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THE IMPLEMENTATION OF AIS TECHNOLOGY FOR THE EXCHANGE OF INFORMATION AT SEA

The paper presents a system of information exchange between ships by means of AIS on the basis of utilisation of CNS VDL 6000 equipment installed on Gdynia Maritime University's vessel m/v Horyzont II. It describes the method by which data on the ship is conveyed and discusses the potential for exploitation of the system and also its limitations.

ZASTOSOWANIE TECHNIKI AIS W CELACH WYMIANY INFORMACJI NA OBSZARACH MORSKICH

W artykule opisano system wymiany informacji między statkami przy wykorzystaniu AIS w oparciu o eksploatację urządzenia zainstalowanego na statku Akademii Morskiej w Gdyni – m/v „Horyzont II". Zawarto tu sposób informowania o danych statkowych, możliwości eksploatacyjne i ograniczenia systemu.

1. BASIC INFORMATION ABOUT AIS

The aims of the Universal Shipborne Automatic Identification System, abbreviated to AIS, are to send automatic reports from ship to ship, from ship to shore and from shore to ship (Fig.1) and to display, by means of coefficients and specially created software, information on the following[6]:

- vessels and marine objects: identification (ship's identity, type), degree of privilege according to the criteria of the 1972 International Regulations for Preventing Collisions at Sea (navigational status), parameters for current geographical position and movement (position, course, speed) the number of persons aboard, the existence of dangerous goods and their nature (safety-related information)
- essential information for navigational safety such as local navigational warnings
- essential information for Vessel Traffic Services (VTS): messages involving VTS and visual objects as well as information on the operational working of navigational markers and an evaluation of the risk of collision in the area covered

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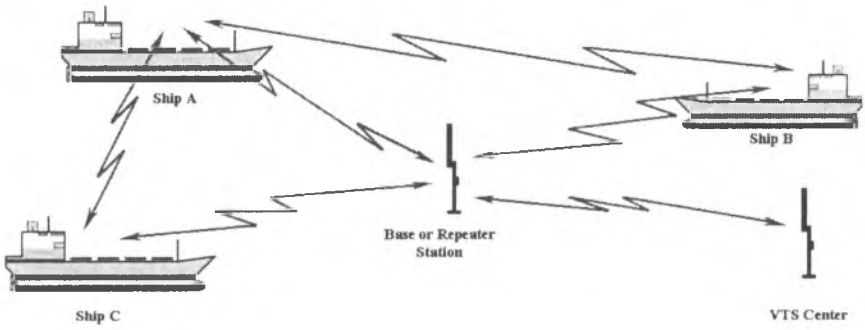

Fig.1. A diagrammatic representation of the information exchange process using the AIS technique

The AIS concept is based upon automatic data exchange between ships and between ships and shore stations. Information is sent over an advanced digital VHF data link, where each AIS station gets its own time slot(s) for the transmission of data. This means that each one of the stations can receive information transmitted from the others without transmission conflicts. The capacity of the data link can theoretically handle several thousand AIS stations within VHF radio range of each other at the same time and without overload [1].

AIS is to be operated in accordance with the guidelines adopted by the International Maritime Organization. Ships fitted with AIS must maintain it in operation at all times, except where international agreements, rules or standards provide for the protection of navigational information. AIS devices are to be installed on [3]: ships, coasts as base and repeater stations, in centres of Vessel Traffic Service, in Search and Rescue sea and air craft, navigational markers.

Two types of shipborne AIS can be distinguished [6]:

- Class A – designed for all seagoing vessels covered by the SOLAS convention and the IMO AIS carriage requirement
- Class B – intended for non-SOLAS vessels such as those in domestic traffic, smaller ships, fishing boats and pleasure craft.

The core unit for shipborne AIS operation, which is defined by international standards, is the AIS transponder. The transponder consists of the following main parts:

- A VHF transceiver for radio communication
- An embedded computer to handle the information exchange
- A GNSS receiver for synchronisation
- An AIS Class A system also requires a Minimum Keyboard and Display – MKD unit to provide basic control and display functions

2. THE AIS SYSTEM INSTALLED ON *M/V HORYZONT II*

Gdynia Maritime University's vessel m/v *Horyzont II* is used for training students and also for conducting maritime research. As in the former capacity she belongs to the fleet of the Republic of Poland, she has been equipped with Class A AIS. The CNS VDL 6000 AIS equipment was purchased and installed by the firm ENAMOR under Certificate No. TC/013/880700/98. The classification review was performed by the Polish Register of Shipping, Gdynia. The inspection showed that the equipment was compatible with international specifications for equipment, software and records. It also confirmed that the AIS equipment installed was fully efficient and ready for use.

