Nearshore Automatic Identification Systems

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General Introduction to AIS

Marine Automatic Identification Systems (AIS) were first developed to allow ships and coastal stations to accurately locate and identify each other, it is a marine technology based on positions and timing derived from the GPS satellite network, commonly described as "*the most significant development in navigation and safety since the introduction of radar*".

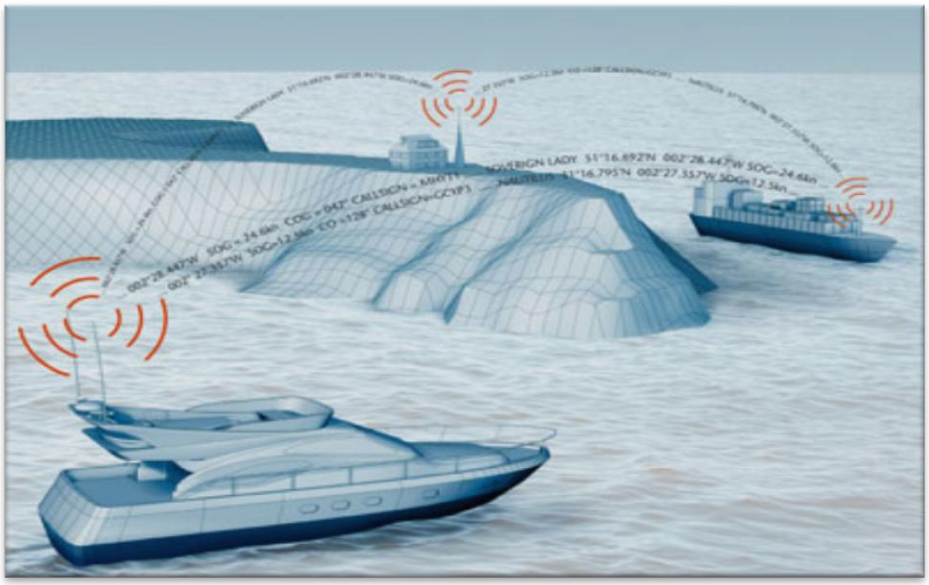

Figure 1 - Typical AIS ship to shore and ship to ship scenario

Primarily it is used as a form of visual tracking whereby a vessel transmits its position and basic self information while at the same time it can view all other vessels transmitting their information within its reception range, the information is usually presented on electronic navigation chart (ENC) displays. An auxiliary application of AIS technology is as an Aid To Navigation (ATON), this is normally a transponder transmitter/receiver device or system,

external to vessels, that is designed to provide information to enhance the safe and efficient navigation of vessel traffic. These ATONs consist of a variety of platforms such as buoys and shore based stations which are designed to transmit a variety of messages to aid the safety and efficiency of navigation. The functions described in this document explore the potential and actual applications of AIS technology applied to marine civil engineering, in particular the provision of binary messages such as the type 8 TideMet message with an embedded weather and tidal data payload.

