The Development of AIS and an Aid to Navigation

Alan Grant[1], Phil Thompson[2] and Nick Ward[1]
[1]The General Lighthouse Authorities of the United Kingdom and Ireland
[2]Trinity House, United Kingdom

Dr. Alan Grant is a Principal Engineer for the Research and Radionavigation directorate of the General Lighthouse Authorities of the UK and Ireland. He is project manager and technical lead for all GNSS projects within the directorate. He received the degrees of B.Sc. and Ph.D. from Staffordshire University and the University of Wales respectively. He is an Associate Fellow of the Royal Institute of Navigation, a member of the US Institute of Navigation, and is a Chartered Physicist.

Mr. Phil Thompson is the Operations Systems Manager for Trinity House, responsible for the telemetry, differential GPS (DGPS) and AIS systems. He has worked in radio communications engineering for many years. He received the degree of BEng and PgDip from the University of Essex and is a member of the Institution of Engineering and Technology, and the Royal Institute of Navigation.

Dr. Nick Ward is Research Director of the General Lighthouse Authorities of the UK and Ireland, with responsibility for strategy & planning of research & development. His area of specialisation is in radio-navigation and communications, including Automatic Identification Systems (AIS). He is currently vice chairman of the International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA) e-Navigation committee. He is a Chartered Engineer, a Fellow of the Royal Institute of Navigation and a Member of ION.

ABSTRACT

The mission of the General Lighthouse Authorities of the United Kingdom and Ireland (GLAs) is to deliver a reliable, efficient and cost-effective Aids-to-Navigation (AtoN) service for the benefit and safety of all mariners.

The Automatic Identification System (AIS) was developed as a means of providing information from vessel-to-vessel and vessel-to-shore, although other applications were envisaged from the start. Recent trials by the General Lighthouse Authorities have shown that this system can be integrated into the provision of effective Aids to Navigation (AtoNs). This paper will provide an insight into the changes in technology in this area and will introduce the development and use of AIS as an AtoN.

In particular the paper will focus on how AIS can be employed in this manner and will report on two recent demonstrations conducted by the GLAs at Oban in Scotland, which demonstrated:

- e-ANSI (electronic Aids-to-Navigation Systems Information) – demonstrated a system that provides the mariner with (near) real time information on the status of local AtoNs. The information was conveyed using the AIS network and was associated with a symbol on the electronic chart; and
- Virtual AtoNs - showed how AIS can be used to provide timely marking of an incident, or area to be avoided, in a cost effective manner, even though a physical AtoN has yet to be deployed.

This paper will discuss the ongoing work conducted by the General Lighthouse Authorities of the United Kingdom and Ireland on this technology

KEYWORDS: AIS AtoNs Maritime

INTRODUCTION

The General Lighthouse Authorities of the United Kingdom and Ireland comprise the Northern Lighthouse Board, Trinity House and the Commissioners of Irish Lights. The three Authorities work closely together to provide marine Aids-to-Navigation (AtoN) within their areas of jurisdiction.

Marine AtoNs are constantly evolving with changes in user requirements and developments in technology and the GLAs continue to research new methods and systems to ensure that they provide the mariner with the best service [1,2]. Marine AtoNs range from the more traditional aids such as lighthouses and buoys, through to radionavigation systems such as the Automatic Identification System (AIS), Differential Global Navigation Satellite Systems (DGNSS), Radar and e-Loran.

This paper provides an insight into the development of AIS as an AtoN. AIS was designed to enable information to be passed from vessel-to-vessel and vessel-to-shore. The International Maritime Organisation (IMO) mandated the use of AIS by all vessels covered by the Safety of Life at Sea (SOLAS) convention (vessels over 300 tonnes or those carrying passengers) to be fitted by July 2004.

AIS transmits vessels information, such as position, course, speed and other relevant data over two dedicated VHF frequencies. This information is then received by other vessels in the vicinity or by relevant shore infrastructure, such as a local vessel traffic service (VTS) and can be overlaid on an electronic chart display and information system (ECDIS) or shown as a text list. Used in this way, AIS enables vessels to build an image of vessels around them and to identify potential hazards along their intended route.

There are two classes of AIS; Class A is for use on SOLAS vessels and Class B is for use on smaller commercial and recreational vessels. In essence they work in the same manner although Class B AIS has some differences in the signal protocol, radiated power (and hence range) and the information transmitted.

AIS AS AN ATON

Although AIS was initially developed to enable vessels and shore infrastructure to build a marine traffic image around them, it also lends itself to be used as a means of providing additional information to the mariner.