2.1. DETAILS OF THE CNS VDL 6000 AIS SYSTEM

The CNS VDL 6000 AIS consists of (Figure 2 & 3):

- Class A AIS transponder - *VDL 6000 Transponder*, the radio modem and the GPS receiver
- Minimum Keyboard and Display - the MKD Unit
- Connection Unit connected to the power source, Pilot/AUX, External Display, ship's Sensors and also the Long Range Unit
- GNSS antenna
- VHF antenna.

Both interfaces, the external display and the mobile computer (for pilot service), are required according to the SOLAS Convention as the Presentation Interface (PI) for Class A AIS systems.

Fig.2. MKD Unit, Connection Unit and VDL 6000 Transponder in the CNS VDL 6000 AIS system

2.2. TRANSFER OF DATA THROUGH THE CNS VDL 6000 AIS EQUIPMENT

The information distributed in the AIS network is, to a large extent, standardised but AIS also offers the opportunity to exchange free text messages or virtually any information that can be digitalised, provided that the corresponding functionality is available on board or at a shore station. The information distributed between ships gives significantly improved situation awareness when AIS data are correlated with information provided by, for example, radar, and integrated into the ship's Electronic Chart Display and Information System. The communication between ships and shore stations not only gives a shore authority, a VTS or other ground-based party real-time awareness of the ship's movements, but also offers services to the ships themselves. This could include the distribution of Automatic Radar Plotting Aids (ARPA) targets, weather information and aids to navigation data.

Shore stations that are remotely located can also be connected to a network of regionally and centrally placed operations or management centres, offering great flexibility and capacity. Depending on the required functionality, customer-specific application software can be developed. The information distributed between the AIS stations is currently based upon a set of 22 different message types defined by the standard. The definition of message types is an on-going process, and it can be assumed that new types will be added in the future

The overall AIS operation is divided into the following operational modes:

- autonomous and continuous mode – automatic broadcast transmissions without any external control (although the mode as such may be set by a "competent authority")
- assigned mode – transmission intervals and/or allocation of time slots are controlled by a competent authority
- polled or interrogated mode – transmission occurs in response to interrogation from a ship or competent authority

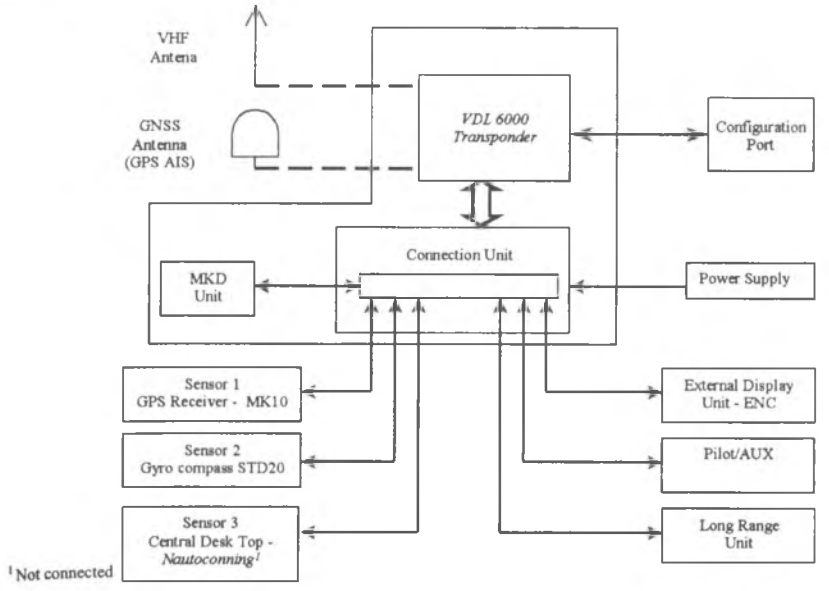

Fig.3. Installation scheme of the CNS VDL 6000 AIS system [1]

2.3. EXPLOITATION OF THE SYSTEM ON BOARD M/V *HORYZONT II*

The CNS VDL 6000 system installed on m/v *Horyzont II* is Class A AIS equipment conforming to international norms. Information sent can be classified as follows [9,10]:

➢ **Static information**:

Identification data: MMSI number – 261208000, IMO number – 009231925, Name – Horyzont II, Radio call sign – SPGN, Dimensions of ship (overall length – 56.34 m, width beam – 11.36 m), Type of ship – defined by a two digit code – No. 99, Location of the position fixing antenna (the position of the shipborne external GNSS receiver antenna connected to the AIS in relation to the centre of symmetry of the ship): A – 21; B – 35; C – 12; D – 0, Height over keel – 21,75 m.

