Automatic Identification System
Principle of AIS operation

dr inż. Stefan Jankowski

s.jankowski@am.szczecin.pl

Caution

- Not all ships carry AIS.

- The officer of the watch (OOW) should always be aware that other ships, in particular leisure craft, fishing boats and warships, and some coastal shore stations including Vessel Traffic Service (VTS) centres, might not be fitted with AIS.

- The OOW should always be aware that AIS fitted on other ships as a mandatory carriage requirement might, under certain circumstances, be switched off on the master's professional judgement.

Caution

- AIS should always be in operation when ships are underway or at anchor.

- If the master believes that the continual operation of AIS might compromise the safety or security of his/her ship or where security incidents are imminent, the AIS may be switched off.

- Unless it would further compromise the safety or security, if the ship is operating in a mandatory ship reporting system, the master should report this action and the reason for doing so to the competent authority.

- Actions of this nature should always be recorded in the ship's logbook together with the reason for doing so.

- The master should however restart the AIS as soon as the source of danger has disappeared.

Application and requirements

All ships of 300 gross tonnage and upwards engaged on international voyages and cargo ships of 500 gross tonnage and upwards not engaged on international voyages and passenger ships irrespective of size shall be fitted with an automatic identification system (AIS), as follows:

• ships constructed on or after 1 July 2002;

Application and requirements

All ships of 300 gross tonnage and upwards engaged on international voyages and cargo ships of 500 gross tonnage and upwards not engaged on international voyages and passenger ships irrespective of size shall be fitted with an automatic identification system (AIS), as follows:

- ships engaged on international voyages constructed before 1 July 2002:
    - in the case of passenger ships, not later than 1 July 2003;
    - in the case of tankers, not later than the first survey * for safety equipment ** on or after 1 July 2003;
    - in the case of ships, other than passenger ships and tankers, of 50,000 gross tonnage and upwards, not later than 1 July 2004;
    - in the case of ships, other than passenger ships and tankers, of 300 gross tonnage and upwards but less than 50,000 gross tonnage, not later than the first safety equipment survey* after 1 July 2004 or by 31 December 2004, whichever occurs earlier;

Application and requirements

All ships of 300 gross tonnage and upwards engaged on international voyages and cargo ships of 500 gross tonnage and upwards not engaged on international voyages and passenger ships irrespective of size shall be fitted with an automatic identification system (AIS), as follows:

- ships not engaged on international voyages constructed before 1 July 2002, not later than 1 July 2008

