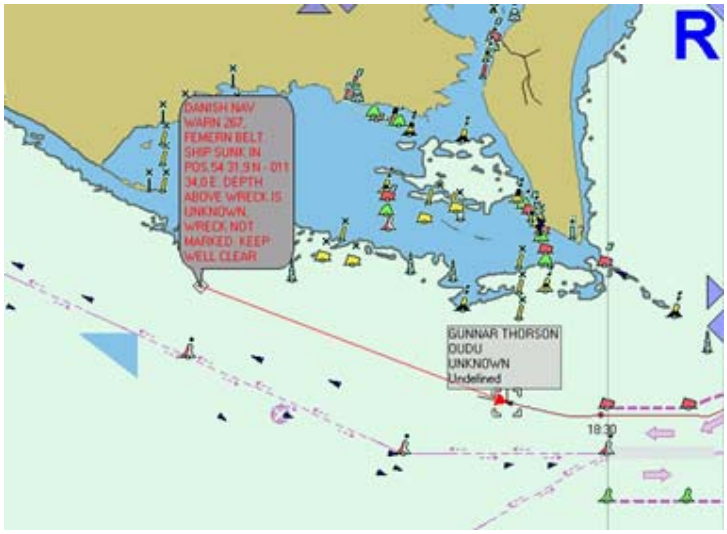
e-NAV7/16/1

Experience with AIS AtoN (Aids to Navigation)

Is there a future for electronic AtoN within e-Navigation?



Report number	FRV-Rapport-2009-01
Title	Experience with AIS AtoN
Dokument name	FRV-Rapport-2009-01-v2.0.pdf
Keywords	AIS, AtoN, e-Navigation, display symbols, electronic charts
Report type	Technical report for internal and external use
Publishing date	April 23rd 2009
Version no.	2.0
Department	Innovation & Analysis
Author	Jens K. Jensen
Approval [content]	CJB
Class	Public
Approval [form]	DEA

FARVANDSVÆSENET
Danish Maritime Safety Administration

Overgaden oven Vandet 62 B · Postboks 1919 · Dk - 1023 København K · Tlf. +45 3268 9500 · Fax +45 3257 4341 · www.frv.dk

Content

1 Background 2
2 Examples of operational use 2
2.1 Emergency wreck marking 3
2.2 Emergency obstacle marking 5
2.3 Marking of waypoints / turningpoints 6
2.4 Virtual guiding AtoNs without creating an obstacle 7
2.5 Enhancement, monitoring and control of traditional AtoNs 7
2.6 Supplementary marking of Offshore Structures 8
3 Observed effects 9
3.1 Can mariners detect AIS AtoNs? 9
3.2 AIS AtoN symbology 11
3.3 Other display issues 13
4 Potential role of electronic AtoNs 13
4.1 Highlighting important existing physical AtoNs 13
4.2 Marking new or temporary objects 14
4.3 Providing AtoNs without creating an obstruction 14
4.4 Providing AtoNs where physically difficult or particularly expensive 14
4.5 Providing waypoints? 14
5 Experience and related issues reported by other IALA members 15
5.1 eNAV6-19-28: Development of virtual AtoN systems, by the General Lighthouse Authorities 15
5.2 eNAV6-19-01: IALA AtoN Attribute and Metadata Information Standard 15
5.3 eNAV6-08-07: Working paper regarding the development of Maritime Information Systems 15
5.4 ANM12-Output-10: Draft guideline on the establishment of AIS as an AtoN 16
5.5 eNAV6-08-02: 'Draft guideline on minimum comprehensive mix of AtoN in fairways, etc.' 16
6 'EfficienSea' – a testbed for e-Navigation 16
7 Discussion and Conclusions 16
7.1 Display capability and recognition by mariners is a prerequisite for a useful AtoN service 17
7.2 AIS AtoN display symbology issues 17
7.3 AIS AtoNs in relation to charted objects 17
7.4 Potential role of electronic AtoN technology 18
7.5 Do electronic AtoNs have a future in the e-Navigation era? 18
8 Definitions 19

1 Background

This report is a summary of operational experiences and observations gathered by the Danish Maritime Safety Administration regarding active use of AIS Aids to Navigation (AtoN) technology, and reports by other Aids to Navigation authorities.

In brief, the technology currently enables us to transmit electronic Aids to Navigation signals, but the signals are likely to not be presented or understood by mariners. The fact that the responsibility for developing different parts of the puzzle, which are needed if AIS AtoNs are to become an effective tool, is divided across many institutions within the maritime domain, (IMO, IALA, IHO, ITU, IEC and manufacturers organizations), is currently a limitation to reaching the potential of AIS AtoN technology.

However, the e-Navigation strategic development process initiated by the IMO and supported by IALA, IHO, ITU, IEC and manufacturers, constitute a window of opportunity, to fully develop new technology for providing new kinds of Marine Aids to Navigation services, which can be made flexible, low cost and quick to deploy. Such electronic AtoN services may significantly benefit safer and more efficient sea transport.

It is essential to clarify the potential role of future electronic AtoN technologies, risks involved, and to ensure a holistic approach to the technological developments between AtoN service providing and associated ship borne capabilities, and essentially recognition by mariners.

DaMSA encourage other administrations to engage in the development and report their experiences gained for the benefit of the e-Navigation process.

