Tide and Metrological data over AIS

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Describing the implementation of a Tide and Weather station transmitting live data over standard AIS (marine Automated Identification System). The paper further describes both the connection of an existing Port's Tidal data network and of *AIS TideMet* a self contained transponder data station.

Background to AIS

Developed to allow ships and coastal stations to accurately locate and identify one another, AIS is the mariner's most significant development in navigation and safety since the introduction of radar. AIS is a marine technology based around positions and timing derived from the GPS network. Primarily the system is used as a form of visual tracking whereby a vessel transmits its position and basic information while at the same time view all other vessels transmitting their information within its reception range. The technology assumes that there may be potentially 2250 vessel 'slots' on each of two VHF radio channels (AIS1=161.975MHz, AIS2=162.025MHz) 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 and vessels over 300 gross tonnes. An auxiliary application of AIS is as an Aid To Navigation (AtoN), this is defined as *"a device or system external to vessels that is designed and operated to enhance the safe and efficient navigation of vessel traffic"*. These AtoNs consist of a variety of devices such as buoys and shore stations designed to promote and enhance safety and efficiency of navigation, the function described in this document is the provision of weather and tidal data over an AIS AtoN station.

Tide & Metrological data over AIS

In recent years the hydrographic survey profession has moved away from tide gauges in favour of using RTK GPS elevations as their preferred vertical datum. This is not a practical solution for the reliability and all weather requirements of a navigational user such as shipping or ports and harbours. At present the marine user is restricted to requesting local tide and weather value over speech channels from VTS or by reading some form of visible tide value such as a tide board, as they will certainly not have access to a survey quality receiver for deriving tidal heights from GPS. Some experiments have been tried for posting live values on websites which can be viewed using Internet access, however, the reliability of these services has not been adequate, access has been difficult for a live marine situation such as a vessel berthing and message latency is a commonplace issue on websites. The introduction of AIS has provided a radio frequency standard together with the provision of message structures to allow the reliable transmission of tide and met data within the local area of measurements. Furthermore, AIS allows the majority of vessels, of all sizes, to receive such data without the need to invest in any additional hardware, or (in the most basic of realisations) even any additional software.

Functional Description of an AIS AtoN

The AIS AtoN is box of electronics programmed to transmit three messages (type 21, 6 and 8) at predefined timings and sequence over the AIS frequencies. The transmit functions amd MMSI of the AtoN must be configured prior to installation. The configuration parameters specify what messages are transmitted over the air, how often the transmissions occur and sometimes the slot on the VHF data link (VDL) they are transmitted over. Message 6 is defined as an Addressed Binary Message, data from a message 6 may contain a status report on the health of the AtoN or other status information. Message 21 is defined as an Aids-to-Navigation Report and is usually transmitted every 3 minutes containing the origination MMSI, name of the AtoN (if applicable), type of AtoN (fixed or floating), position of the AtoN and the positional accuracy. Unlike the message 6, this report is broadcast and meant to be seen by all AIS transponders. Binary Message 8 is a broadcast message containing a binary payload which may vary depending on its parameters, in the case of the Tide and Metrological data message the packet is formed as in the table below ...

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

Fig 1 - IMO Type 8 Tide and Met. message definition

The structure of an AIS message.

The roots of AIS technology lie in the background of radio data links over the marine VHF band and are designed for reliable transmission using message formats defined by the IMO. The actual AIS link is referred to as the VDL (VHF Data Link) and messages transmitted (VDM) in an encoded text format which resemble the NMEA encoding familiar to most GPS and marine data users. The actual binary payload is further encoded in a 6 Bit ASCII format for transmission ...

```
!AIVDM,1,1,,A,33P9<?gv@oOq34LM2QO78mwh2011,0*44
!AIVDM,1,1,,A,13OaBj501JOq8:2M14nMiJuj2HRD,0*69
!AIVDM,1,1,,A,4h2=aQiuQO>h1OpiMVLwBcA005k0,0*58
!AIVDM,2,1,2,B,8>jHCp00Bjqbl?u@>7V`P00000006L=D02100000000000H8000002kh006d,0*7F
!AIVDM,2,2,2,B,gop,2*6D
!AIVDM,1,1,,A,13P9<?gv0pOq33nM2Q6W@5t42000,0*37
!AIVDM,1,1,,A,13P9<?wP@IOq3;>M2NN0FP8605k0,0*61
!AIVDM,1,1,,B,39NWrE@OiSOqu;4M3OtuTc2:011Q,0*1E
```

Fig 2 - VDM output showing type 8 message highlighted

As can be seen by the large number of zeros in the previous example of type 8 output the IMO specified message formats appear to suffer from the following faults ...

