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The Automatic Identification System operating jointly with radar as the aid to navigation

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Abstract
The paper presents joint operation of AIS-AtoN and radar. There was brought forward a fact of divergence of the information visualized in radar in cases when AIS receivers are produced by different manufacturers. It happens that the AtoN AIS information is not displayed by radar screen. It is also essential that not every ship is provided with AIS equipment; therefore the users cannot always fully take advantage of AtoN AIS in respect of functionality.

Introduction

The Automatic Identification System (AIS), an autonomous broadcast system designed and popularized at the turn of the 21st century, was implemented to enhance navigational safety. It was designed as a tool to facilitate identification of vessels via exchange of identification data and to aid the planning of anti-collision manoeuvres. It also supports the functioning of maritime traffic systems by complementing data of particular influence on the safety of navigation vessel to vessel, vessel to coastal station, coastal station to vessel. AIS – type devices include:

- class A designed for SOLAS – convention vessels;
- class B designed for non-convention vessels;
- base stations;
- simplex and duplex AIS relay devices;
- derived from class A devices installed on a navigation mark, the so-called AtoN AIS (AtoN – *Aids to Navigation*) [1].

Aid to navigation (AtoN) is any external device for a vessel, whose task is to assist in indicating its position, warning about danger or obstruction. Typical structures helpful in maritime navigation are, among others, lighthouses, beacons, buoys, etc. AIS as an aid to navigation (AtoN) provides information which facilitates the identification of navigation signs in any weather conditions. Additionally, it complements the already existing signals transmitted by navigation marks and missing marking on a body of water, using a synthetic and virtual AtoN AIS where installation of a physical AtoN is technically difficult or impossible [2]. This article refers only to the AIS system installed on navigation marks. Further in the article, the term AISAtoN will be used to define it.

One of the main elements of the AIS system are AIS coastal stations. They receive signals from transponder-equipped vessels (both class A and B) to enable their identification and the reading of static and dynamic parameters. They are connected to form extensive nets in order to facilitate exchange of information and to deliver it to central databases. Incorporating AIS AtoN into this system allows additional delivery of information in the interests of navigational safety, not only for vessel identification. Such comprehensive information makes it possible to conduct an analysis of fixed and floating structures, and to plan the functioning and expansion of the AtoN system. There are three kinds of AIS AtoN devices:

– real AIS AtoN;
– synthetic AIS AtoN;
– virtual AIS AtoN.

A real sign is physically located on the water and the AIS device is installed on it. In the case of

the synthetic AtoN, information is transmitted to the coastal station which sends it to other system users. The virtual AIS AtoN does not physically exist and information about it is transmitted by coastal stations. It is used for marking hazards to navigation, where a more permanent AtoN has not been established yet or establishing it is, for various reasons, uneconomical [1].

AIS devices fitted on AtoN, apart from identification, provide information and data which enhance the level of services offered by the existing AtoN, such as real heights of tides and the local weather conditions in the vicinity of the AtoN. For monitoring floating AtoN their position is obtained from an electronic positioning system indicated by a GPS receiver (e.g. RTK GNSS) or a position from "the guar zone" if the AtoN goes beyond that zone. Additionally, in real time the device conducts diagnostics and sends the information to the system to monitor the system's efficiency and performance. It is transmitted as a Message Type 21 (Message 21 – AtoN report). In case of damage, change of position (e.g. due to floating) or lack of lighting at night, AtoN could pose a hazard for safe navigation and therefore, an additional navigation warning should be generated as message 12 (Message 12 – Addressed safety related message) containing information on the status of the AtoN in a given body of water.

Using AIS to aid navigation is very significant, so ITU depicted the AIS message 21 for the exclusive use with AtoN, which does not mean that other messages can be used for AtoN. The primary purpose of using AIS AtoN is to enhance safety of navigation via the following activities [2]:

- identification of AtoN irrespective of weather conditions and its display on AIS receivers and electronic maps;
- complementing existing navigational information;
- transmitting accurate position of floating AtoN and indicating whether a floating AtoN is off position;
- marking or delineating tracks, routes, areas, limits or offshore structures (e.g. wind turbines and oil platforms);
- providing hydrometeorological information from connected sensors.