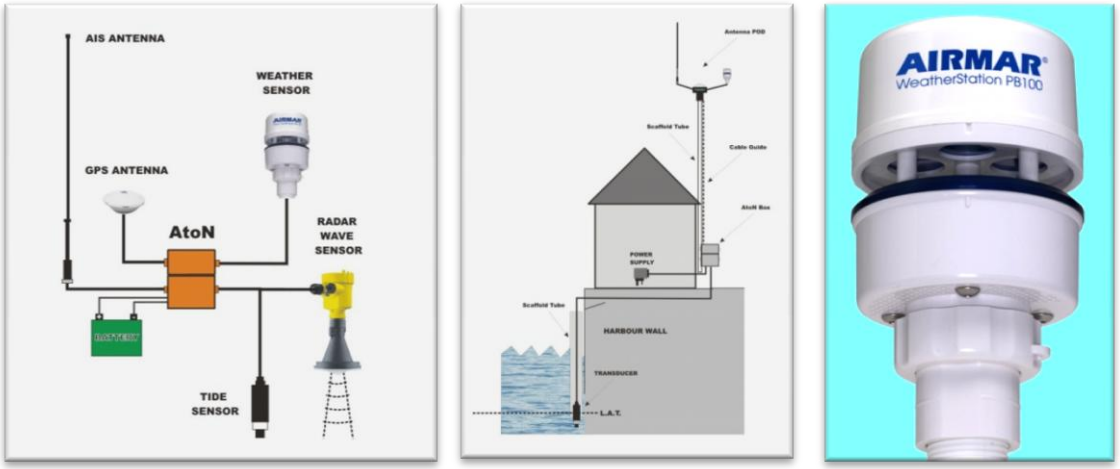

Figure 2 - AIS TideMet station – schematics and weather sensor

The roots of AIS technology are in the background of radio data links over the marine VHF band and are designed for reliable transmission using message formats defined by the International Maritime Organisation (IMO). The actual data link is referred to as the VHF Data Link (VDL) which transports Data Messages (VDM) sent in an encoded text format resembling the NMEA data strings familiar to most GPS and marine data users.

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!AIVDM,1,1,,A,33P9<?gv@oOq34LM2QO78mwh2O11,0*44
!AIVDM,1,1,,A,13OaBj5O1JOq8:2M14nMiJuj2HRD,0*69
!AIVDM,1,1,,A,4h2=aQiuQO>h1OpiMVLwBcAO05kO,0*58
!AIVDM,2,1,2,B,8>jHCpOOBjqbl?u@>7V`POOOOOO6L=DO21OOOOOOOOOOH8OOOOO2khO06d,0*7F
!AIVDM,2,2,2,B,gop,2*6D
!AIVDM,1,1,,A,13P9<?gvOpOq33nM2Q6W@5t42OOO,0*37
!AIVDM,1,1,,A,13P9<?wP@IOq3;>M2NNOFP8605kO,0*61
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Figure 3 - Example AIS messages

This technology assumes that there may be potentially 2250 vessel slots on each of two VHF radio channels within a radius of about 25Km from the AIS receiver. Due to the great safety benefits offered by AIS, this technology was made compulsory throughout the world in 2002 for all passenger ferries, workboats and vessels over 300 gross tonnes.

In addition to conventional marine navigation the real time live current value of tide and metrological data is of direct use in a wide variety of marine civil engineering applications. This environmental data source can be of use in the design, planning, construction and operational phases of many marine projects.

PARAMETER	BITS	DESCRIPTION
Message ID	6	Identifier for Message 8; always 8
Repeat Indicator	2	Used by the repeater to indicate how many times a message has been repeated.
Source ID	30	MMSI number of source station
Spare	2	Not used. Should be set to zero.
IAI	16	DAC = 001; FI = 11
Latitude	24	Measuring position, 0 to + /- 90 degrees, 1/1000th minute
Longitude	25	Measuring position, 0 to + /- 180 degrees, 1/1000th minute
Date and time	16	Time of transmission, Day, hour, minute, (ddhhmm in UTC)
Average wind speed	7	Average of wind speed values for the last 10 minutes. 0-120 kts, 1 kt
Wind gust	7	Wind gust is the maximum wind speed value reading during the last 10 minutes, 0 - 120 kts, 1 kt
Wind direction	9	0 - 359 degrees ,1 degree
Wind gust direction	9	0 . 359 degrees, 1 degree
Air temperature	11	Dry bulb temperature - 60.0 to + 60.0 degrees Celsius 0.1 of a degree
Relative humidity	7	0 . 100 %, 1 %
Dew point	10	- 20.0 - + 50.0 degrees, 0.1 degree
Air pressure	9	800 . 1200 hPa, 1 hPa
Air pressure tendency	2	0 = steady, 1 = decreasing, 2 = increasing
Horizontal visibility	8	0.0 . 25.0 NM, 0.1 NM
Water level (incl. tide)	9	Deviation from local chart datum, . .10.0 to + 30.0 m 0.1 m
Water level trend	2	0 = steady, 1 = decreasing, 2 = increasing
Surface current speed	8	0.0 . 25.0 kts 0.1 kt
Surface current direction	9	0 . 359 degrees, 1 degree
Current speed, #2	8	Current measured at a chosen level below the sea surface, 0.0 . 25.0 kts, 0.1 kt
Current direction, #2	9	0 . 359 degrees, 1 degree
Current measuring level, #2	5	Measuring level in m below sea surface , . 0 .30 m 1 m
Current speed, #3	8	0.0 . 25.0 knots, 0.1 knot
Current direction, #3	9	0 . 359 degrees, 1 degree
Current measuring level, #3	5	Measuring level in m below sea surface, 0 . 30 m 1 m
Significant wave height	8	0.0 . 25.0 m, 0.1 m
Wave period	6	Period in seconds, 0 . 60 s, 1 s
Wave direction	9	0 . 359 degrees, 1 degree
Swell height	8	0.0 . 25.0 m, 0.1 m
Swell period	6	Period in seconds, 0 . 60 s, 1 s
Swell direction	9	0 . 359 degrees, 1 degree
Sea state	4	According to Beaufort scale (manual input?), 0 to 12, 1
Water temperature	10	-10.0 - + 50.0 degrees, 0.1 degree
Precipitation (type)	3	According to WMO
Salinity	9	0.0 . 50.0 ., 0.1.
Ice	2	Yes/No
Spare	6	Total Number of bits 352 Occupies 2 slots