- Over specified, much of the message is not of interest to many users.
- Badly aligned bit format so that data is not byte aligned and computer friendly.
- Messages not size optimised by splitting into rapid and slow change data.

As an example the tide value (water level parameter) within the existing type 8 message is unacceptable to modern vessel traffic as it is only accurate to the nearest decimeter, within the Ohmex solution the spare bits at the end of the message have been utilised to send the centimeter portion of the tidal elevation. Using the spare bits maintains the integrity of the message but allows special software to meet the accuracy requirements. The individual tide and metrological message is defined by parameters DAC=1 and FI=11, this is not very easy to use, as the software has to first decode a message as a type 8 then work out from the DAC/FI code if the data is relevant as a TideMet message. The limitations on use of a DAC code having been assigned to countries leaving the 63 possible FI codes a little limited.

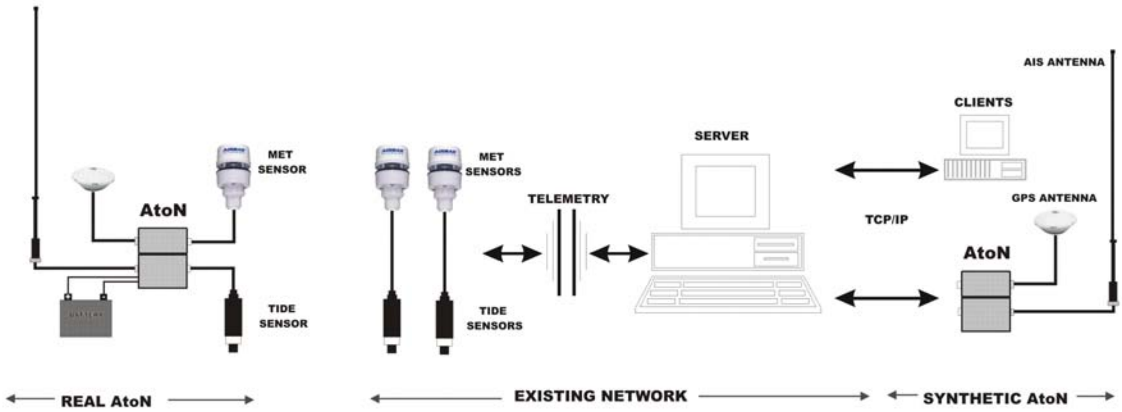

Fig 3 – Layout of a Real & Synthetic AtoN

Standalone ‘Real’ AtoN TideMet station

The AIS TideMet system has been designed around a standard AtoN device developed for the marine industry by L3 Communications Inc. This Transponder unit is a fully automated system, once it has been installed and turned on, 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 AtoN’s settings and local offset data as required. The AtoN unit is fully compliant with the IMO specifications defined in IMO MSC.74(69) Annex 3, IEC 61993-2, and ITU.R M.1371-1. The device is currently the only one that has been fully tested and certified to comply with the recommendations laid down in IALA A-126. This AtoN engine can be found within many derived AtoN products on the market. Ohmex have taken this device and added electronics to measure tide and weather conditions, this data is processed and the message passed to the AtoN for transmission using the allocated time slot. AIS AtoN devices fall into three broad categories depending upon their electronic complexity ...

- Type 1 - Transmit only, no receiver.
- Type 2 - Receiver for control functions only.
- Type 3 - Dual channel transmit and receive for autonomous mode.

The AIS TideMet system is a Type 3 device as it makes use of the RATDMA slot allocation mechanism. By the nature of how the output messages are structured and its content each of the AtoNs also fall into the following three general configurations ...

- **Real** - AIS AtoN which is physically located on the AtoN position.
- **Synthetic** - AIS AtoN which is not physically located on the AtoN position.
- **Virtual** - AIS AtoN Messages transmitted for an AtoN which does not physically exist.

In use as a standalone system the TideMet AtoN is operated in 'Real' mode making use of the position generated by the integrated DGPS unit. When used as a transmitter for messages from a computer network then the AtoN is operated in the ‘Synthetic’ mode sending upto three individual type 8 messages representing different TideMet data stations with their respective positions.