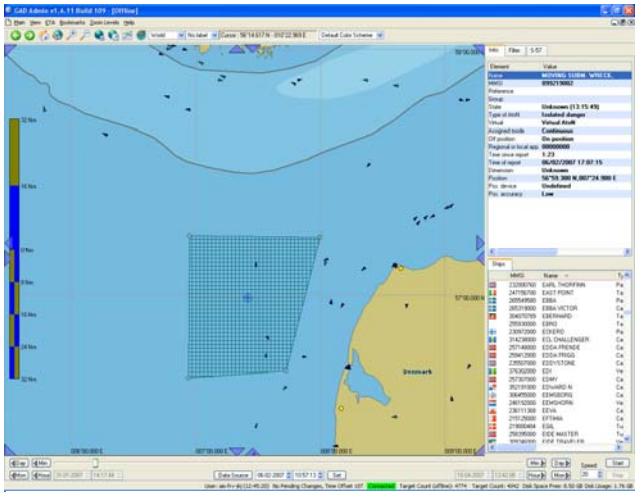
2 Examples of operational use

In 2004, DaMSA initiated the development of a shore based AIS network in Danish waters. As part of the requirement for the network, it was foreseen that the system should include capabilities for transmitting Synthetic AIS AtoN signals to supplement and highlight existing physical AtoNs, or virtual AIS AtoN signals to highlight new obstacles or areas of danger. It was also anticipated, that AIS AtoN technology should be used on certain off shore AtoNs for monitoring and control purposes

2.1 Emergency wreck marking

Jyske Rev, February 2007

A former Russian whiskey class submarine was under tow to Bangkok, to become a museum ship. I was lost by the tug near 'Jyske Rev' off the northwest coast of Denmark in harsh weather conditions. A navigational warning was issued as usual, and DaMSA notified it's buoy tender to locate the wreck and deploy relevant markers. However, due to the bad weather and the time it would take locate and mark the wreck, we chose to deploy a virtual AtoN named 'New Wreck, depth unknown', and to automatically alert vessels to the relevant navigational warning by an addressed safety related AIS message, when entering the area near the wreck.



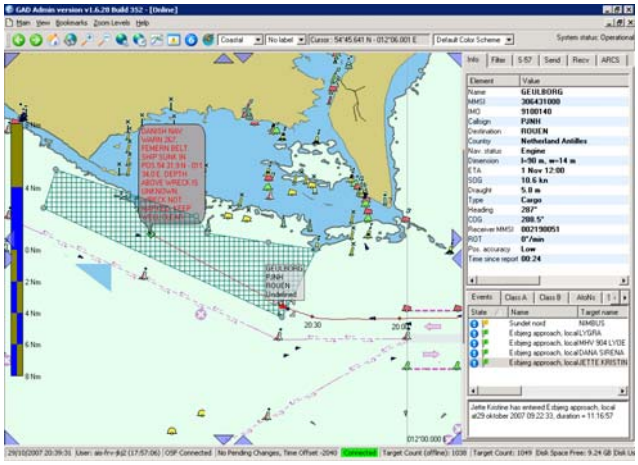
Virtual AIS AtoN and area of Message Service on Jyske Rev

It was generally agreed, that this kind of usage of AIS AtoN technology proved to be quick and easy to deploy, and once the shore infrastructure exists, such AtoN services can be provided at almost no extra cost.

Not much operational experience was gathered in this instance – however it was noted that at least one vessel replied "well received" to the AIS Safety Related Message alerting the vessel to the navigational warning.

Omer N, October 2007

When the cargo vessel OMER N's capsized in the busy strait Femer Belt between Denmark and Germany, the wreck ended up slightly closer to shore, not far from the busy deep water route, with part of the wreck just above water.

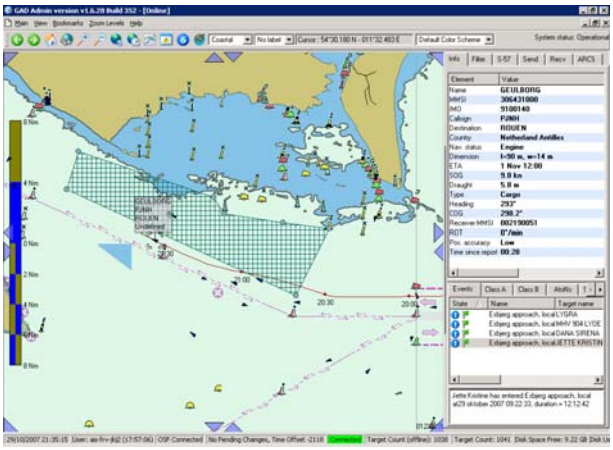


AIS AtoN and Message Service indicating new wreck

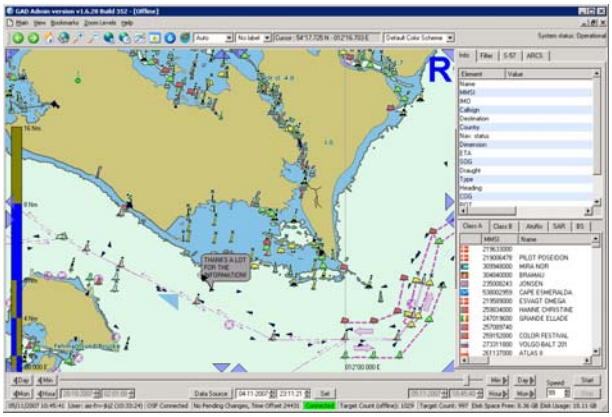
DaMSA shortly after deployed a virtual AIS AtoN, marking the new wreck even before the buoy tender could reach the position. An automatic message service was deployed, using AIS safety related messages to alert mariners of the new danger ahead, by the text 'New Wreck' – and a reference to the navigational warning issued. We configured the service to alert only those vessels, who were taking the shorter path close to the wreck, while not distracting those vessels, who were following the deep water route at a safe distance.

At this incident, it was observed that there was a documented effect of the message service – several vessels were noted who actually altered their course to go closer to the marked safe water route, away from the wreck, shortly after receiving the AIS alert.

Emergency Wreck Marking and similar marking of new or temporary obstacles is considered to be one of the strongest cases for using AIS AtoN technology.



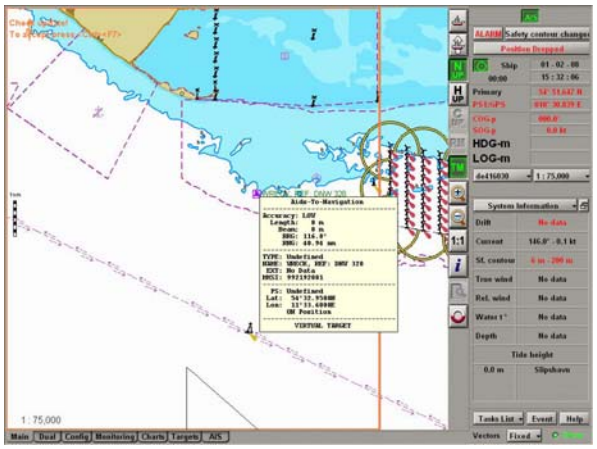
The vessel changed course after receiving the alert regarding new wreck via AIS Safety Related Message



This vessel replied 'Thanks a lot for the information'

It was noted, that in some instances, vessels replied to the AIS text transmission, although there was no operator to receive the response.

