

Class A Other Reports

- * MMSI Number, i.e. to tie this report to the associated set of position reports for this vessel.
- * IMO Number.
- * Radio Call Sign.
- * Name of ship, max. 20 characters.
- * Type of ship/cargo from built-in table.
- * Dimension of ship to nearest 1m.
- * Location on ship which is the reference point for position information.
- * Type of position fixing device from built-in table.
- * Draught of ship, max. 25.5m, in 0.1m increments.
- * Destination, max. 20 characters.
- * ETA at destination in UTC (Master's discretion).
- * Receive and transmit text safety messages.
- * Receive and transmit application identifiers.

Derived/ Calculated Information

- TCPA - time to closest point of approach
- DCPA - distance to closest point of approach

Class B Vessels

These are not required to report items marked with * and have no transmit requirements for safety messages and application identifiers. They should however, be able to receive some of this information, once the specifications have been finalised.

Class A VHF Frequencies, Power Output and Related Data

Channel Designation and Frequency

AIS1	162.025 MHz
AIS2	161.975 MHz
Transmit power	12.5 Watts
Data Rate	9.6 kbps
Packet Size	256 bits
Transmission Type	SODTMA
Transmission Time	26.66 milliseconds/packet. Transmission to be alternate between the 2 AIS channels
Update Interval:	
Position report	Min 10, Max 2 seconds (3 mins at Anchor)
Other	<6 minutes

Class B

Transmit Power	1 watt
Transmission Type	CSTDMA
Update Interval	<30 seconds