AIS AtoN messages can be generated based on information acquired from AIS installed on AtoN. The device then sends a message about AtoN identification, weather conditions and sea state. It delivers messages from other AIS AtoN devices for monitoring purposes and transmits information on synthetic and virtual AIS AtoN which, for reasons practical or economical, are not always physically used on AtoN. A synthetic AtoN is composed of a GNSS receiver, a central processing unit and a packet radio or GSM placed on the AtoN. The data is sent to coastal stations where it is converted into AIS format and transmitted to other devices which view this data as if it came from an AIS device on AtoN. On an ECDIS graphic display presentation there should be an AtoN and the coastal station transmitting messages from this AtoN.

On AIS AtoN nautical charts it is indicated by a magenta circle surrounding the existing AtoN symbol and an adjacent legend stating AIS. The font will be upright for a fixed AtoN and italic for a floating AtoN. To indicate a virtual AIS AtoN, there will be a V-AIS next to the symbol, which is shown in figure 1 [3].

Fig. 1. AIS AtoN symbols shown on paper maps [own study]

Symbols displayed on all shipborne navigational systems and equipment are defined in IMO resolution [4] (Fig. 2).

Fig. 2. AIS AtoN symbols displayed on all shipborne navigational systems and equipment [own study]: a) AIS Based AtoN, Real Position of Charted Object, b) AIS Based AtoN, Virtual position

AIS as an aid in navigation cooperating with radar

One has to bear in mind that not all vessels are equipped with AIS devices, as stipulated by the SOLAS Convention, which specifies which vessels should be outfitted with AIS devices (SOLAS, Chapter V, Rule 19) [5]. Depending on the devices the vessel is equipped with, AIS information can be not displayed at all (class B AIS devices) or can be shown on a display (class A AIS devices) and on an electronic map or radar. Users who do not possess ECDIS or radar will not be able to fully avail themselves of AIS AtoN's functionality. There are also differences in information display on ECDIS and radar, depending on producers. Radar is the primary navigation device used by a watch officer while manoeuvring a vessel and with low visibility it is his only "eyes". With norm PKN-IEC / PAS

Fig. 3. Radar echo of the DRAUGEN oil platform [own study]

60936-5, which is a translation of the English version of the international technical specification IEC/PAS 60936-5:2003, Poland presents a minimal, advised part of AIS information – a section of message 1, 2 (AIS class A) and optionally 18 and 19 (AIS class B) – which can be introduced in radar of own vessel to be presented in graphic or alphanumeric form.

Depending on producers of the devices, not all information from AIS is displayed on radar. Figure 3 shows a radar image where one can see an echo of the DRAUGEN oil platform in the Norwegian Sea – target No. 13. An AIS receiver indicates the structure as AtoN (Fig. 4).

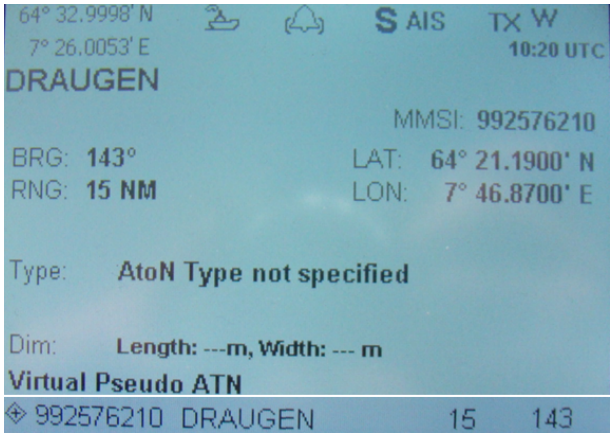

Fig. 4. Information about the DRAUGEN platform on display of AIS receiver [own study]

As can be observed on the radar's screen, the information about the structure is displayed as radar echo, despite the fact that the AIS display function is switched on. The AIS graphic mark is not shown. A similar situation can be seen in the next two figures (Figs 5 and 6) with echoes from the oil platform and the vessel NORMAND MERMAID moored by the platform. The figures show AIS information from this vessel and the one under way in the direction of the oil platform of vessel ESVAGT DON.