It was however also noted, that most vessels did not seem to react to the new danger, until they were close enough to see the wreck visually – or see the physical mark, that was deployed shortly after.



This display system showed the AIS AtoN target, but only after we increased the transmission frequency

At this point, DaMSA was contacted by MARNAV (Marstal Navigational Education Centre), who had observed, that the virtual AIS AtoN marking the wreck was visible on some of their display systems, but not on others. MARNAV had contacted the manufactureres, Furuno, Transas and Maris, regarding the issue, and the manufactureres had different explanations as to why they could not display the AIS AtoN target. One manufacturer claimed, after receiving AIS data from MARNAV, that the target *should* not be displayed, since it was not being transmitted every 3 minutes as required by the ITU-R 1371-1 recommendation, however this recommendation does not *require* the transmission frequency to be every 3 minutes, and the IALA recommendation A-126 is of a quite different oppinion. There are no test standards for displyal equipment, that state anything on how display systems should be tested, regarding handling AIS AtoN targets, so this is really up to the manufacturer how to handle – or whether to handle at all.

DaMSA was in fact transmitting the AIS AtoN target alternating between transmissions from 2 different base stations, each making one transmission every 6 minutes, resulting in an update rate of one received AIS AtoN signal every 6 minutes when far away from the wreck in either direction – or one AIS AtoN signal every 3 minutes, when close to the wreck. When we received the information from MARNAV, DaMSA increased the transmission frequency to one transmission every 3 minutes from both base stations. After this, MARNAV reported that their Furuno AIS and Transas ECDIS 3000i were capable of displaying the AIS AtoN target, however neither their Furuno radar or Maris ECDIS displays, both claiming to display AIS targets, still did not display the AIS AtoN target.

We investigated the issue, and found that the danish pilots were also unable to see the virtual AIS AtoN target on their portable pilots displays, as were the operators at the danish MRCC on their displays.

We concluded, that due to the lack of display requirements and test standards for displaying AIS AtoNs, the effect of deploying virtual AIS AtoNs was much less, than the effect of the AIS Safety related Message service, since we could not rely on AIS AtoN signals to be displayed to mariners, even if they had a graphical display capable of displaying AIS information, however the AIS text messages would be available on the MKD of a class A AIS station.

These experiences made us wonder how many vessels were actually capable of detecting an AIS AtoN signal. As a result of this, we initiated a process of gathering information on the issue by asking danish pilots to register whether or not they could detect virtual AIS AtoN targets on various vessels display systems, whenever passing an area where such AtoN targets were present. These results are reported in the section “Observed effects”.

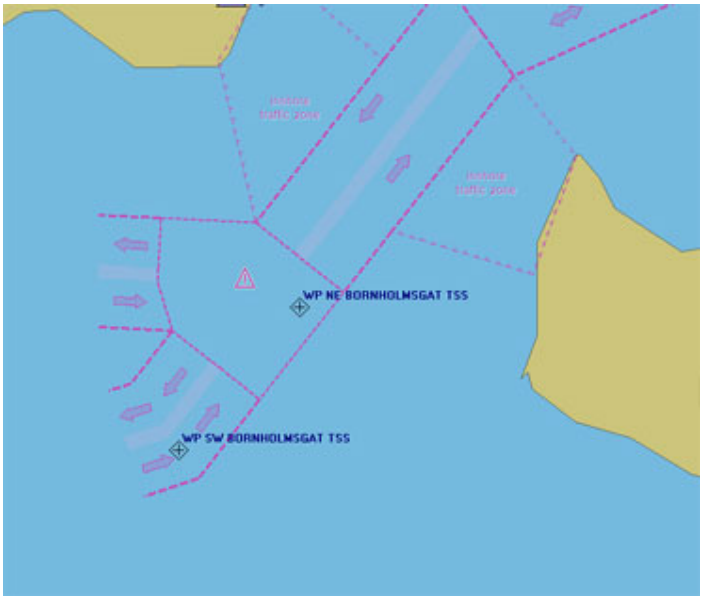
2.2 Emergency obstacle marking

Quite similar to the Emergency Wreck Marking incidents described above, the AIS AtoN and AIS Message Service systems were taken into use, when a lighthouse on Skanseodde, marking the approach to Fredericia port, was damaged in January 2008, and the remains of the lighthouse

constituted a dangerous submerged obstacle. While the virtual AIS AtoN could be deployed quickly, and continue to highlight the temporary marker that was deployed, the message service was considered to be the most beneficial instrument, to alert only those who needed to know.

2.3 Marking of waypoints / turningpoints

July 2006, a traffic separation scheme was established in the Bornholms Gat between Sweden and the Danish island Bornholm. With AIS, we could prove that traffic patterns certainly changed into a more orderly flow, however over a period of 2 years, 4 vessels grounded on the west coast of Bornholm, as a result of drunk, sleeping or otherwise inattentive mariners, who simply forgot to turn to the north-east, when entering the traffic separation scheme from west or south-west.



AIS AtoNs: Creating waypoints without creating obstacles?

DaMSA considered various options for addressing the issue, and for a trial period 2 waypoints were created in the form of virtual AIS AtoNs, indicating the points where vessels should turn. The hope was that without creating obstacles, virtual waypoints might help the mariners plan and execute their navigation.

During this trial, pilots were asked, when boarding vessels in the area, to note whether these AIS AtoNs could be detected by the equipment onboard various vessels. The results are reported in the section “Observed Effects” below.

The trial intentionally sparked a debate on what the role of virtual AIS or other electronic Marine Aids to Navigation could and should be.