Figure 4 - IMO type 8 TideMet binary message payload

The AIS TideMet system has been designed around a standard ATON device developed for the marine industry by L3 Communications Inc. This type 3 transponder unit is a fully automated system, once it has been installed and turned on then no maintenance is required to keep it operational. The only time the user needs to perform any function on the transponder is to change the local offset parameter data as required. The ATON unit is fully compliant with the IMO specifications and is currently the only one that has been fully tested and certified to comply with the recommendations laid down in IALA A-126. Ohmex have taken this device and added electronics and transducers to measure tide and weather conditions, this data is processed and the message passed to the ATON for transmission using the allocated time slot. The AIS TideMet system makes use of an automatic slot allocation mechanism.

The AIS transponder device must meet a very strict standard of radio, message format and electrical specification governed by the IMO. The standard AIS class ‘A’ transmitter used by most large vessels or ATONs is rated at 12.5 watt output power, this provides broadcast ranges of up to 35 kilometres from the transmitted source, more than adequate for the environmental data which is parochial to the immediate area of measurement. AIS is an omnidirectional broadcast so can be received offshore but also by inland receivers such as sheltered river harbours or shore based monitoring stations. Some experiments have been tried for posting live environmental values on websites for live use by work vessels with Internet access, however, the reliability of these services has not proved to be adequate, access has been difficult for live marine situations such as vessel manoeuvre and message latency is a commonplace issue on websites. In civil engineering or dredging applications the TideMet data can be easily captured on a low cost receiver used on all work vessels without the need for dedicated radio telemetry links.

All Maritime Navigational Aids, Automatic Identification Systems (AIS) and Radar require to be licenced and must adhere to strict specifications. The UK regulations governing maritime radio are, in general, derived from the International Telecommunication Union (ITU) Radio Regulations, the relevant EU Directives (99/5/EC) and the Wireless Telegraphy Act 2006. All radio equipment must meet certain essential criteria, this is a legal requirement under the Radio and Telecommunications Terminal Equipment (R&TTE) Regulations. Within the UK the government body OFCOM are tasked with issuing licences for the use of the AIS radio frequencies and the issue of a unique MMSI number for each transmitting AIS site. Unfortunately the implementation of this is a little disjointed as current AIS licenses can really only extend to an MMSI used by vessels, the international nature of shipping means a local national license is difficult to enforce. Static, temporary or moored AIS transmission equipment such as ATONs need to be issued with an individual MMSI, unfortunately this license assumes the equipment to always be at the same location as part of the license, this becomes a problem in the case of a surveyor or dredging company who wish to deploy a TideMet locally to the place of work for short periods of time at different locations, probably even in different countries.

Energy platforms

For contractors involved in the construction and service of energy projects such as offshore wind farms or wave energy platforms the operational use of AIS has become mandatory. The primary concern is safety so that all current work vessel positions can be seen by each other and also by the site management. The use of up to date navigation charts and AIS positioning helps prevent the accidental fouling of underwater cables with mooring or positioning anchors. During the construction of energy platforms the normally accepted contractual limit of when safe working is permissible is a stated maximum significant wave height. This parameter is transmitted by an AIS TideMet station fitted with a radar tide sensor thus forming a common reference for all to enable the decision for safe working to be mutually agreed.