As such, the GLAs are developing new AtoNs based around AIS.

There are three systems currently being developed:

- Virtual AtoNs
- Real AtoN AIS
- Synthetic AtoNs

<u>Virtual AtoNs</u>

Virtual AtoNs are virtual or electronic marks, provided where no physical AtoN exists. If a vessel becomes a casualty, the GLAs would be informed and would attend the casualty to mark the incident to ensure other mariners remain safe. It takes a finite time for the GLA vessel to arrive on scene, during which time there may be no sign of the incident, especially if the vessel has submerged. It is during this time that AIS can be used to provide a significant benefit.

By providing an additional AIS message to mariners in the vicinity of the incident, the GLAs can effectively “update” the vessel’s ECDIS and display virtual buoys to mark the position of the incident. In this way, even before physical AtoNs can be deployed, mariners in the region can be made aware of the potential dangers and can take avoiding action.

This can be useful for other scenarios, such as areas where the channel may change frequently or for marking channel separation schemes, when they are first established.

<u>Real AtoN AIS</u>

Real AtoN AIS is the deployment of a specially modified AIS transponder on an AtoN, enabling the mariner to interact with the AtoN.

For example, an AtoN AIS unit can be fitted to a buoy and can use the AIS message structure to provide information as to the status of that Aid. This can range from confirmation as to the light flash character, through to the transmission of weather data (if available from equipment on the buoy) and may also include service information such as the status of the buoy batteries.

This additional information provides another level of support to mariners’ in the vicinity as they can interrogate the buoy, should they observe any unusual effects. For example, mariners’ in the vicinity would expect to observe a particular coloured light of a particular flash character. If the lamp fails and they don’t observe this light it introduces an element of doubt in the mariner’s position.

However, with AtoN AIS fitted to the buoy, the mariner can use results from their AIS unit to confirm the buoy location in terms of a range and bearing and they can also interrogate the buoy and receive confirmation that the lamp has failed.

Another means of using AIS is in the deployment of Synthetic AtoNs.

<u>Synthetic AtoNs</u>

In this approach an AIS base station is used to broadcast information about an AtoN, for example a buoy, as if that message was broadcast by the buoy itself. In this mode, the mariner will be able to identify the buoy on their electronic chart, both on the marked chart position and using the AIS information. If the buoy position is monitored and provided to the base station, then the mariner will be provided with its current position as well as the charted position.

This approach would only be taken where it is not possible for the buoy to broadcast its own AIS information.

DEMONSTRATION OF AIS AS AN ATON

AIS employed as an AtoN has been the subject of two demonstrations this year, with AtoN AIS demonstrated as part of the e-ANSI project and virtual AtoNs demonstrated as part of the MARUSE project.

e-ANSI

Traditionally AtoNs provide the mariner with spatial reference points using visual shapes, colours, lights and sometimes sounds. More recently AtoN remote monitoring gave the controlling authorities confidence that the service being provided, was as intended. That confidence could be shared with the mariner if there were automatic electronic updates of the AtoN status.

Electronic Aids to Navigation Systems Information (e-ANSI) is a system being developed by the International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA) to enable such information to be passed to the mariner. The GLAs are active members of IALA and are heavily involved in the IALA e-ANSI working group. As such, the GLAs hosted a demonstration this new information system at the Northern Lighthouse Board (NLB) Depot at Oban in Scotland, earlier this year.

The demonstration focused on the generation and transmission of defined e-ANSI events, the display of them on a proprietary Electronic Chart System (ECS) and used AIS to provide the e-ANSI messages.

<u>The e-ANSI System</u>

The e-ANSI system is made up of several key components; the AtoN monitoring system, the e-ANSI servers (regional and global) and then a broadcast system to inform the mariner (Figure 1).

<u>Prototype Equipment</u>

Given the feasibility test nature of the demonstration, prototype equipment was used from IALA commercial members Tideland and Gatehouse; as such, it as necessary to define new message descriptions, which was undertaken by Tideland (Table 1).

As discussed, the aim of the e-ANSI concept is to provide mariners with additional information on the performance of an AtoN. For the demonstration, it was unfeasible to install the equipment to a buoy and then wait for it to fail, so the AtoN monitoring equipment was installed in the NLB launch. The main advantage here was manoeuvrability meaning that the launch could move on/off station when required and provide a more dynamic target on the ECDIS.

AIS was used as the most convenient method to transport e-ANSI messages from the base station to the receiving ECS equipment and also provided the local traffic image to the ECS.

