Introduction

Automatic Identification System (AIS) is a technical system that makes it possible to monitor ships from other ships, and from shore based stations. AIS is a requirement. (see International standardisation below). AIS-equipped ships continuously transmit a short message containing information of position, course over ground (COG), speed over ground (SOG), gyro course (heading), etc. Ships equipped with AIS meeting anywhere on earth will be able to identify and track each other without being dependent of shore stations.

Shore stations will also get the same information from “AIS-ships” within the VHF area of the station when monitoring the coastal areas and the ports. The AIS is using a broadcast and an interrogating self organised technology the so called AIS STDMA/ITDMA that operates ship-to-ship and ship-to-shore including limited communication capabilities. AIS does not require a radar.

The International Telecommunication Union (ITU) has defined the technical standard and ratified the global frequencies. (see International standardisation below). International Electrotechnical Commision (IEC) has accomplished the test standard. (see International standardisation below). This pamphlet will stress the advantages of the AIS, show how to use it and why the techniques can operate and handle the information from all ships even in the most dense shipping waters of the world.

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International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA)
presented the first proposal of AIS to IMO. IALA is mainly dealing with shore based aids to navigation including Vessel Traffic Services (VTS). The problem to identify ships on the radar displays in the VTS centres was, however, one of the reasons for the VTS committee of IALA to initiate the development of a Digital Selective Calling (DSC) transponder system (AIS). Their operational requirement for the AIS was mainly focusing on the needs of the VTS stations to identify radar targets approaching the coast. Requirements from seagoing mariners and others with interest in AIS were not looked at.

Who is demanding AIS and who could derive advantage from AIS

The demand from politicians and maritime authorities to monitor movements of ships in their territorial waters, in order to prevent accidents and maritime disasters is rapidly increasing. Coastal states are responsible for traffic separation schemes, routing areas and fishing areas in their territorial waters.

These states demand compulsory compliance by the users of these waters and have a need to control “areas to be avoided”.

The fact that users are monitored and identified from shore will most probably result in a greater compliance with traffic separation schemes, routing measures and fishing regulations.

It has been argued that accidents in coastal areas could be avoided, if ships were identified. This is maybe true in some cases, but a shore based station, identifying a ship, is limited to advise actions only by using the VHF radio communication facilities. Furthermore, misunderstandings of the advice can appear due to, for instance, language problems.

The Exxon Valdez, the Aegean Sea and the Braer were all identified, long before they ran aground. Consequently, radio contact is not always the solution.

The only person to stop the engine or change the course to avoid a grounding or collision is the Officer Of the Watch (OOW). The OOW is also deciding on actions to follow in order to comply with the Collision Regulations (COLREG).

Ships equipped with AIS enables the OOW’s to be the first ones to benefit from the AIS system by getting an improved situation awareness capability.

Ambiguous calls, with a stressed voice, in the night, as: “Ship on my starboard side, ship on my starboard side, this is M/S XXX, I am turning to port”, have made many OOW’s wishing for an AIS to identify M/S XXX and to get the information about when and how much M/S XXX is turning and to whom she is directing her call. All the OOW’s, within radio range, will be put under severe stress due to this inaccurate and incomplete information. The stress will last until at least the ARPA radar equipped ships, after two to three minutes, will detect that one of the targets on the display is turning and might be M/S XXX. It has been argued that OOW’s, onboard AIS equipped ships, sometimes will actively agree on actions in conflict with COLREG, due to their knowledge about the name of the other ship.

This might happen, but one must not forget that mariners make such calls anyway today without knowing whom they are addressing. To prohibit the OOW to use AIS would be like to prohibit the use of radar.

Pilots, barge captains, ferries etc.

In very busy areas, as harbours, rivers and archipelagos, the need for a high update rate mode AIS is evident. The limitations of the ARPA radar to track ships due to target swapping from a ship to land, beacons, bridges and other ships makes the ARPA capabilities very limited in narrow and congested waters.