- The Administration may exempt ships from the application of the requirements of this paragraph when such ships will be taken permanently out of service within two years after the implementation date specified in subparagraphs .2 and .3.
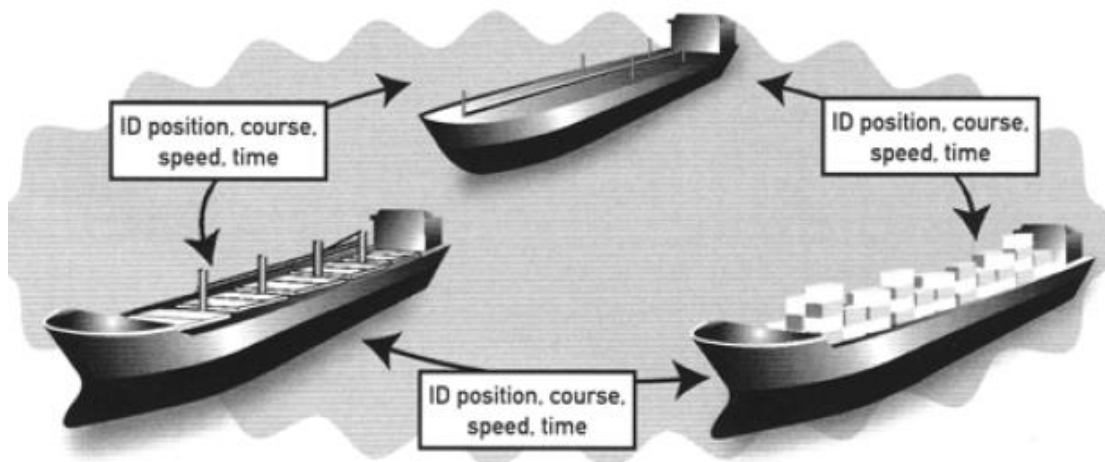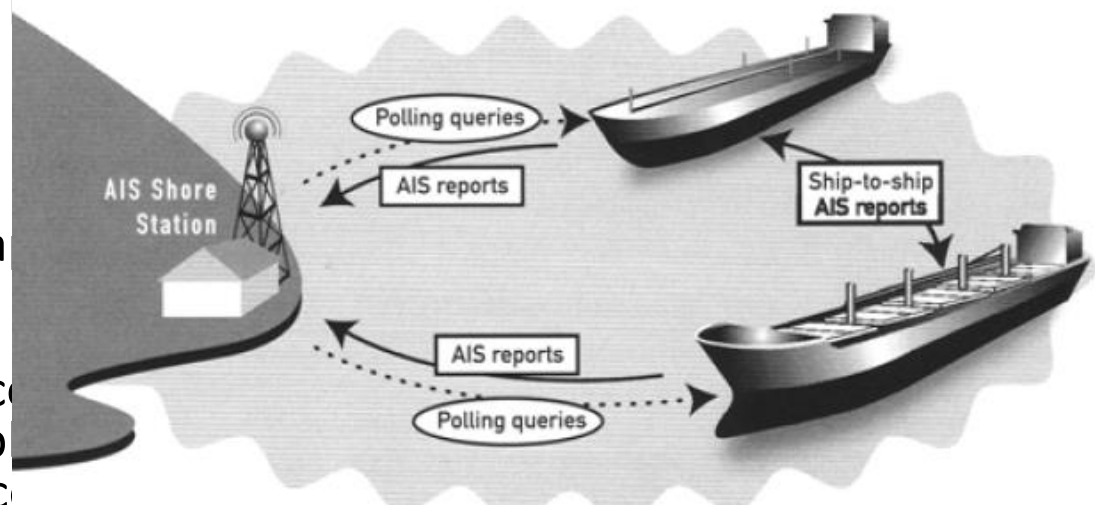
Scope

- The AIS should improve the safety of navigation by
  - assisting in the efficient navigation of ships,
  - protection of the environment, and
  - operation of Vessel Traffic Services (VTS).
- These are provided by satisfying the following functional requirements:
  - in a ship-to-ship mode for collision avoidance;
  - as a means for littoral States to obtain information about a ship and its cargo;
  - as a VTS tool, i.e. ship-to-shore (traffic management).
- The AIS should be capable of providing to ships and to competent authorities, information from the ship,
  - automatically and with the required accuracy and frequency, to facilitate accurate tracking;
  - transmission of the data should be with the minimum involvement of ship' s personnel and with a high level of availability.

Functionality of AIS

The system should be ca

- an "autonomous and c
  mode should be capab
  alternate modes by a c...

ject to a competent
that the data
et remotely by that

ansfer occurs in
ent authority.

Capability of AIS

The AIS should comprise:

- a communication processor, capable of operating over a range of maritime frequencies
  161.975 MHz – ch 87B
  162.025 MHz – ch 88B
  with an appropriate channel selecting and switching method;

- Transmit output power: 2 W / 12.5 W

- a means of processing data from an electronic position-fixing system which provides a resolution of one ten thousandth of a minute of arc and uses the WGS-84 datum.;

- a means to automatically input data from other sensors;

- a means to input and retrieve data manually;

- a means of error checking the transmitted and received data; and

- built in test equipment (BITE).

