**AIS and ARPA Navigation**

Exercise: AIS and ARPA Navigation

**Introduction:**

***Objective:***

The objective of this exercise is to familiarize participants with the principles and operation of Automatic Identification System (AIS) in cooperation with Automatic Radar Plotting Aid (ARPA) systems. Participants will gain practical skills in utilizing AIS and ARPA to enhance situational awareness, track targets, process data and make informed decisions for collision avoidance.

***Exercise Steps:***

* Introduction to AIS
* Overview of AIS and its role in modern maritime navigation.
* Explain the benefits of AIS, such as information exchanged, target plotting and tracking, collision avoidance features and improved situational awareness.
* Explain the functions and features of AIS systems, such as analyzing target data, target tracking and collision prediction.
* Familiarize participants with the various elements displayed on an AIS system, including static data, dynamic data and voyage-related data, target vectors and collision warning indication.
* Explain how to interpret target information provided by AIS, such as Static and Dynamic Data, Voyage-related Data and Safety messages.

***AIS and ARPA Operation and Settings:***

* Demonstrate the operation of an ARPA system, including system initialization, acquisition of radar targets, adjustment of display settings and trial manoeuvre.
* Discuss the importance of properly configuring ARPA settings, such as radar offset, target vectors, CPA and TCPA alarms in order to suit the operational requirements.

***Practical ARPA Exercises:***

* Utilize real or simulated radar data and ARPA systems or simulators to conduct practical exercises.
* Guide participants in using ARPA to track targets, determine target courses and speeds, CPA and TCPA, predict potential collisions and make informed navigational decisions.

***Collision Avoidance Strategies assisted by ARPA:***

* Discuss collision avoidance strategies using ARPA, including the utilization of International Regulations for Preventing Collisions at Sea (COLREGs).
* Present different collision scenarios and guide participants in using ARPA to assess the situation, calculate CPA and TCPA, evaluate risk of collision and take appropriate evasive actions.

**Theoretical Part:**

1. Designation and modes of operation

The Automatic Identification System, AIS has been introduced in shipping for solving the following basic problems:

* For exchange of navigation information between ships for avoiding collision;
* For transmitting data about the ship and its cargo to the land services;
* For transmitting navigational information from the ship to the coastal systems VTMIS for a more precise and reliable management of the traffic and of the search and rescue operations;
* For monitoring and tracking of vessels.

According to the requirements of the convention SOLAS (The Safety Of Life At Sea), Ch. V Reg. 19, AIS equipment Class A is mandatory for all vessels as per SOLAS after 31.12.2004:

* All ships over 300grt sailing in international waters;
* All cargo ships over 500grt even if they are not sailing in international waters;
* All passenger ships irrespective of tonnage.

The SOLAS Convention envisages possibilities for enforcing additional national and regional regulations for using the system by non-conventional vessels. For example, in the European Union the AIS is also mandatory for fishing vessels as well as for vessels sailing in the inland waterways. In the Republic of Turkey the use of AIS class B with a maximum power of the transmitter – 12W is mandatory and in Russia the AIS equipment must be compatible with the satellite navigation system GPS as well as with GLONASS.

According to SOLAS convention the shipborn AIS equipment must be able:

* To give the possibility to coast stations, stations of other ships and airplanes, possessing the required equipment, automatically to receive information including the identification and type of ship, its position, course and speed, its navigational status and other information related to the safety of shipping;
* Automatically to receive the information transmitted by the other ships which have AIS equipment (AIS-equipped ships);
* To allow monitoring and tracking of ships;
* To provide possibilities for data exchange with the coast services having the required equipment.

The graphical symbols used most often in the system AIS are shown in Table 1.

|  |  |
| --- | --- |
| **Symbol** | **Description** |
|  | **Active target: the vector of Speed Over Ground / Course Over Ground, SOG/COG is shown by a broken line starting from the center of the triangle. The compass course and the speed through the water are shown by a line from the point of the triangle** |
|  | **Active manoeuvering target: the turning speed is shown with a flag of a line, added to the line of the compass course. If the target is considered dangerous the triangle, the compass course and the flag of the turn must be bold or marked in red and must be flashing until confirmed.** |
|  | **It is possible to add a broken line for predicting the movement of the target during a manoeuvre** |
|  | **Fixed target: the triangle is inscribed in a rectangle drawn by a broken line** |
|  | **AIS target shown in real scale reduced drawing: The profile of the target is directed on the compass course and the position of the AIS symbol – on the location of the GPS aereal. It must be used only in small ranges (i.e. in scale 1:10000 and smaller).** |
|  | **Lost target: the position and orientation of the symbol are in accordance with the last received data. It remains on the screen until confirmed.** |
|  | **A-to-N AIS: Means for navigational provision (lighthouse, buoy, etc., aids to navigation) equipped with AIS: diamond with a + mark, shown in the place of aids to navigation.** |
|  | **AIS SART: Search and rescue transponder: a circle with + mark shown in the position of the distressed vessel.** |

***AIS operates in three different modes:***

**„*Ship-to-ship*“** – a basic mode of the system for enhancing the safety of shipping. In this mode each ship transmits to all other ships in the vicinity the information mentioned above. The updated messages are transmitted within a few seconds in order to maintain the data actual. A considerable advantage of the system for enhancing the safety of shipping is the possibility AIS to show the “invisible” for a radar observation targets in rough sea surface, strong rainfalls, as a result of interference or other limitations, as shown in Figure 1.