Figure 5 - The EU Wavestar energy project

Ohmex is a founder member of the EU Wavestar wave energy project with responsibility for provision of maritime safety, weather and tide instrumentation. In the successful prototype currently running at Nissum Bredning in Denmark the weather information is used to predict the wave climate so the paddle performance can be optimised and also raised out of the water prior to storm or other high energy events which may damage the platform. These structures in shallow water become prime sites for fish habitats so naturally attract fishing vessels, for the larger prototype being constructed at Hanstholm the AIS will be required to transmit a safety zone area and warning message to prevent collisions during inclement weather conditions.

The AIS TideMet device can also be connected to a GPS base station and transmit GPS differential corrections directly to local AIS position receivers using binary message type 17. These local GPS corrections enable vessels to safely navigate around structures and locate floating terminals or moorings, particularly in areas outside the envelope of coastal marine beacons or satellite based augmentation systems (SBAS).

Live data input to dispersion models

The use of live AIS TideMet information could be of great potential use in real time dispersion model calibration and calculations, helping the simulations by providing the actual values of the main prediction variables of tide, current and wind conditions.

Figure 6 - Outfalls, Search & Rescue and Oil Spill applications

- **Sea outfalls** - In the case of sewage discharge the live data would help determine the optimum position in the tide cycle for effluent discharge with the facility to also check on the current wind conditions.
- **Search and Rescue** – In addition to TideMet data the AIS ATON embodies the facility to relay type 9 search and rescue messages transmitted by helicopters and life saving vessels in the event of a marine accident or man overboard incident.
- **Pollutant Spill** – AIS data could aid the dispersion model scenario of an oil spill or other contaminant discharge incident where a mathematical model is used to calculate the likely spread and resources required to contain the pollution.

Ports & Harbours

The most significant users of AIS TideMet information are Port and Harbour authorities concerned with the general safe navigation of vessels, safety of persons in transit and prevention of environmental pollution. Increasingly the use is spreading to workboats and craft involved in their general marine construction activities and dredging. Surveyors and dredger operators have moved away from tide gauges in favour of using precision GPS elevations as their preferred vertical datum, this is not a practical solution for the reliability and all weather requirements of a navigational user. At present most marine users are restricted to requesting local tide and weather values over speech channels from the port control or by reading some form of visible tide value such as a tide board, they will certainly not have access to a survey quality receiver for deriving tidal heights from precision GPS. Although main dredging contractors make extensive use of precision GPS for accurate elevation control of their major excavation activities, many minor dredging operations rely on tide gauge information to control the vertical elevation of their

excavators. The TideMet elevation information is readily available on the AIS receivers used by most dredging excavator and hopper barges and can easily be incorporated as real time live input to most machine control systems.

Example Application – London 2012 Olympics

The prime UK installation of the AIS TideMet system is at 3 Mills Lock (formerly Prescott Lock) the gateway to the new London 2012 Olympic site, destined to be the greenest Olympic Games in modern history. The body in charge of construction and design said it would champion low waste, low carbon emissions and promote green forms of transportation. With this goal British Waterways has undertaken the most sustainable waterway restoration possible with refurbishment and modernisation of the Bow Back Rivers, a network of post-industrial waterways that have been derelict and underused since 1945.