VTS ‘Synthetic’ AtoN network system

The Port of Southampton already has an established software system for receiving, recording and storing its tide and met data. Data from remote sensor sites is transmitted over dedicated radio or wired links to the VTS centre where the computer system quality controls the incoming data before distributing it over the internal Intranet system. An important point is the data received by the mariner is from a trusted VTS source who are able to discern any sensor malfunctions before data values are supplied. The AIS TideMet was interfaced with the long term project at the Port of Southampton for providing the Pilots with a truly portable navigation system using AIS as its basis, the requirement to monitor the port’s tide and weather conditions was seen as a natural extension to that project. In this case software was written to intercept network messages from the Intranet system and broadcast these over the L3 AtoN, using the device purely as a local transmitter.

Receiving software

A major current obstacle with TideMet data transmitted over AIS using binary messages is that, as yet, very few of the 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 used is in itself a potential hazard to navigation, the data is not live or corrected 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 electronic chart systems. A number of software providers have added the potential to decode AIS Message 8, and many more will do so as the use of the message becomes more widespread.

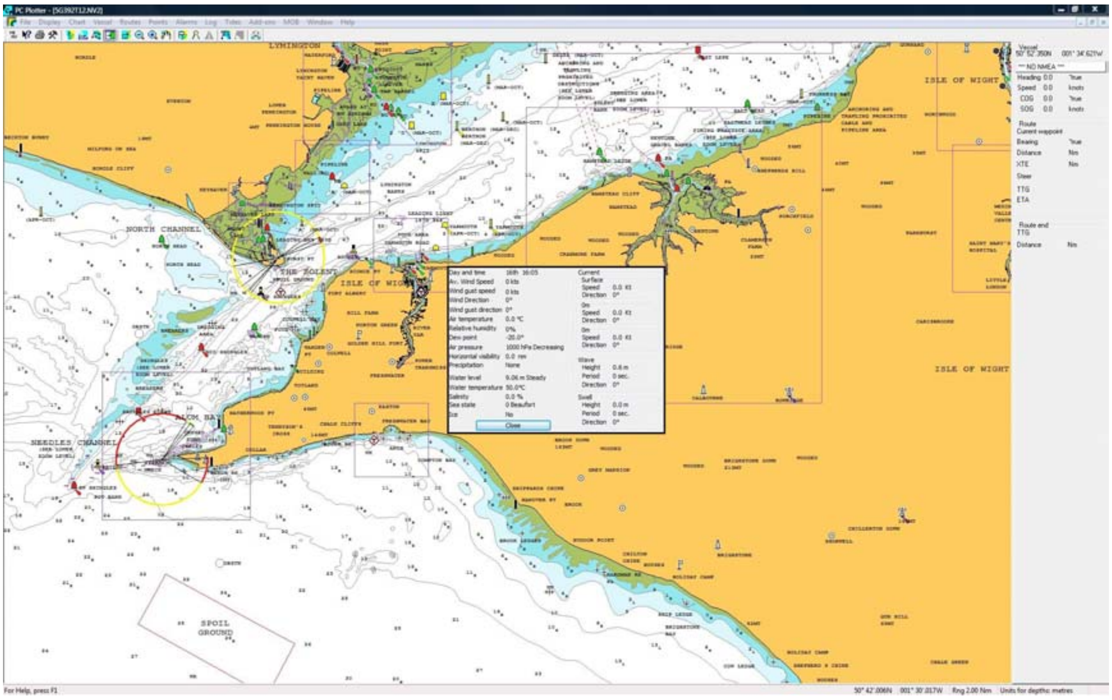

Fig 4 – Example AIS software with Tide/Met decoding

Licensing of AIS AtoN devices

All Maritime Navigational Aids, Automatic Identification Systems (AIS) and Radar require a licence and to 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 as licenses can really only extend to an MMSI used by vessels, the international nature of shipping means a parochial 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 AtoN locally to the place of work for short periods of time at different locations, probably even in different countries. Another problem is the license is based on allocation of a fixed FATDMA slot in the timing regime for the device, whereas, the modern AtoN devices using the RATDMA standard can listen for available slots and allocate their own transmission slots accordingly.