Concerns were raised by Danish, Swedish and German administrations regarding mariners recognition of such objects – and the experiences gathered include the realization, that unless the role of a new Marine Aids to Navigation technology is understood by Aids to Navigation authorities and mariners alike, and unless all the technological components involved in providing, communicating and visualizing / displaying such electronic AtoNs are developed in a holistic, coherent process, the benefits of such a flexible technology is not likely to be reached. Also the risks associated with providing Aids to Navigation partly or entirely through electronic means should be elaborated and managed.

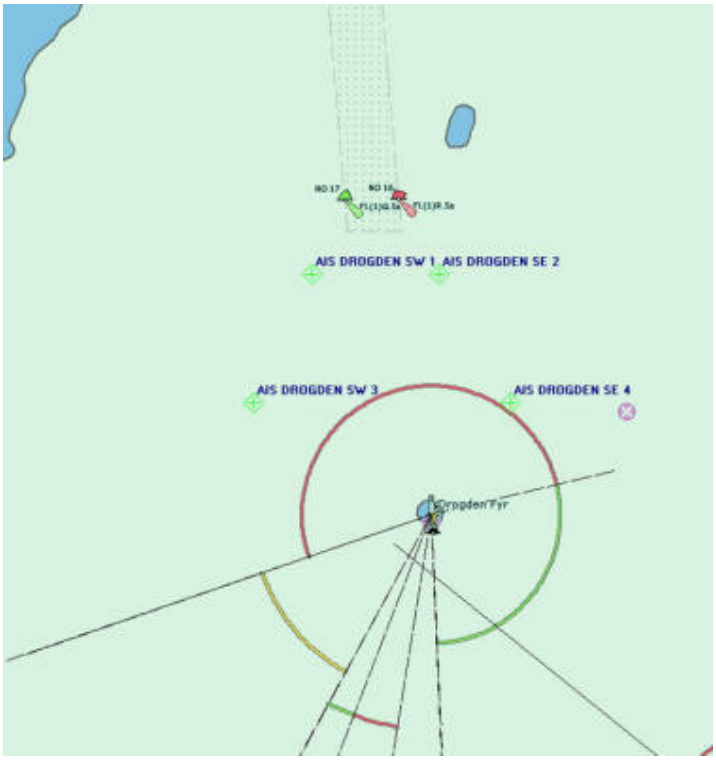
These kinds of trials are considered useful by DaMSA, to raise debate on the use of AIS AtoNs for such purposes, in order to identify the gaps that need to be filled within the framework of the e-Navigation process, and we encourage other administrations to report their related observations.

2.4 Virtual guiding AtoNs without creating an obstacle

The area near the southern end of the dredged channel in The Sound between Denmark and Sweden (Drogden Channel), is difficult to navigate. There is often strong current in the area, and the flow of traffic around the Drogden Lighthouse is unregulated, often resulting in close passages of vessels and unfortunate approaches of the dredged channel from the south. For these reasons, the light buoy marking the south east entrance to the channel, is the Danish AtoN most frequently hit by vessels. It was moved northwards in December 2007, however to further improve the approach to the channel, and to gain further experience with virtual AtoNs, another trial was initiated in 2008.

4 additional virtual AIS markers were deployed to mark a 'funnel' at the entrance to the channel, without creating obstacles to navigation.

Operators at a nearby facility were planning a survey interview for vessels approaching the area, regarding the use of differentially corrected positioning systems, and questions regarding the capability of detecting the virtual AtoN on the vessels navigation systems were added to the survey. Results are reported in the section "Observed Effects" below.



Virtual AtoNs marking the entrance to Drogden Channel, without creating obstacles. VTS operators asked: "Why are the names of the AtoNs obscuring the view?"

Immediately after the 4 virtual AtoNs were deployed, operators at the nearby Sound VTS centre requested that DaMSA should move the names of the virtual AtoNs, as they were obscuring the attempt to create the 'funnel' entrance to the channel. However, the AIS AtoN technology does not contain any means of indicating, *where* the name of an AIS AtoN should be displayed in a chart display. This is currently up to the display system to decide and thus subject to each manufacturers implementation.

2.5 Enhancement, monitoring and control of traditional AtoNs

DaMSA is currently in the process of deploying AIS AtoN stations on a number of lighthouses, in order to enhance the visibility of the lighthouse electronically with this new technology, and to utilize the means available in AIS AtoN technology to broadcast online health status of the lighthouse, and for monitoring and control purposes. Using such platforms to broadcast Meteorological and Hydrological information is being considered, however not much practical experience has been gathered at DaMSA yet.

The results derived from previous experience with virtual AtoN trials indicate however, that only few mariners are likely to benefit from the broadcast AIS AtoN signals, since only very few vessels carry

graphical displays capable of displaying AIS AtoNs.

On this background, there seems to be a long way ahead, until mariners are likely to benefit from the advanced capabilities of AIS AtoN broadcasts containing up to date health status or met/hydro information, unless these issues are addressed, as part of the e-Navigation process.

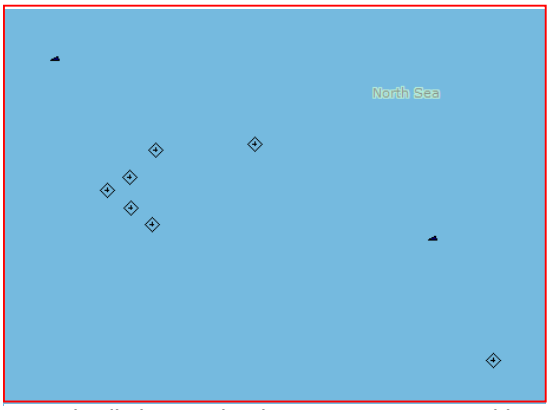
It is primarily foreseen to be of significant economic and operational benefit to our own administration, to be able to monitor the health of physical AtoNs by using this technology. In particular, the ability to detect and track important (and often very expensive) floating AtoNs if they go off position, is expected to be of benefit.

2.6 Supplementary marking of Offshore Structures

AIS AtoNs have been taken into operational use, as additional means to highlight Offshore Structures in Danish waters. In other parts of the North Sea, AIS AtoNs are also used for this purpose.