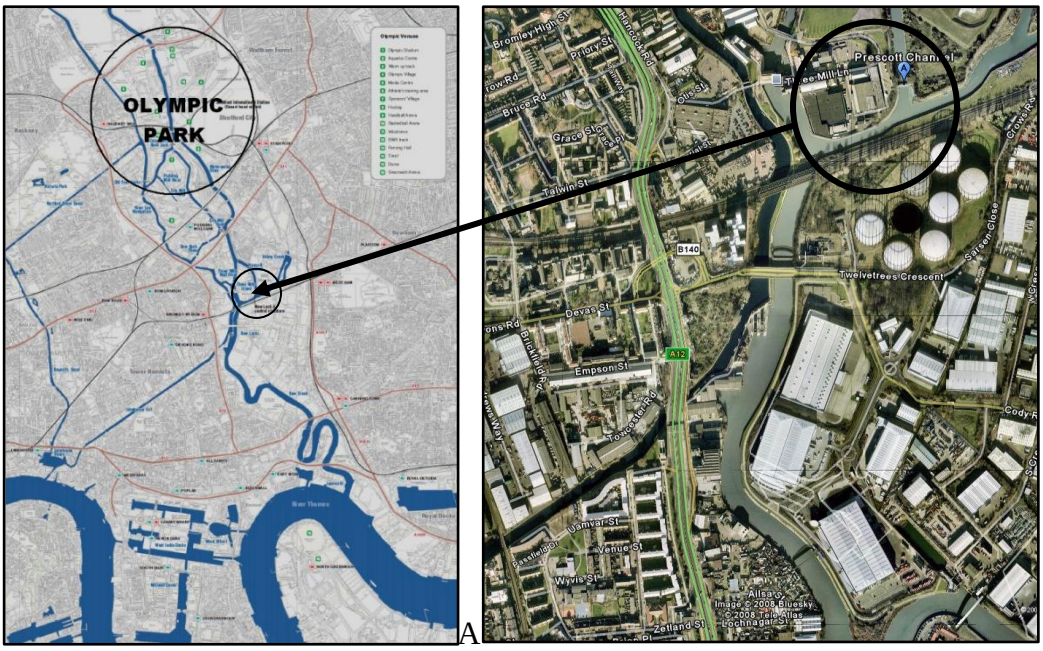

Figure 7 - Three Mills Lock – Thames access to Olympic site

Green benefits of the scheme will include 24-hour navigation with access for large 350 tonne barges. Early estimates indicate that around a third of the heavy traffic for the Games could go by water during the construction phase alone. The rivers could carry up to 8,000 tonnes of construction materials per day, removing up to 1,200 lorry journeys from congested local roads each week and saving about 4,000 tonnes of CO2 emissions during the construction period alone. During the Games and the immediate legacy period waste and recyclates, with an estimated volume in excess of 1.75m tonnes could be transported by water to the processing site at Rainham in Essex saving a further 175,000 lorry journeys.

Figure 8 - TideMet Installation at Three Mills Lock

To facilitate the larger volume of both commercial and leisure vessel traffic a modern control centre has been incorporated in the new lock structure at Three Mills. The centre includes the installation of an AIS TideMet system that will make extensive use of the latest tracking technology to both aid the flow of traffic and maintain a high level of safety within the inland waterway system. Early trials of the system showed tide broadcasts being seen as far away as Gravesend to the east and Waterloo bridge to the West of the site. Particular attention will be made to the safety of mixing leisure vessels and working barges, thus avoiding any potential disaster occurring similar to the collision between the Marchioness riverboat and Bowbelle dredger in the Thames during 1998 which resulted in 51 deaths. Under IMO regulations all of the tug and leisure vessels will be obliged to carry AIS transponders which will show their position to all other AIS users within the immediate range of the network and also in the navigable approaches from the river Thames.

Receiving software

A major obstacle with TideMet data transmitted over AIS using binary messages is that, as yet, very few of the low cost software packages used commercially can decode and display the relevant data contained within the message. In fact the emphasis on predicted tide values shown on most of the chart displays is in itself a potential hazard to navigation, the data is not live and is uncorrected for local atmospheric conditions so could easily be up to 1m or more in error. However, this situation is already beginning to change, as navigators and Pilots begin to demand more accurate information and are becoming more familiar with modern technology, in particular the use of electronic chart systems. A number of software providers have added the potential to decode AIS binary messages, and many more will do so as the use of the messages becomes more widespread.