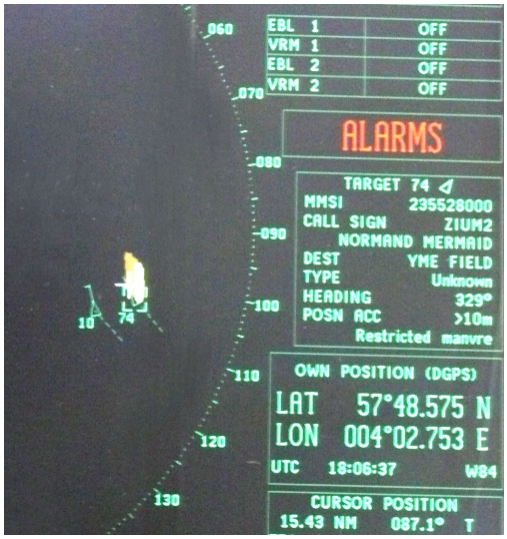

Fig. 5. Display of information from NORMAND MERMAID [own study]

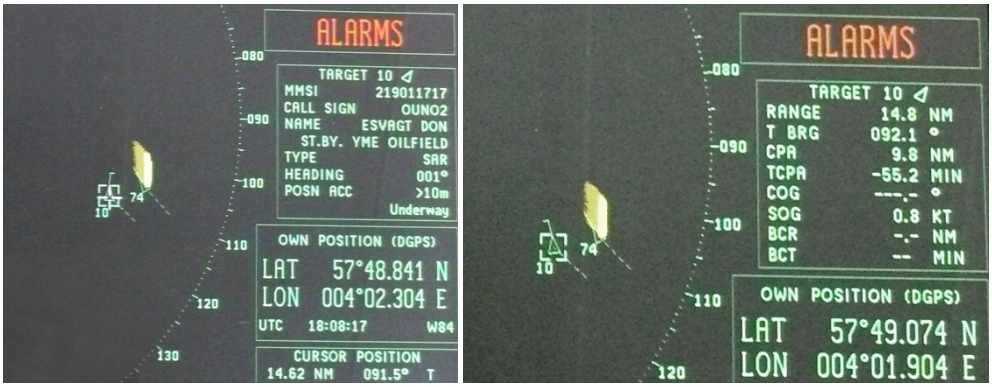

Fig. 6. Display of information from ESVAGT DON [own study]

On the display of AIS receiver and on the electronic map we receive information about additional AtoN which show oil platforms in the North Sea (Figs 7 and 8], whereas the radar does not display this information. Fixed marine structures such as wind turbines and oil and gas platforms are considered to be hazardous for navigation, so according to the authors it is vitally important to include information about them in the AIS AtoN system.

The figures that follow (Figs 9, 10, 11) show yet another example where the AIS system presents information about platform A6A as AtoN, whereas the indicator's screen shows echo from this structure – target No. 80, however, there is no graphic mark from the AIS system.

With the advancement of integrated navigation systems presenting, more often than not, information on multifunction indicators, emerging is a problem with excess of displayed information. Radar echo from a fixed structure, with AIS additionally placed on this structure, together with a graphic mark representing it on the map, provides

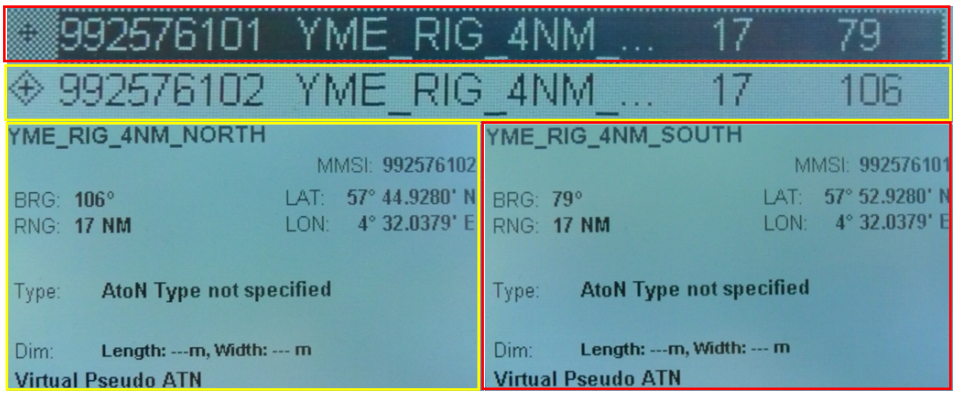

Fig. 7. Presentation of information about AtoN on the AIS receiver's display [own study]

Fig. 8. Presentation of information about AtoN on an electronic map [own study]

Fig. 9. Radar echo from oil platform A6A [own study]

Fig. 10. Presentation of information about platform A6A on the AIS receiver's display [own study]

three pieces of information representing the same structures. Simultaneous display of these pieces of information "clutters" the display. Hence the question – is there a need for filtering this information? Information about a given AtoN comes from three independent sources, so even if one of them malfunctions, the information will still be displayed.