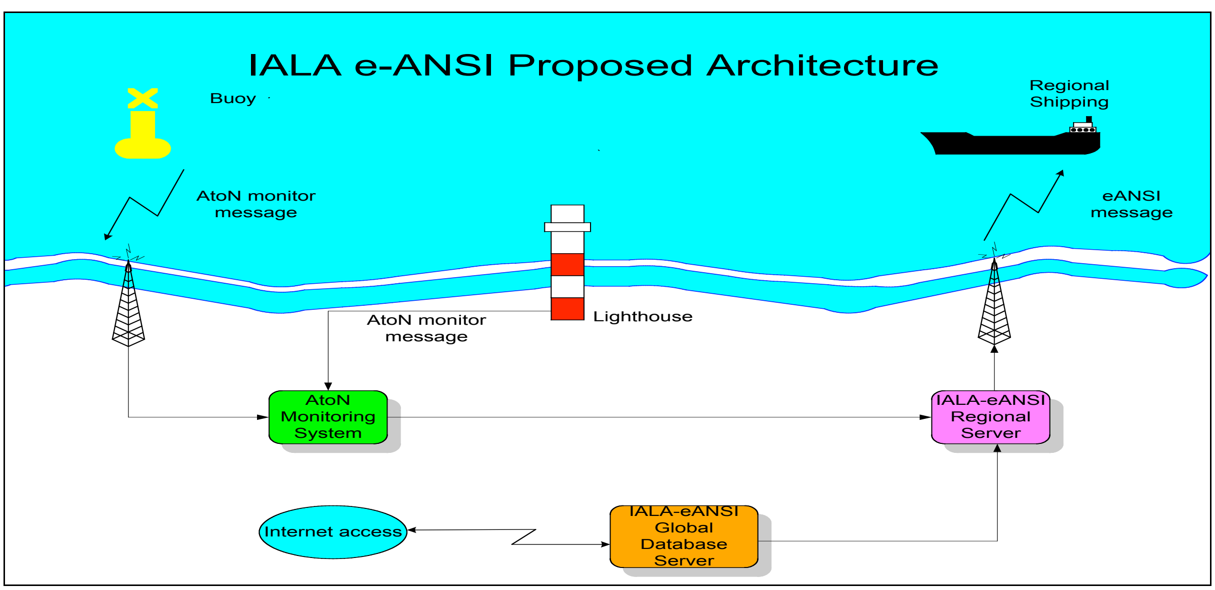


Figure 1: Schematic of the IALA e-ANSI architecture used to provide additional AtoN information to the mariner.

Table 1 : Prototype e-ANSI messages

Message Type	*Description*	*Contents includes*
1	AtoN drifting off station	ID, Charted LNG/LNG as well as Current LAT/LNG, Time of last transmission, Drift Speed and Drift Bearing
2	A new or uncharted hazard	LAT/LNG, Nature of Hazard and Time of Occurrence
3	AtoN malfunction	ID, Charted LAT/LNG, Nature of Hazard and Time of Occurrence
4	A message to cancel a message 1-3	Message ID, Transmit time, Message type
5	Communication check or "heartbeat" message	Message ID and Transmit time

To ensure that other mariners were not inconvenienced or confused by the e-ANSI messages, an addressed binary message format (AIS Message Type 6) was used rather than the standard broadcast aids to navigation Message 21. This meant that the message was targeted to the AIS transponder used in the trial

Equipment set up

The demonstration equipment was configured (Figure 2) so that an AtoN was connected via a UHF radio link to a laptop running Tideland's NavTerm™ software. This software was used to provide the Remote Monitoring and Control (RM&C) component which monitors the performance of the AtoN. In the event of an exception, for example the AtoN drifts off position, the RM&C is used to generate the appropriate e-ANSI message.

The message is then sent via a local area network to the e-ANSI Server ™, where it is encapsulated into an AIS message ready for broadcast. The receiving AIS unit passes the encapsulated e-ANSI message to the Gatehouse proprietary GAD ™ Electronic Charting System, which decodes the message and provides a new AtoN icon on the chart along with the additional information.

E-ANSI DEMONSTRATION

The demonstration was designed to test all available message types and started with the scenario that the AtoN was off station. This is where a buoy or other floating aid has moved beyond its stated position and acceptable guard area.