**„*Ship-to-shore*“** – in the territorial waters, coast services can install automatic AIS stations for monitoring the movement of ships in the area. Besides for observation these stations can be used for receiving additional information from ships, like type of cargo, destination, estimated time of arrival ETA, etc. The coast services use AIS for monitoring dangerous cargoes and for control of the commercial fishing in their territorial waters. The AIS information can be stored and replayed in accident investigations, oil spills or other events. AIS is also useful in organizing and conducting SAR operations at sea.

**„*Within the Vessel Traffic Management and Information Systems, VTMIS*”** – when integrated within the information systems for monitoring and control of the traffic of vessels, the AIS offers good possibilities for monitoring and control / management of the traffic in the area. The Automatic Identification System enriches the information from the radar surveillance providing a layer of the AIS data over the traffic picture. The system provides a continuous access to the navigational information in the area even in cases when due to some reason the radar picture deteriorates or is missing. In cases where the installation of coastal radars is not always possible (as for example with some off-shore VTS) the Automatic Identification System may be the only means of traffic surveillance. The communicative possibilities of AIS can be used for sending text messages to ships, which contain information about the ports, anchorages, tides, currents, ship agents, customs, pilot stations, etc. DGPS corrections as well as other information from the shore are also included in AIS reports.

A screenshot of a computer

Description automatically generated

а)

A close-up of a map

Description automatically generated

b)

Figure 2. Presenting static and dynamic AIS information (а) and b respectively) on the VTМIS operator’s display (from VTMIS simulator NaviHarbour)

The range of the system is limited by the radio waves propagation mechanism for VHF range – in Ship-to-Ship mode it does not exceed 20nm and at low power of the transponders – 15nm and in „Ship-to-Shore“ mode the range is up to 40nm on condition that the coastal areal is situated at a height of 100m.

The use of AIS from the point of view of the ships and watch-keeping officers on the bridge has the following advantages:

* Possibilities for improved presentation of a concrete situation;
* Eliminating the ambiguity in identification of the radar targets;
* Overcoming the problems resulting from swap of targets in the process of the radar tracking when the targets are situated too close to each other;
* The possibility to observe behind different structures which interfere with the radar surveillance in detecting and identification of other ships;
* Detecting the maneuver (the alteration in course and speed) undertaken by other ships in real time much earlier before the ARPA system has completed its estimations;
* Detecting ships hidden in the shadow of the other ships or by the heavy rain and sea clutters;
* Information about the movement of the other ships (speeding-up or delay, rate of turn, etc.) in real time.

The advantages in using AIS in the Vessel traffic management and information systems VTMIS by VTS operators are expressed in the following items:

* Automatic identification of the radar targets;
* Continuous surveillance in the cases when the radar display is worsened by rains, interferences, etc.
* Automatic recording of the situation in the appropriate electronic data bases.

The AIS system is not deprived of some disadvantages as well, the more important being:

* Conventional limitations (restrictions) – the installation of AIS equipment is not mandatory for ships below 300grt. The vessels without AIS transponder remain “invisible” for the system;
* Limitations in the area of operation – the AIS system works in the VHF range whose coverage is limited (restricted) up to the line of site;
* Limitations in the validity and quality of the exchanged information – depending on the experience and qualification of the crew and on the operational capabilities of the ship equipment, not only on own ship but also on all remaining vessels in the area;
* To affect considerably the improvement of safety of shipping, the ship AIS equipment must be integrated with the navigational system on the bridge.

**3. Types of information in AIS**

The information exchanged in the AIS system can be divided into four categories: Static Data, Dynamic Data, Voyage-related Data and information about safety of shipping – Safety-related Data.

*The Static Data* includes:

* Identification of the ship presented in 4 fields, namely:
  + Name;
  + Call Sign;
  + IMO number;
  + Maritime Mobile Service Identification number, MMSI
* Ship sizes (Length and Beam);
* Position of the receiving antenna of the navigational satellite system used (Position-fixing Antenna);
* Vessel Type.

To reduce the amount of the information exchanged the size of the ship and the location of the GPS antenna are presented by using four digits A, B, C and D in relation to the point in which the antenna of the positioning system has been installed (the so called Position-fixing point) as shown in Figure 4.

The static data is re-transmitted every 6 minutes.