Today there is a strong feeling among mariners navigating in harbours, rivers and archipelagos, that AIS will improve the safety and to a great extend solve the “limitations of the radar” due to the following AIS capabilities:

- “Look behind” a bend in a channel or behind an island in the archipelago to detect the presence of other ships and identify.
- Predict the exact position of a meeting with another ship in a river or in an archipelago for instance to avoid narrow areas.
- Identify the ships port of destination.
- Identify the size and the draft of ships in vicinity.
- Detect a change in a ship’s heading almost in real time.
- Identify a ferry leaving the shore bank in a river.
- Identify fixed obstacles, like oil rigs, ship wrecks, dangerous to shipping.
- Identify slowly moving targets, like log rafts, sounding arrays etc., which are unable to take rapid evasive actions.
VTS

Radar is today the main sensor of the VTS to detect a ship. The VTS radar has almost the same errors in range and bearing resolution as all other radar’s, although it has a 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 rather limited.

VTS’s are today limited to track ships, for instance, in a bay or when approaching a harbour from sea. There is a requirement for improving of the VTS to be able to:

- Cover areas where radar coverage is almost impossible to achieve, like rivers and archipelagos.
- Identify radar blips on the VTS radar automatically.
- Interrogate ships for information regarding type of cargo.
- Track with a high update rate, the ferry going between two ports in the bay or a river continuously, without needing to...
do it every time the radar tracking has swapped to another target or, when the ferry has been moored to a pier or passed too close to a beacon or a passing ship.

- Know which port a ship is bound for.
- Know the size and the draft of ships in the vicinity.
- Detect a change in a ship’s heading almost in real time.
- Identify slowly moving targets, like log rafts, sounding arrays etc., which are unable to take rapid evasive actions.

The only AIS solution, that could solve all the requirements of the VTS, is a high update rate, mode AIS, with interrogating capabilities.

The establishment of a landbased AIS reception network, may actually mitigate the need for VTS in some areas. The cost of installing and maintaining an AIS network is minute compared to a VTS radar net-work.

**Marine Search and Rescue (SAR)**

*SAR operations would be much* more efficient if all the Rescue Units (RU) were fitted with AIS to quickly identify the ship closest to a distress situation.

During a search operation all the crafts could be tracked and plotted enabling the Marine Rescue Co-ordination Centres (MRCC) to monitor the progress, to direct the available resources efficiently and to ascertain a search coverage without gaps. Furthermore, all surrounding ships and RU’s as well as the MRCC could identify an AIS equipped ship in distress. The actual emergency status of the ship could also be determined automatically.

Man Over Board (MOB) alarm will most probably be one of the features allowing all other ships in vicinity to have the same MOB position displayed, when one of the ships have activated the MOB alarm.

**Fishing boats and pleasure crafts**

*Most of the small ships* will not be equipped with AIS which makes the radar the most important sensor to detect their existence.

If mandatory AIS carriage requirement could be applied to fishing vessels, it would enable national fishing agencies to enforce fishing restrictions more efficiently.

**Shore based pilotage – heading**

*The captain on a ship with no radar* or a radar disturbed by sea/ rain clutter and with a very weak radar return from shore and navigational aids, may today be assisted with his navigation if he is able to get navigational assistance from shore.

Shore based pilotage with radar is normally limited to small and moderately sized ships which generally are more manoeuvrable than, for example, large tankers. The limitations of radars, makes shore based pilotage suitable only in areas where the navigable water is sufficient to separate the traffic, and where the ship could be supervised only by giving bearings to, for example, waypoints.