In the case of virtual AIS AtoN, information is presented on an AIS and ECDIS display. Not all vessels are equipped with AIS class A receivers and electronic maps, which means that information about hazards such as submerged wrecks or floating rocks will not be delivered to the users of such vessels. Needless to say, radar indicators will not display the above-mentioned structures. In many cases where radar is the primary source of navigational information, the display of a graphic mark of such a virtual AIS AtoN on the screen of radar's indicator could warn the watch officer about any hazard.

Conclusions

Applying AIS as an aid to navigation poses a valuable source of information not only about vessels, but also about any and all signs and marks which provide help in navigation, weather conditions and sea state in a given body of water. Incorporating AIS AtoN into one system makes it possible to monitor in real time and to deliver

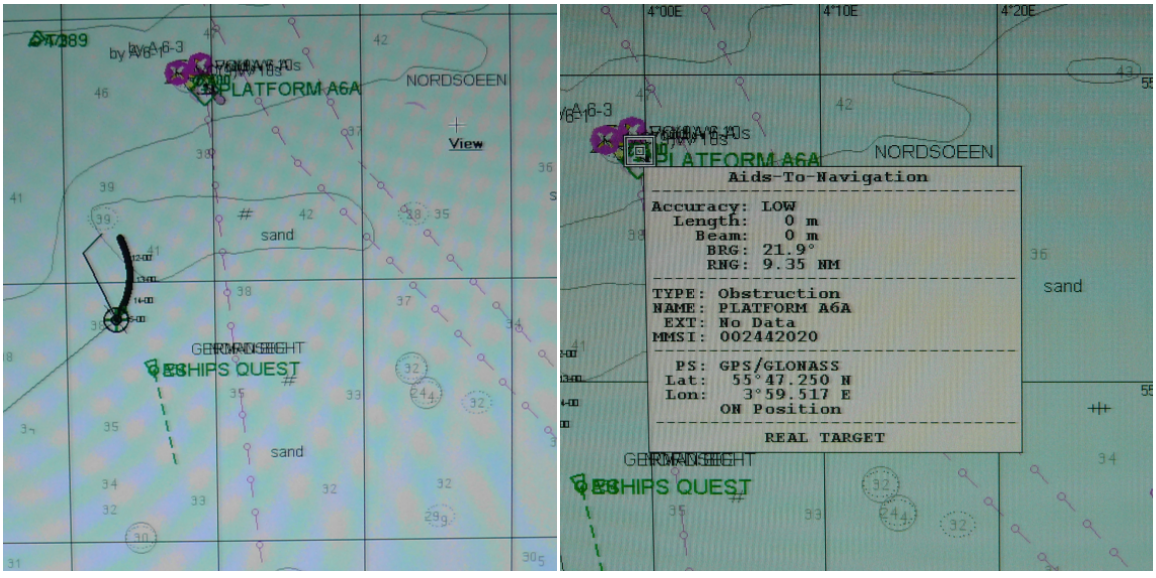

Fig. 11. Presentation of information about platform A6A on an electronic map [own study]

information indispensable for the safety of navigation and constitutes within AIS a new source of data, not only about vessels. Thanks to GNSS positioning, using AIS AtoN provides navigators with accurate information about signs and marks.

Currently the SOLAS convention specifies which vessels have to be fitted with AIS. Many vessels do not possess devices in which a user might make full use of the received information, about the situation around the vessel, and thus AIS is considered to be an additional source of information with regard to information acquired from radars or observation. Moreover, indicators of different producers present varied information or present it in various ways, which may lead to lacks of vitally important information in the sense of navigational safety.

Increasing the number of vessels equipped with AIS and widespread use of AIS AtoN should lead to the modernisation of devices and inter-device information transfer.

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