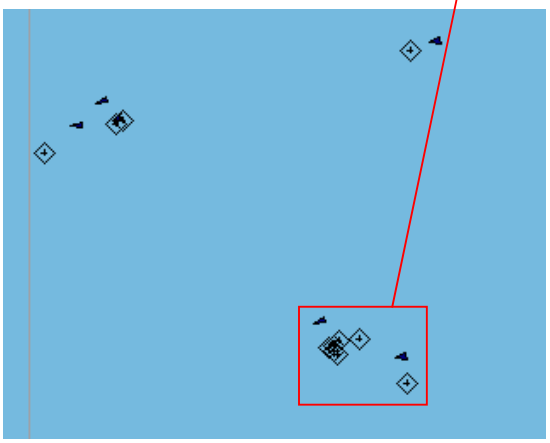
Recently, more than 30 Oil and Gas drilling platforms were marked in the Danish sector of the North Sea, using synthetic AIS AtoNs, transmitting the signals from 2 base stations in the region. While we consider the use of AIS AtoNs to be a useful supplementary means of marking off shore structures, this case brought another issue to our attention.

When an off shore drilling platform or wind farm consists of several objects, or an area, more than one point needs to be marked – however each mark should have a different priority, depending on the zoom level, much like objects in electronic charts.



At a detailed zoom level, many AIS AtoN objects may be relevant to mark different objects

How should we use AIS AtoNs to highlight one main drilling platform with 4 'satellite platforms' at a distance from each other? Well, if we look at what should be presented to a mariner in his display, this depends on the zoom level, just like electronic chart objects. At a 'Coastal' scale, it would at most be relevant to display one object, indicating the existence of an oilfield or wind farm in question, in order not to obscure the display by having several objects on top of each other. At an 'Approach' or 'Harbor' scale, it might however be relevant to see each individual offshore platform, or the corners of the area of a wind farm. None the less, AIS AtoN messaging do not contain any means of providing information regarding which the zoom level priority of an AIS AtoN object.



At a less detailed zoom level, too many AIS AtoN objects will overlap in the display, obscuring the view

The experiences gathered in this case raises a number of questions, and generally indicate, that the role of AIS AtoN technology in comparison with charted AtoNs is largely unexplored. Should AIS (or other electronic) AtoNs only be used for highlighting single large scale objects, or new / temporary objects? Should there be a formal link between AIS (or other electronic) AtoN objects, and an associated charted object? These issues need to be addressed in the context of e-Navigation, if AIS or other electronic means of providing Marine Aids to Navigation are to be useful technologies in the future.

3 Observed effects

This section summarizes observed effects and issues, noted by DaMSA over the past 3 years of experience.

3.1 Can mariners detect AIS AtoNs?

Two studies have been carried out, to determine the current state of vessels ability to detect AIS AtoNs:

Pilots notes from vessels passing Bornholms Gat or Drogden Channel

In this study, pilots from the Danish Pilot Service took notes on the make and model of various equipment on board vessels passing areas where virtual AIS AtoN were in trial operation.

Out of 20 vessels, where the notes were useful for analysis. This is a very small sample to build conclusions on, but we derived the following:

1. Class A AIS station with MKD: In 1 vessel , the only means to display AIS information was the AIS class A MKD. In 2 instances, the pilot was *unable* to detect the AIS AtoNs on the vessels class A AIS transponder MKD.
2. Radar displays with AIS input: At least 6 vessels carried graphical radar displays declared capable of displaying AIS targets. However only one type of radar display (SAM electronics) displayed the AIS AtoN targets. Two other types (JRC, Furuno FAR 2825) did not.
3. ECDIS or other graphical chart displays: At least 11 vessels carried an electronic chart display, declared capable of displaying AIS targets. In 5 vessels (less than half), AIS AtoNs were visible on the shipborne ECDIS (SAM Electronics, Transas ES-4 models), in the remaining cases (Other Transas models, Furuno, Kelvin Huges and Maris – including the pilots own portable laptop solutions) AIS AtoNs were NOT displayed.

It is noted, that the test specification for AIS class A stations does not *test* the ability to display AIS AtoN targets in the MKD. The test specification for radar displays require new graphical radar displays to be capable of displaying 'AIS targets' – however no definition of 'target' exist – and AIS AtoNs are not specifically mentioned. A similar situation exists for the ECDIS test standards. Is an AIS AtoNs an 'AIS target'? This is currently up to manufacturers to decide.

Questionnaire survey conducted near Drogden Channel

In this study, 137 vessels were asked a number of questions, that gave the following answers (the calculated percentages refer to the basis of 137 participating vessels):

8 Question: Do you have ECDIS or Electronic charts on your ship?	Abs.	Pct.
ECDIS	37	27%
Electronic charts	57	42%
None	41	30%

9 Question: Is your AIS data being displayed on your ECDIS/Electronic charts?	Abs.	Pct.
Yes	82	60%
No	40	29%

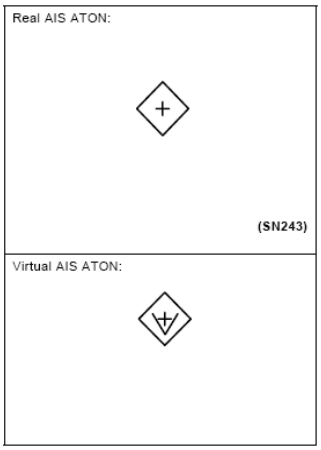
10 Question: Can you see the four virtual AIS markers between Drogden Channel and Drogden Lighthouse at your AIS display?	Abs.	Pct.
Yes	57	70%
No	25	30%

Unfortunately, question 10 was not very specific regarding which type of 'AIS display' we were referring to – this could be AIS MKD, radar display with AIS, ECDIS or another electronic chart. We thus assume, that 30% were unable to detect the AIS AtoNs on *any* of their displays.

In conclusion – the studies above indicate, that if *mariners know what they are looking for*, up to 70% of them *may* be able to *detect* an AIS AtoN. Only 60% of vessels carry a graphical display capable of displaying AIS data, and an optimistic estimate based on the notes made by the pilots indicate that in the order of half of these (25-30% of all vessels) are capable of displaying AIS AtoNs on these graphical displays.