If only the DGPS position from a ship, but no heading, is transmitted via the AIS the VTS operator will get an exact position of the ship’s antenna at the moment, as well as the speed and course over ground for the same antenna. The ships heading and the position of other parts of the same ship, at the same moment, is however unknown. This uncertainty of the real situation could lead to mistakes of importance. For instance, a 350 meter long tanker with the antenna situated on top of the wheelhouse at the stern, starts to turn to starboard. The ship’s course will then change to starboard, but initially the stern with its antenna will swing slightly to port, as the ship is turning around its so called pivot point. There is obviously, besides to determine and transmit the exact position of the antenna, a need to include the heading in the transmission. The ARPA radar tracks the part of the ship, which gives the best radar return, normally on a loaded tanker the superstructure at the stern. A big tanker, turning with the superstructure at the stern tracked by radar, could have turned 30-50 degrees, before this is detected by the ARPA radar, on another ship or at the VTS, and now up to 4-5 minutes has passed since the turn started.
To be able to improve the tracking and the detection of a course change of a ship from other ships or from the VTS, ship’s heading and DGPS antenna position also have to be transmitted at a high update rate. The best way of transmitting this kind of information would be, if vessels were equipped with an AIS working in “Beacon Mode” and a high update rate.

Radar

It has been argued, that with an AIS display presenting AIS ships, the OOW will forget to “fine tune” his radar to detect small crafts. It is important to emphasise, that the radar is and will remain one of the most important instruments on the bridge, even in the future. It is important, that the OOW is taught the difference between the radar and the AIS, and the importance of tuning the radar to detect small crafts without AIS onboard.

Anti Collision

The radar has been the primary mean to prevent collisions at sea in restricted visibility. The necessity to use a plotted ship’s course and speed through water, to be able to get it’s actual heading as accurate as possible, is obvious. Still the difference in course and speed through water, between a tanker and a carcarrier in a strong wind, is considerable.

With an AIS the identification, heading and the change in heading could be determined with a high update rate and some of the inherent limitations of radars could be solved. The AIS also shows the navigational status of another ship with AIS, i.e. that two ships equipped with AIS, that meet in restricted visibility, have all the information, that the navigation lights could show, including name and and port of destination.

The heading is taken from the compass and is not affected, neither when the AIS is using a high accuracy nor a low accuracy positioning sensor. The faster the nominal update rate is, the faster the nominal update rate is, the faster the mariner on another ship, or an observer in a VTS, will detect a course change. This means that a ship with high speed needs a higher nominal update rate than a ship with slow speed.

<table>
<thead>
<tr>
<th>Type of ship</th>
<th>Reporting interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ship at anchor or moored</td>
<td>3 min</td>
</tr>
<tr>
<td>Ship 0-14 knots</td>
<td>12 sec</td>
</tr>
<tr>
<td>Ship 0-14 knots and changing course</td>
<td>4 sec</td>
</tr>
<tr>
<td>Ship 14 – 23 knots</td>
<td>6 sec</td>
</tr>
<tr>
<td>Ship 14 – 23 knots and changing course</td>
<td>2 sec</td>
</tr>
<tr>
<td>Ship &gt;23 knots</td>
<td>3 sec</td>
</tr>
<tr>
<td>Ship &gt;23 knots and changing course</td>
<td>2 sec</td>
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Path prediction

The large potential of transmitting the rate of turn of the ship, together with all the other movement parameters, is still not fully recognised. This enables both the VTS and approaching ships to make a rather accurate prediction of the path a ship is taking, some 30–90 seconds ahead. This gives more time and better information for all the other players in the traffic environment to plan their moves.

Route planning

Shipping routes within a VTS area are normally well defined, including alternative routes between two points, to the point that they could be indexed. One could anticipate a requirement to plan the route of a ship in advance, either by the OOW or supplied by the VTS. In either case the plan, consisting of the appropriate index numbers could be interchanged utilising AIS. This would enable interested parties to compare the planned route of the ship with the actual path taken.

Short message communication

The limitation of any radio system with all users on the same channel is, the capacity. This is true both for voice and data communication. The proposed AIS would make it possible to utilise a short message scheme, i.e. to produce an indexed list of predetermined traffic messages. There could be addressed (point-to-point) messages like 1) “You are now within VTS area boundaries”, 2) “Switch immediately to VHF channel NN” and so on. In the latter message, the NN is an attribute, to be supplied by the user. The actual transmitted message is constituted of the index number only, together with the eventual attribute. If a common list of messages could be agreed upon, it should be multilingual, thereby avoiding mis-understandings because of language difficulties.

