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AUTOMATIC IDENTIFICATION SYSTEM (AIS) AS A MAIN TOOL OF NCAGS ADP SYSTEMS

ABSTRACT

The modern Naval Co-operation and Guidance for Shipping Automated Data Processing (NCAGS ADP) systems obtain shipping information from different sources to have the most recent shipping picture in the area. Most of these systems use the AIS, because it is the mandatory tool for merchant ships to be equipped with, according to the new regulations of the International Maritime Organisation (IMO). So far, only merchants over 300 gross tonnage have to fit it on board, but the intention is to be installed on all 'sea-goers'. This mandatory tool gives NCAGS ADP systems all necessary data almost automatically in every few seconds. This article provides a short overview of the structure and capabilities of AIS.

INTRODUCTION

In recent years the shipping has come under increasing attention. The concerns are not only its safety and efficiency, prevention of and response to ship-caused pollution, but also the use of vessels for inimical purposes, ranging from simple law-breaking (such as smuggling) through the piracy to serving as a vehicle or target for terrorist acts. The AIS has been developed in response of these concerns. To keep an eye on the shipping, IMO has identified three functions of this system, which are:

- to serve as a collision-avoidance tool while the system is operating vessel-to-vessel mode;
- to provide the information about a vessel and its cargo to local authorities who oversee waterborne trade;
- to assist those authorities engaged in vessel traffic management.

THE AIS OVERVIEW

The AIS is a specific picture giving special information about shipping. It is a shipboard radar display, with overlaid electronic chart data, that includes a mark for every significant ship within radio range, each as desired with a velocity vector[1]. Each ship 'mark' could reflect the actual size of the ship, with position to Global Positioning System (GPS) or differential GPS accuracy. By 'clicking' on a ship mark, you could read the ship name, course and speed, classification, call sign, registration number (IMO number), Maritime Mobile Service Identity (MMSI)[2], and other information. Maneuvering information such as: Closest Point of Approach (CPA), Time to Closest Point of Approach (TCPA) and other navigation information, more accurate and more timely than information available from an automatic radar plotting aid, could also be available[3]. Display information previously available only to modern Vessel Traffic Service (VTS) operations centres could now be available to every AIS-equipped ship (Figure 1).

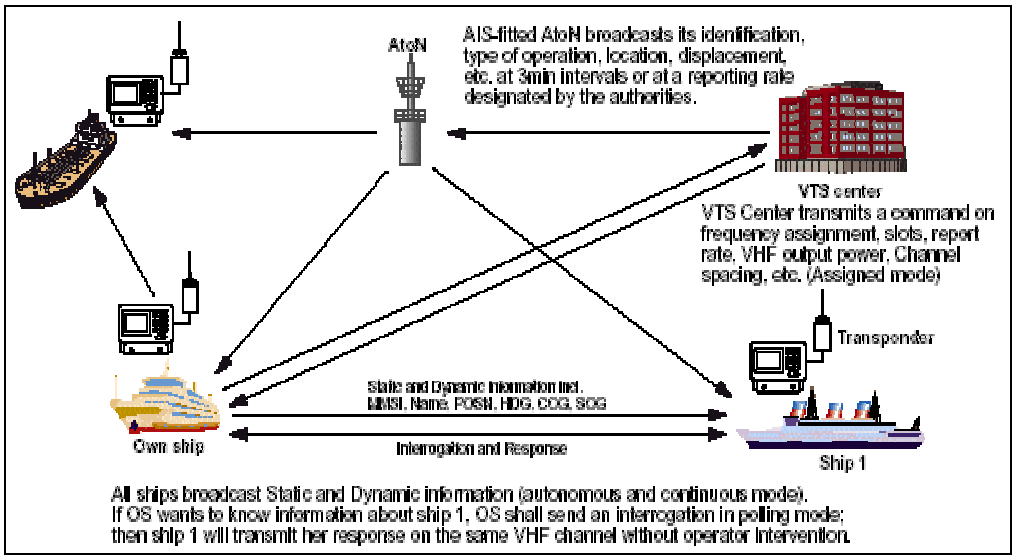

Fig. 1. AIS system information flow

Source: www.busse-yachtshop.de/pic/ais-system-grt.gif, 04.05.2007.

[1] It indicates speed and heading.

[2] MMSI are formed of a series of nine digits transmitted over the radio in order to uniquely identify ship stations, ship earth stations, coast stations, coast earth stations, and group calls.