3.2 AIS AtoN symbology

Currently, IMO has only endorsed one symbol for display of an AIS AtoN, by Safety of Navigation circular 243.



AIS AtoN symbol(s), according to IMO SN243, and proposed change by IEC 62288

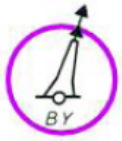
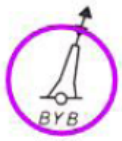
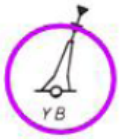
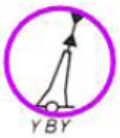
In recent developments, the IEC have proposed the introduction of a 'V' inside the diamond, to indicate if an AIS AtoN is a 'virtual' object, in conjunction with the development of IEC 62288 "Maritime navigation and radio communication equipment and systems . Presentation of navigation related information on ship borne navigational displays . General requirements . Methods of testing and required test results."

At DaMSA, we have elaborated the issue regarding symbology, and are of the opinion, that current AIS AtoN symbology lack the information content, which is currently available in charted AtoN symbology. An AIS AtoN message contains a type indication, identifying whether the AtoN object is a cardinal mark, a safe water mark, or something else – however, this is not reflected at all in current symbology. Symbols only indicate that this is an AIS AtoN, as opposed to a traditional AtoN. Displaying AIS symbols on top of charted symbols are likely to obscure the visibility of the charted symbol, and it is our observation, that mariners and VTS operators alike are not likely to manually select an AIS AtoN object, and perform user operations like clicking in menus, to determine the meaning of an AtoN object.

DaMSA proposal regarding symbols for virtual AIS AtoNs, that indicate the type of AtoN

DaMSA have therefore attempted to develop a proposal on symbology for AIS AtoN display, that aligns the symbology of virtual AIS AtoNs with the symbology used for traditional, physical AtoNs In electronic charts, with a doted outline and a 'v' next to the symbol.

Japan have proposed to the IMO MSC, that symbology for display of AIS AtoNs should be put on the work program of the IMO NAV subcommittee, and some developments in this field can thus be expected. The Japanese proposal introduces a symbology, very much in line with the observations and ideas of DaMSA, as illustrated below.

Fig No	Type of ATON		Real AIS-ATON		Virtual AIS-ATON	
			Floating	Fixed	Floating	Fixed
1	Cardinal Marks	North Cardinal Marks	 AIS	AIS	V-AIS	V-AIS
2		East Cardinal Marks	 AIS	AIS	V-AIS	V-AIS
3		South Cardinal Marks	 AIS	AIS	V-AIS	V-AIS
4		West Cardinal Marks	 AIS	AIS	V-AIS	V-AIS

AIS AtoN symbology proposed by Japan

The role of physical AIS AtoNs versus virtual AIS AtoNs needs to be considered, since AIS AtoN symbols are likely to be displayed as an overlay to existing symbols in an electronic chart. In other words, a physical AtoN, which is already charted, is likely to be displayed in electronic chart, with the AIS AtoN symbol as an overlay. In order not to obscure the view, this dual object presence needs to be taken into account. This is not only a display issue – there really ought to be a formal link between charted objects and the AIS AtoN signal, to enable the fusion of the two objects.

3.3 Other display issues

As pointed out in the section on *"Supplementary marking of Offshore Structures"*, there is a need to determine whether all, some og no AIS AtoN objects are relevant to be visible on a graphical display, depending on the zoom level, and possibly other factors. Electronic charts handle this by assigning objects to certain detail levels – and a similar mechanism is desirable for the ability to determine the relevant detail level for an AIS AtoN object.

As pointed out in the section on *"Virtual guiding AtoNs without creating an obstacle"*, in order not to obscure the visibility of other objects in a graphical chart display, it is desirable that additional information, like the name of an AIS AtoN or other relevant metadata, can be assigned a display position relative to the centre of an AIS AtoN object, just like the information associated with charted AtoN objects.

In conclusion, there may well be a need for a formal link between objects in electronic charts and an AIS (or other electronic) AtoN object – physical or virtual – in order to resolve such display issues, however this requires developments in nautical chart standards to be coordinated with the developments in AIS technology as well as display standards. This could well prove to be a challenge for the e-Navigation process – but might also open new potentials for the automated distribution of updates to objects in electronic nautical charts by electronic means, and making real time health status available for such objects.

4 Potential role of electronic AtoNs

At DaMSA, we foresee that AIS AtoN technology could be a useful tool for us as an AtoN provider, in the following contexts, if the issues of display technology, availability of graphical displays and recognition by mariners are all addressed:

4.1 Highlighting important existing physical AtoNs

Quite similar to the RACON, an AIS AtoN station or a synthetic AIS AtoN signal may be useful for highlighting important objects at a distance beyond visible and even Radar range.

AIS AtoN messages (and potentially future binary AIS messages) may further be utilized to carry additional information regarding equipment, health status or changes to such objects. The full benefit of these capabilities is less likely to be available to mariners, unless display standards support such features.

In particular, an AIS enhanced floating AtoN will be capable of alerting the fact that it may be off position, and AtoN administrations will have the capability of tracking the otherwise lost device.

4.2 Marking new or temporary objects

AIS AtoNs are in particular considered suitable for marking new or temporary objects, that are not charted yet – or to highlight objects of a temporary nature, when active.

Emergency Wreck Marking, damaged AtoNs that constitute an obstacle, floating debris are obvious examples of new dangers that can be rapidly marked or highlighted using virtual or physical AIS AtoNs. Other examples that might need to be temporarily highlighted might be working sites to be avoided, military practice areas etc.

4.3 Providing AtoNs without creating an obstruction

In many cases, AtoNs are deployed to mark grounding risks, which are only relevant to SOLAS vessels with a significant draught. Such AtoNs are not only expensive to maintain for AtoN providers, they also constitute an obstacle to vessels with a smaller draught. If performance standards were agreed upon, that would enable AtoN providers the ability to rely on SOLAS vessels having the capability to make use of AIS (or other electronic) AtoNs – such electronic AtoNs could be provided to the relevant vessels, without creating obstructions for others.