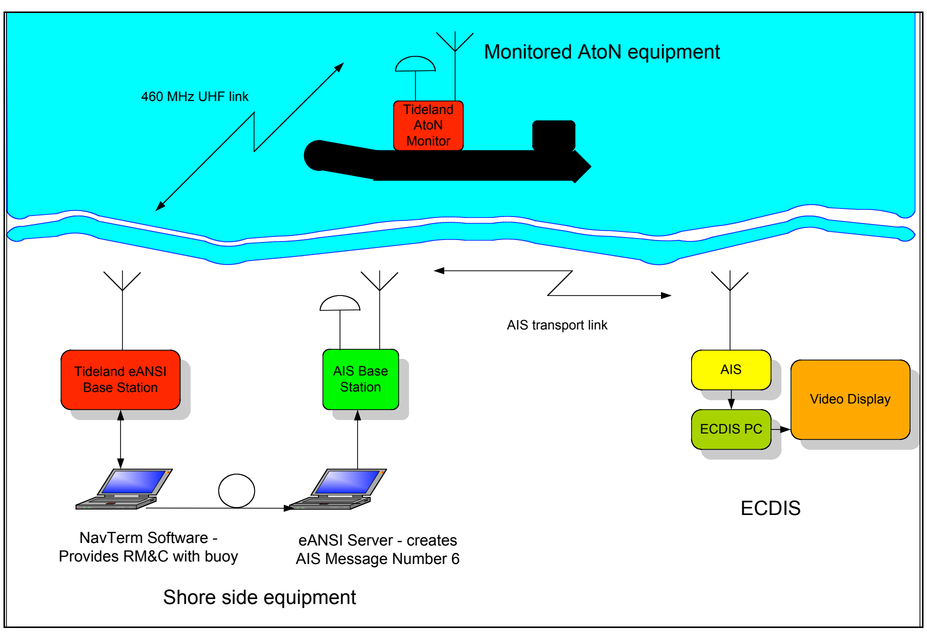
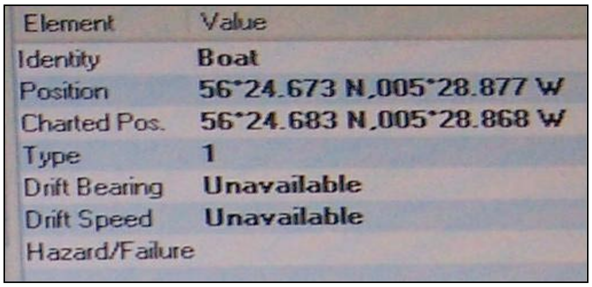


Figure 2: Schematic of equipment set-up used in the e-ANSI demonstration.

In this scenario an e-ANSI message Type 1 would be issued by the RM&C station to report that the buoy is off station. In the demonstration, the NLB launch was used as the AtoN and initially navigated to a pre-defied charted position set as the “true” location of the Aton and, once there drifted away until it was far enough off station to raise the alarm.

The generation of the e-ANSI message was then observed along with the received message and the display of the AtoN information on the ECS.



Element	Value
Identity	Boat
Position	56°24.673 N,005°28.877 W
Charted Pos.	56°24.683 N,005°28.868 W
Type	1
Drift Bearing	Unavailable
Drift Speed	Unavailable
Hazard/Failure	

Figure 3: Textual information from the AtoN “Boat”

The AtoN is represented by a green diamond with cross hairs centred at the reported position. The ECS also presented information on this new AtoN (Figure 3); however a problem with the prototype equipment meant that some information was not presented, in this case the “*Hazard/Failure*” field should have presented “*AtoN drifting*”. After demonstrating e-ANSI Message Type 1, e-ANSI Message Type 2-5 were demonstrated [3].

The scope of the demonstration was to show the benefits of the e-ANSI concept, and showed for the first time, how a system of this type monitors AtoNs, generates the appropriate messages when events occur and also demonstrated the successful transmission and presentation of this important AtoN information.

MARUSE

The MARUSE project was part of the EU 6th framework programme and was supported by the Galileo Joint Undertaking/European GNSS Supervisory Authority (GJU/GSA). The project gathered together 15 institutional and industrial R&D partners from all over Europe to create a consortium led by Kongsberg-Seatex.

The main objective of the MARUSE project was to identify Galileo service differentiators and to demonstrate the benefits of using Galileo, either on its own or combined with other systems such as EGNOS & GPS, in coastal, port approach and inland waterways environments.

The MARUSE project saw the development of Galileo pseudolites and the MARUSE user terminal, which were designed and developed by the MARUSE consortium to enable navigation by “Galileo-like” signals.