Static information is entered into the AIS Transponder at the installation of the unit and should normally not be changed, unless, for example, the ship changes its name, MMSI number, IMO number or radio call-sign, is rebuilt so as to change its basic dimensions or the position of the GNSS antenna is changed. The information is protected from unauthorised access. Static information is broadcast every 6 minutes or at the request of a competent authority.

➢ **Dynamic information**:

- Ship's geographical position received from the shipborne receiver set connected to the AIS (external GNSS) together with accuracy indication and integrity status (exactitude above or less then 10 metres)
- Position Time stamp in UTC from the internal GNSS receiver, a component of the AIS
- Current course over ground (COG) and speed over ground (SOG) values calculated through the shipborne GNSS receiver

- Heading from the gyro-compass
- Navigational status entered manually by the crew according to the International Regulations for Preventing Collisions at Sea, 1972. Ship's navigational status: 00 – Underway using engine, 01 – At anchor, 02 – Not under command, 03 – Restricted maneuverability, 04 – Constrained by her draught, 05 – Moored, 06 – Aground, 07 – Engaged in fishing, 08 – Under way by sailing, 09 – High speed craft, 10 – Wing in ground – hydrofoil, 11–15 – Reserved for future use
- Rate of turn (ROT)

A responsible member of the crew should enter and check the current navigational status and ensure that the geographical position is entered with reference to WGS-84. Positional data are automatically updated from the ship's sensors connected to the AIS transponder. This information is broadcast with an update rate ranging from 2 seconds to 3 minutes depending on the current speed and course alteration.

➢ **Voyage-related information**:

- Vessel's current draught
- Details of any hazardous cargo transported (type of dangerous goods, harmful substances or marine pollutants; IMO classification)
- Destination and estimated time of arrival
- Number of persons on board, including crew

Voyage-related information is entered manually and updated during the voyage. The information is broadcast every 6 minutes, when data is amended, or at the request of a competent authority.

➢ **Short safety messages**

Short safety information can include up to 126 signs, related to safety or important navigational or hydro -meteorological warnings. This information can be sent to a particular ship, group of ships or to all ships in an area of sea. This information is entered and then transmitted on demand.

2.4. UTILISATION OF AIS OPERATION IN NAVIGATION ON BOARD M/V *HORYZONT II*

Data is displayed on the MKD panel in 4-line form, consisting of a title line and 3 operating lines. The identification of radar objects during navigation is the most frequently used option on the MKD of the AIS. Objects can be presented on the display as sorted data, so that the closest aims are displayed first. After identification of AIS/Radar objects such as ships, SAR ships, land objects, base stations or navigational marks, the MKD enables more accurate and up-to-date data to be obtained.

All AIS items display the following information: Name, Number MMSI, Object position (Latitude, Longitude) Positional accuracy indication (High, near exactitude of position < 10m, Low, near exactitude of position > 10m).

Additionally, depending on the AIS equipment used, the following information may be displayed:

Items of **Class A AIS** status: Radio call sign, IMO number, Course over ground – COG, Speed over ground – SOG, Heading – HDG, Rate of turn – ROT, Navigational status, Type of vessel, Dimensions, Estimated time of arrival, Destination, Presence of MKD, Draught.

Objects of **Class B AIS** status: COG, SOG, HDG, Type of vessel, Dimensions, Type of MKD.

Base stations: No additional information. The base is usually laid on land stations with the possibility of synchronisation with an AIS station within range of the base station.

Navigational marks – Aids to navigation: Aid to navigation type (0 = not available = default, 0 - 15 = fixed aid to navigation, 16 - 31 = floating aid to navigation), Virtual flags, Dimension, Off position indicator.

The navigation officer's most frequent questions (on the basis of personal observation on voyages) to the AIS during navigational operations are for information about: Data for the identification of a radar object: name of object, call-signal, IMO number, MMSI number; Prevention of collision: monitor bearings and range changes; Movement parameters: COG, SOG, HDG, ROT; Navigational status, type of vessel; Destination.

2.5. AIS DATA PRESENTATION ON ELECTRONIC NAVIGATIONAL CHART ON M/V HORYZONT *II*

The CNS VDL 6000 AIS on m/v *Horyzont II* is connected to an external display as a Transas Marine Electronic Navigational Chart (ENC) *NaviSailor 2000* – Figure 4.

Data signals from the AIS transmit information about observed objects to a computer and this can then be displayed on the ENC screen. It is possible through the AIS to present data graphically and to display identifying features (MMSI number, IMO number, radio call-sign and name) and movement parameters (course, speed over ground vector and heading).