In order to not impair the main function of AIS by overloading the VHF data link, has IMO (NAV 49) decided to limit the use of binary coded AIS messages. 7 different messages incl. meteorological information is allowed for a trial period of 4 years.
Silent VTS

In some areas of the world e.g. rivers and low traffic areas where the traffic density don’t justify VTS, an idea called “Silent VTS” has evolved. Instead of installing conventional VTS’s on shore the AIS equipped ships will act as their own VTS’s and use the AIS to get their situation awareness.

Display presentation

The AIS provides several possibilities for displaying the AIS information. The minimum required display is a three line alphanumerical display that presents bearing, distance, name and all other information in a spread sheet format, enabling the OOW to make manual inputs and to identify a ship by comparing baring and range from the radar PPI. Most probably the minimum display will be very rarely used. Many ECDIS manufactures are today implementing the AIS symbols in their equipments. Manufactures, as ADVETO, STN ATLAS, TRANSAS MARINE, ANS, ICAN are already handling the AIS in their softwares.

It is sometimes not possible to present the AIS information on an old radar screen but the new performance standard for radar which is developed by IMO includes presentation of AIS information. AIS targets, superimposed on the radar display, will inform the operator weather the targets are AIS equipped or not.

IEC has a draft proposal for AIS symbology to display on ECDIS and or ENC systems.

To reduce clutter on the radar or the ECDIS display, due to too many AIS’s appearing at the same time the AIS symbols could be “Active” or “Sleeping”.
  • “Active” means that a triangle is showing the targets heading and (if high accurate positions used) the COG/SOG vector.
  • “Sleeping” means that the mariner has chosen to suppress vectors and heading line and only a small green triangle pointing in the direction of the heading is shown. A sleeping target could always be activated if the mariner selects it.

High update rate

A modern ARPA radar is able to select and track 20 targets with an update rate of 3 seconds. The symbol on the PPI will follow the target, except when a target swap is appearing. Due to the limitations of the ARPA, a course alteration of another ship will normally not be detected until one or two minutes after the course change. For a large tanker it will take up to five minutes. Further more, another one or two minutes is needed for the ARPA to present a reliable target vector with course and speed through the water.

It is obvious that a high update rate is needed for AIS targets, superimposed on a radar display. If the update rate is too slow there will be situations, when using smaller ranges, where the AIS symbol will not catch up with the radar target.

International standardisation for AIS

Within ITU

Technical characteristics for a shipborne Automatic Identifi-
National and regional AIS systems

An AIS network covering the Swedish coastal waters and the large lakes was established in 1997. The system was improved and updated in 2001. The information from this network is available to the Swedish Maritime Administration for use in VTS:s, MRCC, pilot stations, Icebreaking Operation Center etc. Other Swedish administrations needing information on the sea traffic also have access to this information.

The Helsinki Commission, working with protection of the environment in the Baltic area, decided in 2001 that all the coastal states of the Baltic shall establish landbased AIS stations and exchange the information from these stations. The preparation for that is under way and presently Sweden, Norway, Finland and Russia are exchanging AIS information via Internet connections. The information will also be collected and stored by a central server for creation of traffic statistics for the Baltic Sea.

The European Union requires in a Directive the member states to establish shorebased AIS system before 1 July 2007.
“Being in touch doesn’t mean being in command.” Make the OOW, pilot and the captain the ones, which benefits the most from an AIS system and it will increase the safety of shipping and navigation significantly in the future.

Conclusion

The AIS is making the navigation safer by enhancing the possibility of detecting the whereabouts of other ships, even if they are behind a bend in a channel or river or behind an island in an archipelago. The AIS will also solve the inherent problem with all radars, by detecting fishing boats and smaller ships, fitted with AIS, in sea-clutter and in heavy rain.

Innovative technologies like ECDIS and ship-to-ship and ship-to-shore AIS, have a big potential in improving safety in the maritime field in the future. It will also make it possible to identify, track and supervise ships from shore with a much higher and more sustainable accuracy than with a shore based radar.