4.4 Providing AtoNs where physically difficult or particularly expensive

In certain cases, the establishment of physical AtoNs may be desirable, however it may be physically difficult, or particularly expensive, and for that reason unrealistic. Electronic AtoNs could well play a role in such an environment, making it safer and more cost efficient to navigate areas that would otherwise be unmarked.

One particular instance, where establishment of physical AtoNs are almost unrealistic, is in the polar regions of the globe. There is a growing realization, that the opening of Arctic waters to shipping transit between the Pacific and the Atlantic oceans may be imminent, as a result of climate change. This may create an opportunity for shipping to take the shorter route between the Pacific and the Atlantic across the arctic, saving both time and fuel. However providing Aids to Navigation in such regions is difficult and expensive.

The ability to supplement traditional physical AtoN technology with electronic (virtual) AtoNs may prove to be a feasible option for providing more cost effective and dynamic AtoN services, and thus enable safer and more efficient navigation in the area. However, with the current gaps in display requirements, symbology, and recognition by mariners, providing such a service will have little or no effect.

4.5 Providing waypoints?

Virtual electronic markers might be useful for providing suggested waypoints that could assist mariners in route planning or executing navigational maneuvers. Virtual waypoints might even provide flexibility in making the actual positions shift as a function of meteorological and hydrological parameters, thus providing an up to date guide on how to maneuver difficult passages under strong current or similar conditions.

5 Experience and related issues reported by other IALA members

At the recently held 6th session of IALA's e-Navigation committee (March 2009), a number of IALA members reported on their experiences with AIS AtoNs, and commented on the potential role of AIS AtoNs in the future.

5.1 eNAV6-19-28: Development of virtual AtoN systems, by the General Lighthouse Authorities

This paper informs of the GLA's plans for implementing the active use of virtual AtoNs. The GLA considers virtual AIS AtoNs "*one of the most significant technical developments for the GLA (and other maritime administrations) in the medium term. The main application of Virtual AtoNs in the short term would be warning of new hazards, such as wrecks, obstructions or floating debris. However, Virtual AtoNs could have other applications in the longer term, such as 'cats-eyes' marking the centre of 'motorways of the sea'*".

The GLA points out the need for risk analysis and management, in light of taking such new technologies into use. The paper notes the obvious advantages in the ability to rapid response to new dangers, but also debates the future possibility for replacing deep water AtoNs intended to guide SOLAS vessels only, and for marking particular safe water or danger areas or objects, without creating obstructions.

Technical constraints that prevent the technology from being mature are mentioned, such as the lack of reliable on board display equipment and short comings of display standards, and the need for defining reliable service areas for AIS infrastructure coverage.

5.2 eNAV6-19-01: IALA AtoN Attribute and Metadata Information Standard

In this document, AMSA proposed the development of an AtoN Attribute and Metadata Information Standard by IALA, and to ensure compatibility with IHO's S-57 and S-100 standards for electronic charts. This is a concrete proposal to develop the formal link between objects in nautical charts and AtoNs, their health status, equipment (RACON, AIS AtoN, …) as suggested above in the "*Observed Effects*" section of this document.

5.3 eNAV6-08-07: Working paper regarding the development of Maritime Information Systems

In the work underway in the MIS task group of IALA's e-Navigation committee, it has been stressed again and again, that " *Currently, the performance standards and operation of most ashore and ship borne equipment/systems have been developed independent of one another. As such, there is a need (or challenge) to describe how it will be possible to achieve the goal of e-Navigation:*

> *'the harmonized collection, integration, exchange, presentation, and analysis of marine information onboard and ashore by electronic means to enhance berth to berth navigation and related services, for safety and security at sea and protection of the marine environment.'* "

5.4 ANM12-Output-10: Draft guideline on the establishment of AIS as an AtoN

Also, IALA's ANM committee is considering the future of AIS as an AtoN technology. A guideline is being drafted by the committee, however the mandate of IALA only permits the committee to consider the provision of AIS based AtoNs, and not to consider the ship borne issues related. For this reason, the current draft only dwells on which services are currently *possible* to provide, and how.

5.5 eNAV6-08-02: 'Draft guideline on minimum comprehensive mix of AtoN in fairways, etc.'

This draft guideline is under development in the ANM committee, and notes AIS AtoN technology as a means to highlight particular AtoNs in confined areas, much similar to the RACON technology. The use of virtual AIS AtoNs is not yet mentioned.

6 'EfficienSea' – a testbed for e-Navigation

The European Union is supporting a regional project in the Baltic Sea, called 'EfficienSea'. The EfficienSea is a joint effort between 17 partners in the region, with DaMSA as the lead partner. One of the primary work packages of this project is targeted at gaining experience with promising developments within e-Navigation, by developing a number of test-bed regions. These test-beds are intended to be used by interested parties (shore based and ship based users, vessel owners and agents, authorities, manufacturers, service providers, etc.) to test promising technologies and concepts in the e-Navigation process, in order to gain early experiences with technological and practical opportunities and limitations, and to identify gaps between user needs and expectations, technologies under development, and the standards needed to support a coherent development.

At DaMSA, we believe that field trials is one of the most important mechanisms, when developing new technologies and concepts. The experiences reported in this report would not have been available to us, had we not attempted to use the AIS AtoN technology, even though we realize that the effect of the services provided is limited at present.

DaMSA and the EfficienSea project will publish relevant findings in the process, and encourage other interested parties to communicate their experiences as well, in order to make the most of the open window of opportunity, that is created by the e-Navigation process.

7 Discussion and Conclusions

AIS AtoNs have proven the ability to build flexible, cost effective AtoN services and provide safer and more efficient sea transport, however the lack of display capabilities and recognition of such services by mariners leave such services to be next to useless.

AIS AtoN technology - physical and virtual – is the first step into an electronic AtoN concept where other means of providing electronic AtoNs may evolve. We are now in the fortunate situation that the e-Navigation process over the next few years may benefit from the experiences drawn with virtual AIS AtoNs around the world, and we encourage all Aids to Navigation authorities and maritime users of such services to report their experiences.