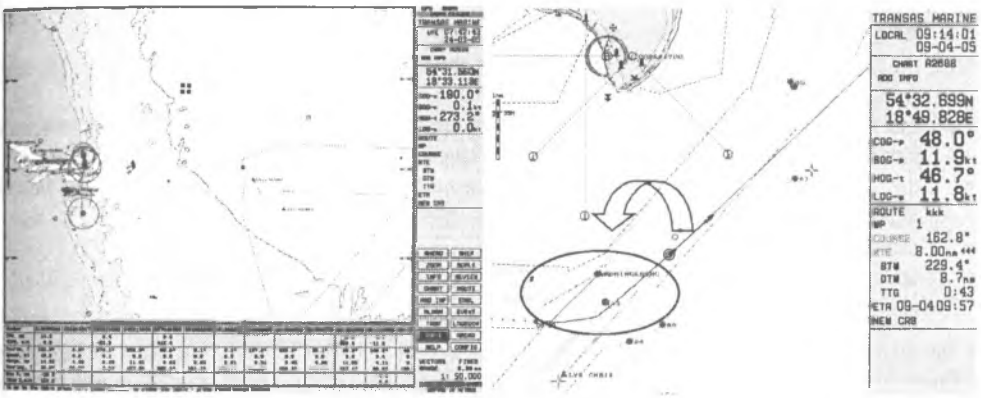

Fig.4. AIS data presentation on Transas Marine's ENC *NaviSailor 2000*. The ARPA & AIS object movement vector on the ENC (no fusion available)

Simultaneously, information about objects being traced is transferred from ARPA to computer equipment (video-radar information is not available at this stage of the ENC). All data (AIS & ARPA) are presented in the ENC's submenu – ARPA. The graphic display of ARPA and AIS differs only in terminology – the ARPA objects are represented as A1, A2, A3, while the AIS objects are presented according to the option chosen earlier – MMSI number (9 figures), IMO number (9 figures), ship's name and radio call-sign. The information is presented on the ENC display as layers, an ARPA layer and an AIS layer (see Figure 10). The result of superimposing these layers is chaotically presented information. When detailed

information about an object is activated on the ENC (observed on both ARPA & AIS), the data displayed are those from ARPA. The solution to this problem is for the object not to be observed on the ARPA equipment as it creates a risk of information misunderstood and could even lead to danger or collision. An alternative solution is to trace the movement parameters of objects on the ARPA objects schedule on the ENC, where information about objects is arranged in alphabetical order (ARPA object first and, then AIS objects followed by MMSI numbers). There is no possibility of change to the presented information on the ARPA schedule, for example by sorting data on an object by distance, bearing, name, IMO numbers or radio call-sign.

During exploitation of the AIS system on m/v *Horyzont II* the present author observed a number of functional imperfections in data presentation on the MKD CNS VDL 6000 AIS when used for navigational purposes. These failings included:

- lack of a facility to sort AIS objects according to name, MMSI number and IMO number
- lack of a facility to find a data object when there are many objects in the vicinity
- lack of a facility to display graphically data on objects and own vessel
- lack of a facility to control the accuracy of information sent through the AIS.

Functional imperfections of AIS data presentation on the ENC include:

- the fact that detailed information only contains data on an object's anti-collision parameters: CPA, TCPA, CRS, SPD, RNG and BRG. There are gaps in the descriptive and classification data on an object (static and some dynamic data);
- difficulty in distinguishing the readings for detailed information on movement parameters of AIS objects from those of ARPA/Radar objects on an ENC, AIS and ARPA data often being overlaid.
- the impossibility of viewing simultaneously detailed information on two (or several) AIS objects;
- the impossibility of distinguishing AIS objects in a schedule as it is difficult to locate particular objects on the schedule when there are many AIS objects in the vicinity;
- the absence of automatic or affected (manual) fusion of an object's movement vector data symbol from AIS and ARPA(Radar)
- lack of back-up for the graphic display of AIS data (only one external display)
- lack of the technical possibility to display AIS data on the ship's radar screens.

It has been established that many incidents occurring in coastal zones could be avoided, if dangerous objects are correctly identified or detected sufficiently quickly. AIS offers officers of watch the opportunity to obtain additional information about objects in the vicinity and to improve vessel control and navigational safety. It is of particular importance that thanks to AIS data an OOW can observe almost in real-time true changes in an object's movement parameters and can make the correct manoeuvres. Despite the apparent advantages in the introduction of the system, an OOW should still perform correct visual & radar observations because many vessels are not yet equipped with the AIS systems and some may not be so equipped in future (those that are not classed as conventional vessels). It is desirable for navigators that the AIS information display on shipborne equipment should increase its scope. This, however, should be linked to changes in software or even with the equipment itself (radar ARPAs) to be fully efficient, although the high cost of this may not make it feasible.

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