The GLAs involvement in the MARUSE project included hosting a demonstration of the technology developed through the MARUSE project [4]. However, the project enabled the GLAs to develop and demonstrate the use of virtual AtoNs and AtoN AIS for the first time.

The demonstration followed the scenario that a vessel being tracked as it navigates into the port, suffers a failure and becomes an obstruction. Figures 4, 5 & 6 depict the demonstration scenario. In these figures, the grey vessel is the casualty; the purple vessel is the GLA buoy tender. For the demonstration the casualty vessel was simulated as the port was operational.

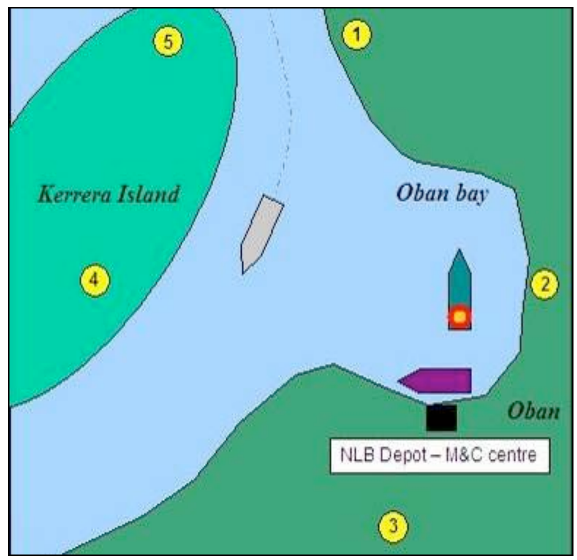


Figure 4: Part one of the demonstration scenario. A vessel entering Oban Bay fails, causing an obstruction (grey vessel). The yellow numbered circles represent the pseudolites positioned about the port, used in the navigation of the GLA vessel (purple).

In the scenario, on notification of the casualty the GLAs initiated their response and in the time taken for the buoy tender to reach the casualty, the area was marked with virtual AtoNs. For the demonstration a local AIS base station was configured to send the appropriate AIS messages to enable vessels in the local area to locate and identify the casualty by presenting virtual buoys on their ECDIS. These are symbolised by the red triangles in Figure 5

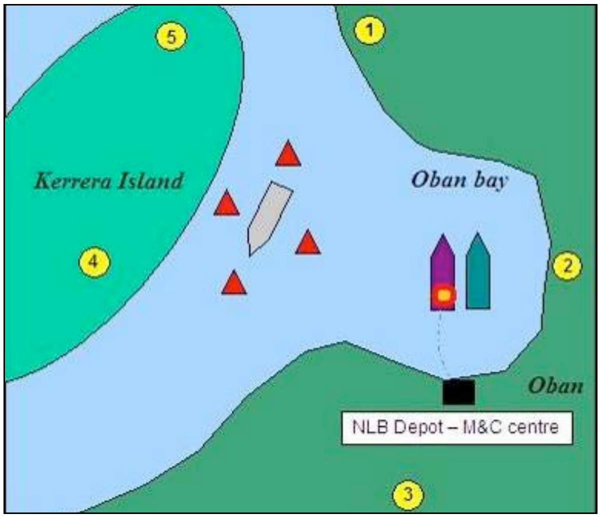


Figure 5: Part two of the demonstration scenario. Upon notification of the casualty, the GLAs used virtual AtoNs provided through AIS to mark the vessel (red triangles). In the meantime the GLAs vessel (purple) retrieves an emergency marker buoy from a second vessel.

The demonstration vessel *NLV Pharos* left port and collected an emergency wreck-marking buoy (EWB) (symbolised by the yellow circle with the red outer ring in Figures 4,5 and 6) from a second vessel (to simulate Ship-to-ship coordination, used to show one of the Galileo service differentiators within the MARUSE project) and then navigated to the location of one of the virtual AtoNs and deployed the buoy – simulating the process used when responding to a real-life casualty (Figure 6).

The demonstration presented to the mariner and other key stakeholders the benefits of virtual AtoNs and particularly how they can be deployed in a timely manner.

STANDARDS

The use of AIS as an AtoN is being developed internationally and the GLAs are involved in the development of the required standards.

The technical implementation of AIS as an AtoN is set out in IALA Recommendation A-126, recently updated [5] to include sections on power management, availability and standard monitoring messages (Type 6).

The AIS AtoN service is defined as having a service availability corresponding to IALA Category 1, 2, or 3 (depending on the importance of AtoN) for the intended transmissions.