A rectangular object with a line and a line

Description automatically generated with medium confidence

Figure 4. Presentation of static data about the size of the ship and the location of the GPS antenna with four digits (A, B, C and D)

The *Dynamic data* includes:

* Ship’s Position with Accuracy Indication;
* Universal Time Co-ordinated, UTC;
* Course Over Ground, COG;
* Speed Over Ground, SOG;
* Heading;
* Navigational Status;
* Rate Of Turn, ROT.

The dynamic data is updated at different time intervals depending on the speed with which the ship is proceeding and manoeuvring. The values are shown in Table 2.

Table 2

|  |  |
| --- | --- |
| **Dynamic conditions of ship** | **Interval** |
| **At anchor (speed below 3 kn** | **180 s (3 min)** |
| **Speed below 14kn, steady course** | **10s** |
| **Speed below 14kn, altering course** | **4s** |
| **Speed from 14 to 23kn, steady course** | **6s** |
| **Speed from 14 to 23kn, altering course** | **2s** |
| **Speed below 23kn, steady course** | **3s** |
| **Speed over 23kn, altering course** | **2s** |

The *Voyage-related data* includes:

* Draught;
* Hazardous/Dangerous cargo, Type;
* Destination and ETA;
* Route/Passage Plan.

The voyage data is transmitted every 6 minutes.

The *Safety-related Data* is entered in the form of a text message and is transmitted once at the discretion of the Master of the ship. Every text message can be addressed to a definite station or broadcasted to all stations.

**Discussion**:

What is the designation and modes of operation of Automatic Identification System AIS?

Describe the signals and tele-communication protocol SOTDMA used by AIS.

What is the coverage range of AIS in different modes of operation?

State various AIS data types and their reporting intervals.

How many types of shipborne AIS equipment do you know? What types of vessels are they for?

Describe the information, provided in addition by the coastal AIS stations included in the VTS.

How many peace of AIS SART must a ship of 30000 gt be provided with?

Address any remaining questions or concerns raised by participants.

**Scenario AIS and ARPA Navigation**:

Exercise description:

Use of Radar/ARPA and AIS typically includes the following steps:

1. Set up the radar display and adjust the settings for optimal performance.
2. Identify the targets on the radar display and activate ARPA tracking for each target.
3. Monitor the target's speed, course, and closest point of approach (CPA) in regard to the own ship.
4. Use the information provided by ARPA to make course and speed adjustments to avoid collisions and maintain safe navigation.
5. Continuously monitor the targets and adjust own course and speed as necessary.
6. Set up the AIS and adjust the settings for optimal performance.
7. Switch on AIS and use its capability to obtain additional target information.
8. Blending Radar/ARPA and AIS information to better evaluate the situation, to enhance target data and to make informed decisions for collision avoidance.

**Entry conditions**:

1. Area: Open Sea
2. Weather Conditions – fine weather as follows:

* Wind N - 5 kts
* Sea Waves Height – 0.3 m
* Visibility - 15 NM.
* Current - none

1. Radar screen settings: Relative motion. True vectors. Radar screen orientation: Head Up. ARPA on.
2. Own ship:

* Underway using engine.
* PSN: ϕ = 49° 56.8′ N λ= 009° 06.8′ W
* HDG - 095°
* SPD - 12.1 kts

1. Target Ship “One”:

* Underway using engine, keeping steady course and speed.
* HDG - 245°
* SPD – 10.2 kts
* CPA – 0.24 NM
* TCPA – 21.8 minutes

1. Target Ship “Two”:

* Underway using engine, keeping steady course and speed.
* HDG - 342°
* SPD – 21.0 kts
* CPA – 1.1 NM
* TCPA – 14.2 minutes

**Video exercise:**

The video attached to this scenario shows own ship and two target acquired by ARPA. Both targets interrogated for HDG, SPD, BRG, RNG, CPA and TCPA. Switched AIS. Target Ship “One” and “Two” AIS info checked. Additional info obtained by AIS such as target draft, length, width, MMSI, call sign, name, status, type, cargo.

This is a great value in regards to:

- exchange of navigation information between ships;

- to transmit data about the ship and its cargo to other ship and to the land services;

- to transmit navigational information for a more precise and reliable management of the traffic and of the search and rescue operations;

AIS target CPA and TCPA is available as well, though there is slight difference comparing with ARPA CPA and TCPA. The primary collision avoidance system is ARPA and AIS data may be considering as another source of info in regards of collision avoidance purposes.

**Conclusion:**

Blended AIS and ARPA exercises provide mariners with practical experience in utilizing AIS and ARPA systems, tracking targets, interpreting AIS and ARPA data and making informed navigational decisions. By developing proficiency in AIS and ARPA operations, mariners can and will enhance situational awareness, improve collision avoidance capabilities, and ensure safe navigation in challenging maritime environments.