[3] http://tide.act.nato.int/mediawiki/index.php - 22.03.2007.

Having this information, we could call any ship over Very High Frequency (VHF) radiotelephone by name, rather than by 'ship off my starboard' or some other imprecise means. We could dial it up directly using Global Maritime Distress and Safety System (GMDSS) equipment. We could send to the ship, or receive from it, short safety-related email messages.

The AIS is a shipboard broadcast system that acts like a transponder, operating in the VHF maritime band, that is capable of handling well over 4,500 reports per minute and updates as often as every 2 seconds. It uses Self-Organizing Time Division Multiple Access (SOTDMA) technology to meet this high broadcast rate and ensure reliable ship-to-ship operation[4].

BASIC TECHNICAL FEATURES

The AIS system consists of one VHF transmitter, two VHF Time Division Multiple Access (TDMA) receivers, one VHF Digital Selective Calling (DSC) receiver, and a standard marine electronic communications links[5] to shipboard display and sensor systems (Figure 2).

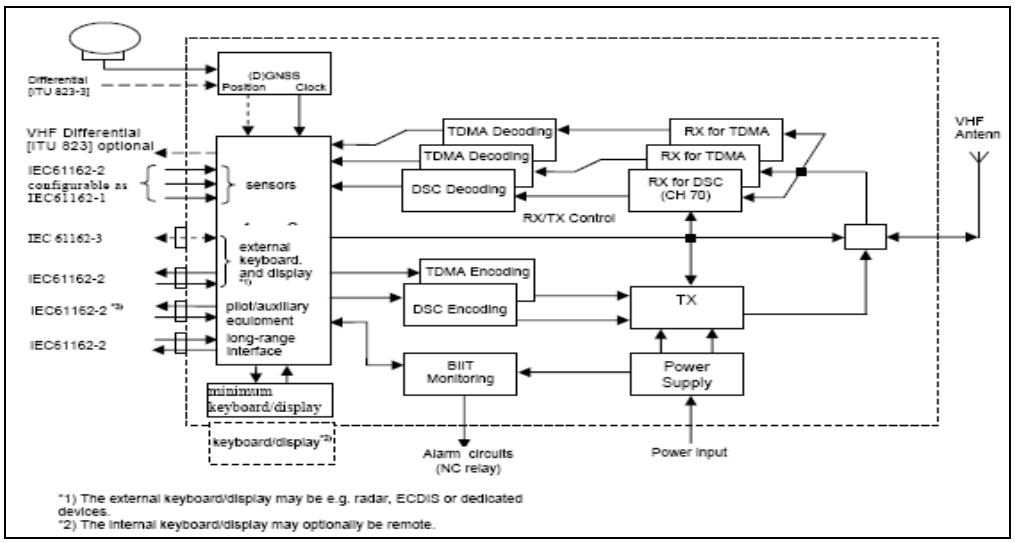

Fig. 2. AIS Schematic Diagram of Class 'A' Shipborne system

Source: www.navcen.uscg.gov/enav/ais/IALA_AIS_ClassA_Schematic.pdf, 04.05.2007.

[4] http://www.navcen.uscg.gov/enav/ais/default.htm, 04.05.2007.
[5] IEC 61162/NMEA 0183.

Position and timing information is normally derived from an integral or external Global Navigation Satellite System (GNSS) receiver (e.g. GPS), including a medium frequency differential GNSS receiver for precise position in coastal and inland waters. Other information broadcast by the AIS, if available, is electronically obtained from shipboard equipment through standard marine data connections. Heading information and course and speed over ground would normally be provided by all AIS-equipped ships. Other information, such as: rate of turn, angle of heel, pitch and roll, and destination and Estimated Time of Arrival (ETA) could also be provided.

The AIS transponder normally works in an autonomous and continuous mode, regardless of whether it is operating in the open seas or coastal or inland areas. Transmissions use 9,6 kb Gaussian Minimum Shift Keying (GMSK)[6] Frequency Modulation (FM)[7] over 25 or 12,5 kHz channels using High Level Data Link Control (HDLC)[8] packet protocols. Although only one radio channel is necessary, each station transmits and receives over two radio channels to avoid interference problems, and to allow channels to be shifted without communications loss from other ships. The system provides for automatic contention resolution between itself and other stations, and communications integrity is maintained even in overload situations.