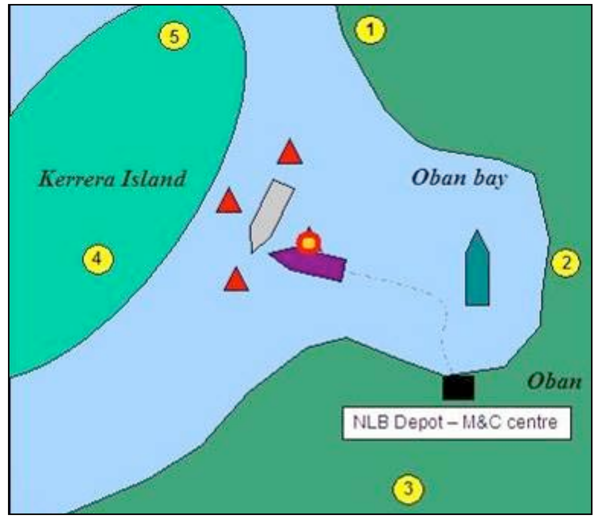


Figure 6: Part three of the demonstration scenario. The GLA vessel uses Galileo pseudolites and GPS to navigate to the stricken vessel and deploys the emergency wreck-marking buoy in place of a virtual buoy.

The AIS AtoN service is defined as the transmission of the following information (message 21) relating to all AtoNs identified as AIS AtoNs: the type and name of the AtoN; a valid 2D position within the accuracy indicated by the position accuracy indicator; type of position fixing device; off position indicator; time stamp; dimensions of the AtoN and reference positions; virtual AtoN flag and RAIM flag.

IEC 62320-2, [6] sets out the minimum operational and performance requirements, methods of test and required test results for AIS AtoN stations.

The GLAs are contributing to this discussion by mapping out the development of this crucial service as part of their Virtual Aids to Navigation Plan [7]. This plan details the necessary stakeholders and legislative and development stages which need to be completed before virtual AtoNs can be introduced into service.

The GLAs have already started the deployment of real AtoN AIS units around the British Isles in order to provide additional information to the mariner

CONCLUSIONS

The General Lighthouse Authorities are committed to the development of new and existing aids-to-navigation to improve safety and protection of the marine environment. AIS as an AtoN is envisaged to be an important tool in the development of an operational e-Navigation solution and as such is subject to ongoing research, development and standardisation support.

There are obvious benefits for the mariner to receive more information on the performance of AtoNs and as such the e-ANSI concept to provide (near) real-time information on aids to navigation status will provide the mariner with additional confidence that the AtoN is operating correctly.

In the context of this paper, the e-ANSI demonstration showed one of the additional benefits of AIS, in the availability of the AIS data channel. This channel can be used to provide safety information to the mariner, as demonstrated in the MARUSE demonstration.

The provision of virtual AtoNs is powerful tool available to the GLAs as it means incidents can be marked in a timely and effective manner while more traditional physical AtoNs are delivered to the incident.

The GLAs are keen to put these new Aids into operation and are working closely with international and national partners to ensure the safety of all mariners within their waters.

ACKNOWLEDGEMENTS
The General Lighthouse Authorities Research and Radionavigation Directorate acknowledge the support provided by the Northern Lighthouse Board for hosting the two trials mentioned in this paper and would also like to acknowledge the equipment support provided by IALA Industrial Members Tideland and Gatehouse for the e-ANSI project and the MARUSE consortium for support of the MARUSE project.

REFERENCES

1. The General Lighthouse Authorities of the UK & Ireland, *"2020: The Vision"*, 2004.
2. The General Lighthouse Authorities of the UK & Ireland, "*GLA Radio Navigation Plan*", 2007
3. The General Lighthouse Authorities, Research and Radionavigation Directorate, report RPT-08-PT-08 *"E-ANSI demonstration project report*", 2008.
4. A.J. Grant, N. Ward, S.E. Christiansen, C. Dixon, A. Suskind, *'MARUSE Demonstrating the use of Maritime Galileo Pseudolites'* US Institute of Navigation GNSS 2007 conference, Dallas Fort Worth, Texas, September 2007.
5. IALA Recommendation A-126, on the Use of the Automatic Identification System (AIS) in Marine Aids to navigation Services, Dec 2008.
6. IEC 2320-2, AIS AtoN stations – Minimum operational and performance requirements – methods of test and required test results, 2008.
7. The General Lighthouse Authorities of the UK & Ireland, "Virtual Aids to Navigation plan", 2008.