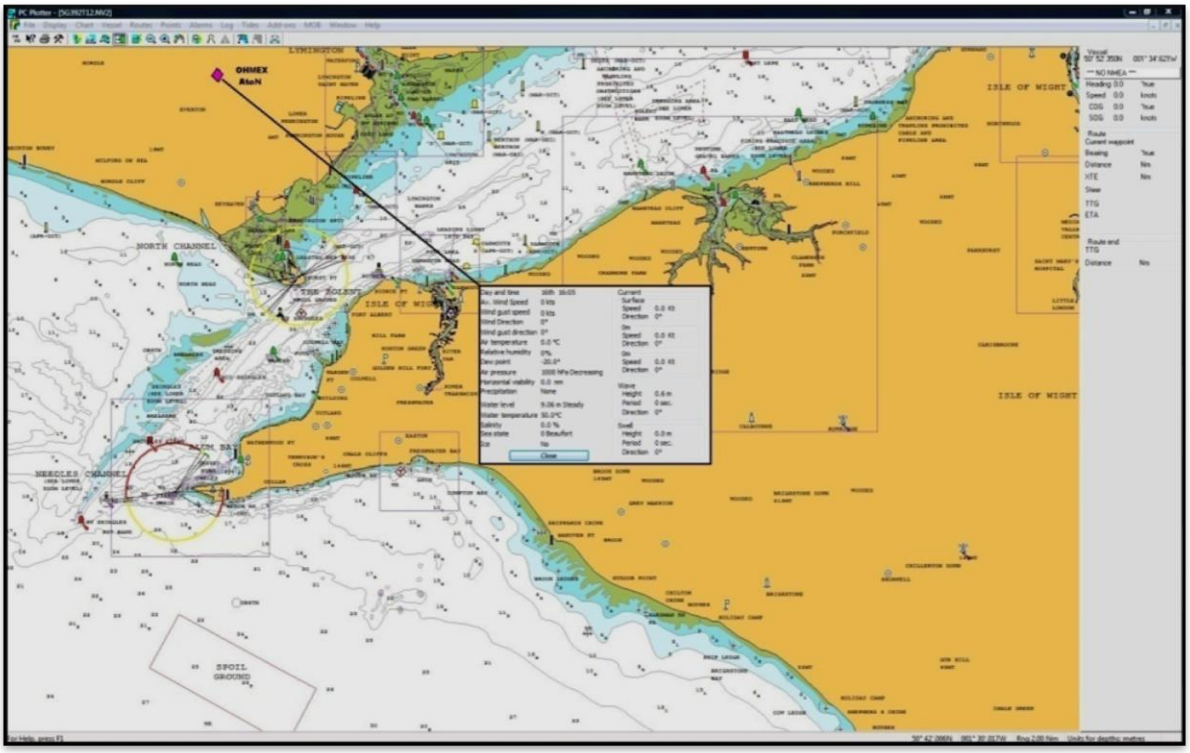

Figure 9 - AIS software showing TideMet data

Current development work

Ohmex is an industrial partner of University of New Hampshire's Centre for Coastal and Ocean Mapping (CCOM) with a particular interest in the development of binary AIS messages and software to decode and display the embedded data. The University's recently established program is aimed at creating a centre for expertise in ocean mapping and hydrographic sciences, many AIS applications are being explored including those with direct benefits in both nearshore and offshore civil engineering. A recent focus is on River Information Systems (RIS) which makes use of AIS stations deployed along inland waterways and rivers to provide forward information which can be used for traffic management, Lock control and water levels for bridge clearance (air gap) information. Another CCOM partner, Hypack Inc the popular hydrographic software package supplier, are currently modifying their Survey package to display live AIS position targets of other vessels in close proximity to the working survey craft. Hypack are also decoding the AIS TideMet message to provide current tidal elevations for clearance information and gross checks on the current precision GPS elevation values.

Acronyms used

AIS - Automatic Identification System
AtoN - Aid to Navigation
GNSS - Global Navigation Satellite System
IALA - International Association of Lighthouse Authorities
IMO - International Maritime Organisation
IEC - International Electro technical Commission
MMSI - Maritime Mobile Service ID
NMEA - National Marine Electronics Association
R&TTE - Telecommunications Terminal Equipment (R&TTE) Regulations
VDL - VHF Data-link Other Vessel Message
VDM - VHF Data-link Message

Reference materials

Tidal & Meteorological data over AIS – E.F.Read, W.S.Heaps – Hydrographic Society, Hydro8 proceedings, November 2008.

Port of Southampton Tide Gauge System – E.F.Read, W.S.Heaps - Hydrographic Society Journal 92, April 1999.

IMO Resolution MSC.74(69), Annex 3, Recommendation on Performance Standards for an Universal Shipborne Automatic Identification Systems (AIS)

IALA Recommendation on AIS Shore Stations and Networking Aspects Relating to the AIS Service, Edition 1.0, September 5, 2002

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