Each station determines its own transmission schedule (slot), based upon data link traffic history and knowledge of future actions by other stations. A position report from one AIS station fits into one of 2250 time slots established every 60 seconds. AIS stations continuously synchronize themselves to each other, to avoid overlap of slot transmissions. Slot selection by an AIS station is randomized within a defined interval, and tagged with a random timeout of between 0 and 8 frames. When a station changes its slot assignment, it pre-announces both the new location and the timeout for that location. In this way new stations, including those stations which suddenly come within radio range close to other vessels, will always be received by those vessels (Figure 3).

[6] A kind of continuous phase frequency-shift keying.

[7] A form of modulation that represents information as variations in the instantaneous frequency of a carrier wave.

[8] A bit-oriented synchronous data link layer protocol developed by the International Organization for Standardization (ISO).

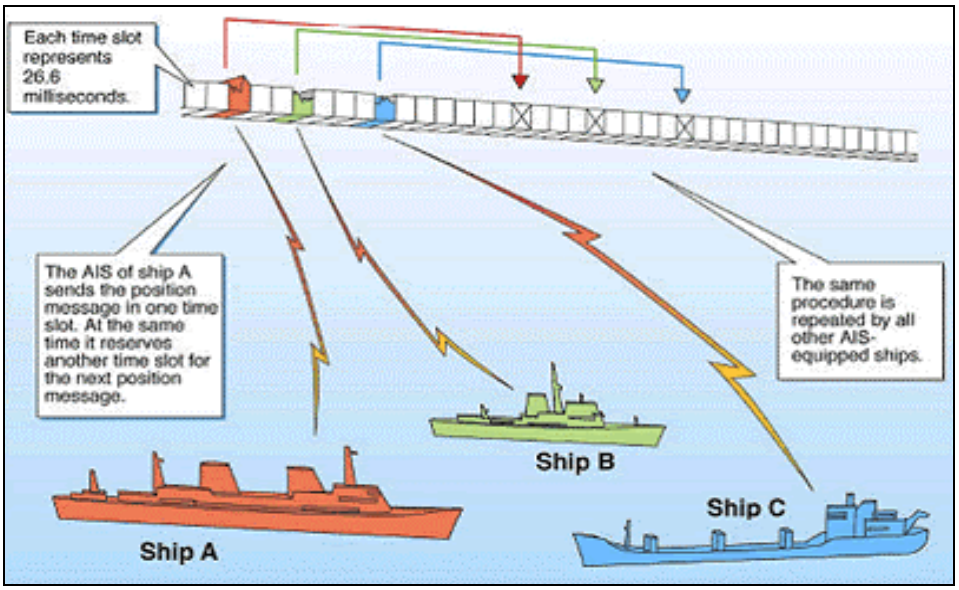

Fig. 3. Position reports in a transmission slots

Source: http://tide.act.nato.int/mediawiki/index.php, 22.03.2007.

The required ship reporting capacity according to the IMO performance standard amounts to a minimum of 2000 time slots per minute, though the system provides 4500 time slots per minute. The SOTDMA broadcast mode allows the system to be overloaded by 400 to 500% through sharing of slots, and still provide nearly 100% throughput for ships closer than 8 – 10 nautical miles (NM) to each other in a ship to ship mode. In the event of system overload, only targets further away will be subject to drop-out, in order to give preference to nearer targets that are a primary concern to ship operators. In practice, the capacity of the system is nearly unlimited, allowing for a great number of ships to be accommodated at the same time[9].

The system coverage range is similar to other VHF applications, essentially depending on the height of the antenna. Its propagation is slightly better than that of radar, due to the longer wavelength, so it is possible to 'see' around bends and behind islands if the land masses are not too high. A typical value to be expected at sea is nominally 20 nautical miles. With the help of repeater stations, the coverage for both ship and VTS stations can be improved considerably[10].

[9] http://tide.act.nato.int/mediawiki/index.php, 22.03.2007.
[10] http://www.navcen.uscg.gov/enav/ais/default.htm, 04.05.2007.

The system is backwards compatible with DSC systems, allowing shore-based GMDSS systems to inexpensively establish AIS operating channels and identify and track AIS-equipped vessels, and is intended to fully replace existing DSC-based transponder systems.