The IEC standards for AIS allow two operating modes for an AtoN AIS. These are RATDMA (Random Access Time Division Multiple Access) and FATDMA (Fixed Access Time Division Multiple Access). An AtoN AIS unit operating in RATDMA mode uses its receiver to listen to both AIS frequencies for about one minute, and makes and stores a map of all the AIS "slots" on the VHF data link. It then looks for two free adjacent slots in which to send its AtoN message 21 or meteorological and hydrological message 8. This mode is ideal for many applications because the AtoN or weather/tide AIS unit can be placed at any location, and requires no reservation of slots by a base station. An AtoN AIS unit operating in FATDMA mode will transmit in a pair of slots which are reserved by an AIS base station. The main consideration in remote AtoN stations is that RATDMA is on for more time than FATDMA so power consumption is higher and less predictable.

AIS TideMet applications

Current tide and metrological data is in use in a wide variety of applications in addition to conventional marine AIS navigation uses. The standard AIS transmitter is rated at 12.5watt power, in practice this gives reception ranges up to 35 kilometres from the transmitted source, more than adequate for Tide and Met data which tends to be parochial to the immediate area of measurement. The data is broadcast radially so can also be received by inland receivers such as sheltered river harbours or shore based monitoring stations. In hydrographic, civil engineering or dredging applications the tide and met data can be easily captured on a low cost AIS receiver on all work vessels without the need for dedicated radio telemetry links. By deployment along inland waterways and rivers forward information of water levels can be used for lock control, sewage pumping or bridge clearance information. . For navigation applications, as well as the obvious benefits of real time tide and weather data becoming available to all mariners, further exciting opportunities are opened up. For example “Dynamic Under Keel” passage planning for large draught constrained commercial vessels will become a cost effective option for many ports, with consequent economic and safety benefits for shiping operators, Port authorities and other harbour users.

The current state of AIS

Unfortunately much of the information transmitted over AIS is in error because either the transponder unit has not been programmed correctly or parameters which should be updated are left unchanged, examples are yachts with the size of a supertanker where dimensions have been entered in feet not meters, many vessels can be seen underway at speeds of 10 knots with the message 'MOORED' displayed alongside as the Master has not changed the current status settings. An example of AIS clutter was that during 2002 when someone local to Dover decided it would be a good idea to use message type 12 (text format safety message) to broadcast Tide information in an easily readable form to all vessels. Unfortunately very quickly others decided to use the same channel with commercial, non-safety messages like "Visit Enzos for your next Pizza " , this resulted in near AIS melt down with no room for genuine AIS traffic. Channel Navigation Information Service based at Dover Coastguard has the facility to receive AIS text messages and the Operators have witnessed many examples of the misuse of the facility. A recent example concerned a vessel passing through the South West bound traffic lane, periodically transmitting a succinct message expressing the view of the navigating officer with respect to another nation's officers, mostly in the procreatory gerund. A further example concerned two officers conversing between vessels in the same fleet. From the messages one could only assume that the two concerned had been intimate in the past and were looking forward to the next occasion when they might rediscover their intimacy. The only problem was that they had forgotten the default 'all-stations' setting and were consequently broadcasting to all and sundry !

The MCA have stated that text messages other than genuine safety related topics should be addressed (MMSI to MMSI) messages rather than broadcast thus indicating that TideMet broadcasts should be in binary rather than text.

Summary

As this rapidly changing technology matures it will become as accepted as radar, the systems to implement its use will become standard and probably enforceable for the sake of safety. Important points recognised as a result of this work are that there are no clear lines of communication between the various authorities involved in this technology and there is a problem with adapting to technical advances outside the existing application areas of AIS.

ACRONYMS

AIS - Automatic Identification System
AtoN - Aid to Navigation
DAC - Digital Area Code
FATDMA - Fixed Access Time Division Multiple Access
FI - Function Identifier
GNSS - Global Navigation Satellite System
IALA - International Association of Lighthouse Authorities
IMO - International Maritime Organisation
IEC - International Electro technical Commission
IMO - International Maritime Organization
MMSI - Maritime Mobile Service ID
NMEA - National Marine Electronics Association
R&TTE - Telecommunications Terminal Equipment (R&TTE) Regulations
RATDMA - Random Access Time Division Multiple Access
VDL - VHF Data-link Other Vessel Message
VDM - VHF Data-link Message
VDO - VHF Data-link Own-vessel Message
VTS - Vessel Traffic Service

References

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