7.1 Display capability and recognition by mariners is a prerequisite for a useful AtoN service

While AIS AtoNs in principle may be detected on an AIS class A stations MKD, it is our basic assumption, that AIS AtoNs are not really of much practical use, unless they can be displayed in a graphical radar or chart display – and this is where we're in a bit of a deadlock situation. The hen and the egg – which came first?

If only few can see an electronic AtoN service provided, Maritime Safety Administrations cannot rely on such services – and will thus not provide such services. Our very brief experience documents that we can only expect in the order of 25% of SOLAS vessels in our waters to have this capability. This doesn't provide a basis for extensively providing such a service.

However, if no one provides such a service, no one will build equipment that displays such services, and mariners will not recognize or be trained to recognize such services.

We hope that the e-Navigation strategy will get us out of this deadlock over the next few years, if we manage to clarify the future role of electronic AtoNs such as AIS AtoNs. With the role properly defined, and relevant gaps in technological means to provide such services, relevant symbology and display standards supporting the service may be developed, training programs for mariners may be developed – and the whole maritime domain may benefit from this opportunity to provide improved Aids to Navigation services.

7.2 AIS AtoN display symbology issues

Current symbols for AIS AtoNs do not express the meaning of an AtoN, leaving little usefulness for the object. Symbology needs to be developed, that reflects which type of AtoN, an AIS AtoN signal represents.

AIS AtoN Metadata (other information related to the object, such as Name of object or it's health status) can be signaled by AIS AtoNs – however means are needed to reflect this information in displays, and in order not to obscure the view of a graphical chart display, it should be possible to determine suitable location of such information, relative to the AtoN symbol.

7.3 AIS AtoNs in relation to charted objects

The needs to be able to associate AIS AtoN signals with a related object in an electronic nautical chart, calls for a coordinated means of providing a unique identifier in both electronic AtoN objects and electronic chart objects. This would enable a formal relationship to be identified, and create a bond between different representations of the same physical or virtual object.

7.4 Potential role of electronic AtoN technology

With Emergency Wreck Marking as the most obvious example, AIS technology has already proven to be a successful supplement to traditional AtoN technology, in terms of the ability to be deployed rapidly, and in terms of providing additional alerting services based on safety related text messaging.

We currently foresee that AIS or other electronic AtoNs will enhance existing Marine Aids to Navigation with a new highlighting technology, plus provide real time health status broadcast, that can be automatically incorporated in the electronic chart display. Virtual AtoN enable the rapid deployment of marking of new danges or temporary objects, that would otherwise have been left for the mariner to read about in navigational warnings.

Electronic AtoN technology may make new AtoNs available for some relevant users (for instance vessels with a draught above some particular level), while leaving other maritime users without additional 'noise' or an obstruction to take into account. In some instances, the relatively low cost of electronic AtoN technology compared to physical structures may allow otherwise unmarked objects to be highlighted. The provision of flexible waypoints, markers without obstructions, etc. holds the potential to move the maritime transport sector into a faster and more efficient

If means to create a formal bond between electronic AtoNs and electronic chart objects is developed, new means of providing automated updates to nautical charts and coherent distribution of health status information for marine Aids to Navigation objects may arise.

7.5 Do electronic AtoNs have a future in the e-Navigation era?

Yes, AIS and other electronic AtoNs hold a significant potential to the maritime domain, but the benefits will only be achieved, if coherent development, both in shore side services, and ship side equipment, technical standards and recognition by mariners are achieved.

8 Definitions

AIS AtoN

AIS used as an Aid to Navigation, as described in IALA recommendation A-126 "The use of the Automatic Identification System (AIS) in Marine Aids to Navigation Services".

AIS AtoN message / broadcast

Transmission of AIS message type 21, as described in ITU-R M.1371-3. This broadcast message contains the current position, name, type of AtoN, plus indicates whether the AtoN is on it's expected position or not. It can also carry basic health status information – i.e. whether or not the AtoN is equipped with lights/Racon, and whether or not these are failing.

Physical / real AIS AtoN

A "Real" AIS AtoN Station is a device located ON the physical AtoN, transmitting AIS message 21. (IALA A-126, section 4)

Synthetic AIS AtoN

For practical or economic reasons it may not be appropriate to fit an AIS transmitter to an AtoN. A "Synthetic AIS AtoN" is transmitted as a message 21 from an AIS Station that is located remotely from the AtoN. The AtoN physically exists and there may exist a communication link between the AIS Station and the AtoN.

(IALA A-126, section 4)

Virtual AIS AtoN

A "Virtual AIS AtoN" is transmitted as a Message 21 for an AtoN that does not physically exist. In this case the AIS AtoN symbol would appear on the display for a specified location, even though there is no physical AtoN. A nearby base station or AtoN station could broadcast this message. The flag in Message 21 would clearly identify this as a Virtual AIS AtoN.

(IALA A-126, section 4)

Chained AIS AtoN

A chain of AIS AtoN Stations allows for communication from an AIS Base Station to AIS AtoN Stations that are remotely located and unable to communicate directly with the Base Station. Encrypted messages are passed from station to station until the intended recipient is reached.

The concept requires an AIS AtoN Station to have knowledge of its neighboring AIS AtoN Stations. Each AIS AtoN Station in the chain must know the entire chain to prevent unnecessary retransmission of the messages. See IEC 62320-2 for further details on chaining of AIS AtoN Stations.

(IALA A-126, section 4)

AtoN meta data

Identity, type, position and other related information regarding an Aid to Navigation. Aids to Navigation authorities maintain information about AtoN in their domain. Some - but not all - of these information are available in Electronic Nautical Charts. Only some limited information can be conveyed by an AIS AtoN transmission (message type 21). AN AIS AtoN is uniquely identified by its MMSI (Maritime Mobile Service Identity) – however this key values currently do not correspond to related information available in Electronic Nautical Charts.

AIS safety related messages (AIS text transmission)

Short messages can be transmitted via AIS, using message type 12 (addressed) or 14 (broadcast) safety related text transmission, as described in ITU-R M.1371-3.