BROADCAST INFORMATION

A Class 'A' AIS unit broadcasts the following information every 2 – 10 seconds while underway, and every 3 minutes while at anchor at a power level of 12,5 watts. The information broadcast includes:

1) MMSI number – unique reference able identification;
2) Navigation status (as defined by the COLREGS[11] – not only are 'at anchor' and 'underway using engine' currently defined, but 'not under command' is also currently defined);
3) Rate of turn – right or left, 0 to 720 degrees per minute (input from rate-of-turn indicator);
4) Speed over the ground – 0,1 knot resolution from 0 to 102 knots;
5) Position accuracy – differential GPS or other and an indication if Receiver Autonomous Integrity Monitoring (RAIM) processing is being used;
6) Longitude – to 0,0001 minute and Latitude – to 0,0001 minute;
7) Course over the ground – relative to true north to 0,1 degree;
8) True Heading – 0 to 359 degrees derived from gyro input;
9) Time stamp – The universal time to nearest second that this information was generated.

In addition, the Class 'A' AIS unit broadcasts the following information every 6 minutes:

1) MMSI number – same unique identification used above, links the data above to described vessel;
2) IMO number – unique reference able identification (related to ship's construction);
3) Call sign – international radio call sign (IRCS) assigned to vessel, often used on voice radio;
4) Name – Name of ship, 20 characters are provided;

[11] The International Regulations for Avoiding Collisions at Sea or Rules of the Road.

5) Type of ship/cargo – there is a table of possibilities that are available;
6) Dimensions of ship – to nearest meter;
7) Location on ship where reference point for position reports is located;
8) Type of position fixing device – various options from differential GPS to undefined;
9) Draught of ship – 0,1 meter to 25,5 meters[12];
10) Destination – 20 characters are provided;
11) ETA at destination – month, day, hour, and minute in Coordinated Universal Time (UTC).

The Class 'B' is nearly identical to the Class 'A', except the Class 'B' limitations of information:

1) Has a reporting rate less than a Class 'A' (e.g. every 30 seconds when under 14 knots, as opposed to every 10 seconds for Class 'A');
2) Does not transmit the vessel's IMO number or IRCS;
3) Does not transmit ETA or destination;
4) Does not transmit navigational status;
5) Is only required to receive, not transmit, text safety messages;
6) Is only required to receive, not transmit, application identifiers (binary messages);
7) Does not transmit rate of turn information;
8) Does not transmit maximum present static draught.

CONCLUSIONS

In recent times the most important task for the NCAGSORG is to gain and sustain a recognised shipping picture. The AIS provides a continuous, comprehensive and useful picture. It is a reliable and accurate source. That is why AIS is treated as a main source of the shipping plot for NCAGSORG. All NCAGS ADP systems (NAMESIS, NSCIMA and BRITE) are 'AIS based'. Use of AIS gives some additional benefits – it allows for a reduction of ADP operators, providing automated updates and eliminating the risk of human error. However, there is at least one disadvantage of AIS – a possibility of switching off the transponder when the ship is under significant threat. It means that a picture is no longer available and NCAGS has to build a shipping plot using different methods.

[12] 'Air-draught' is not provided.

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[3] North Atlantic Treaty Organization, *ATP 2 (B)*, Vol. II, *Naval Co-operation and Guidance for Shipping Manual (NCAGS)*, *Guide to Owners, Operators, Masters and Officers*, December 2006.

[4] Svartefoss P., *Co-operation leads to harmony at sea*, ENVision, The magazine of Regional Headquarters East Atlantic & Headquarters Allied Naval Forces North, Northwood 2002, Vol. 1, No 2.

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STRESZCZENIE

Współczesne zautomatyzowane systemy przetwarzania danych NCAGS uzyskują informację o żegludze z różnych źródeł, aby pozyskać najbardziej aktualne zobrazowanie ruchu żeglugowego w rejonie. Większość tych systemów używa AIS, ponieważ zgodnie z nowymi regulacjami IMO jest on obowiązkowym systemem na wyposażeniu statków. Jak do tej pory tylko statki powyżej 300 ton muszą mieć wspomniany system, ale intencją IMO jest, aby każdy użytkownik morza posiadał takowy sprzęt. AIS daje zautomatyzowanym systemom przetwarzania danych NCAGS potrzebną informację automatycznie w ciągu kilku sekund. Artykuł przedstawia możliwości systemu AIS oraz jego parametry techniczne.

Recenzent prof. dr hab. Andrzej Makowski