Capability of AIS
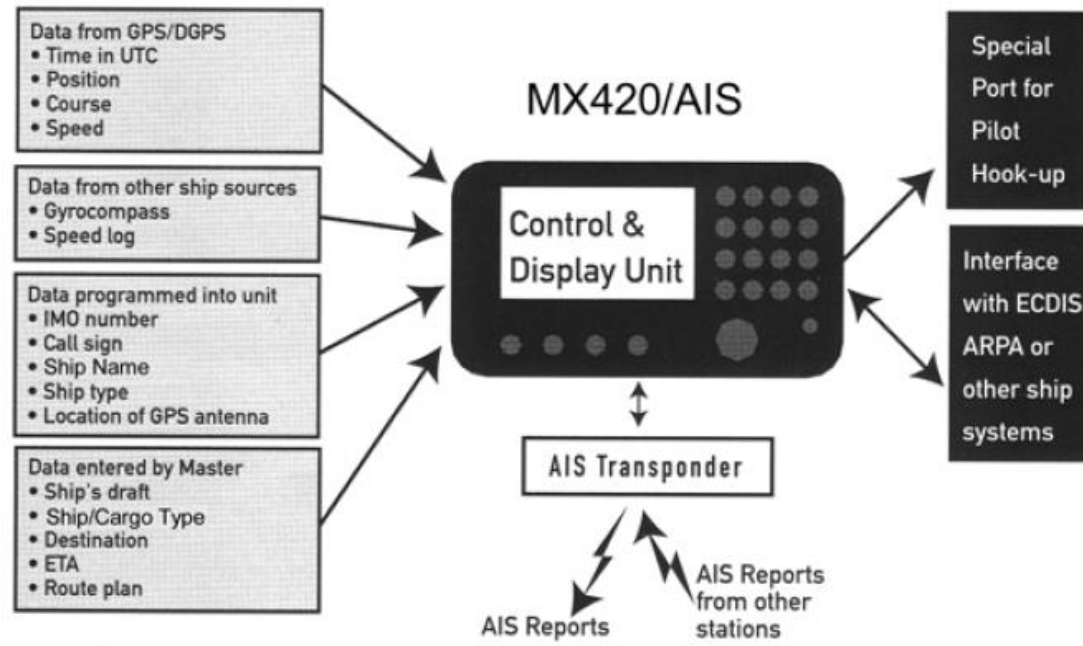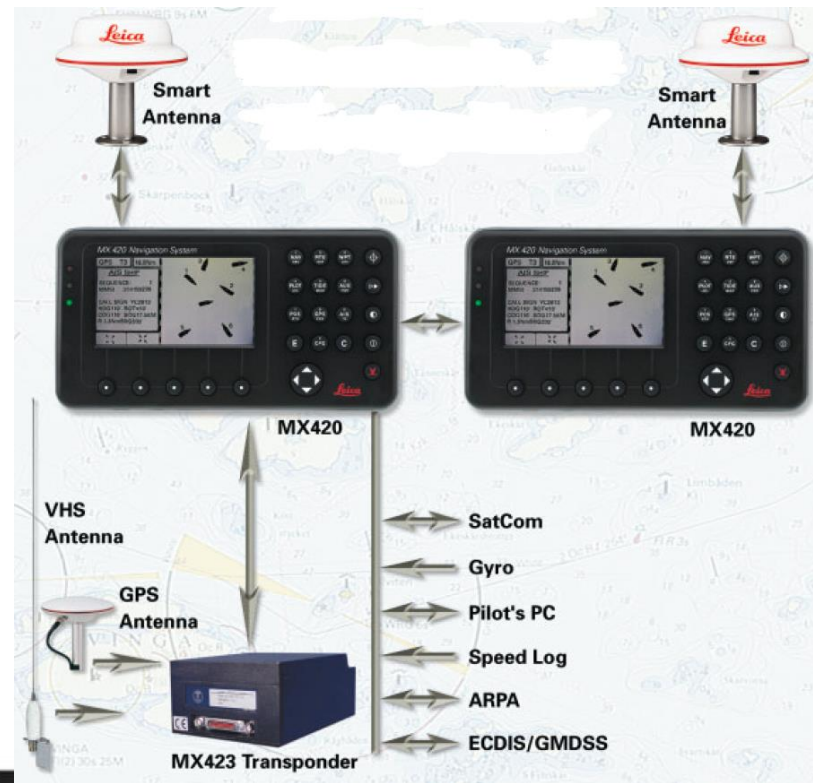
The AIS should be capable of:

- providing information automatically and continuously to a competent authority and other ships, without involvement of ship' s personnel;

- receiving and processing information from other sources, including that from a competent authority and from other ships;

- responding to high priority and safety related calls with a minimum of delay; and

- providing positional and manoeuvring information at a data rate adequate to facilitate accurate tracking by a competent authority and other ships.
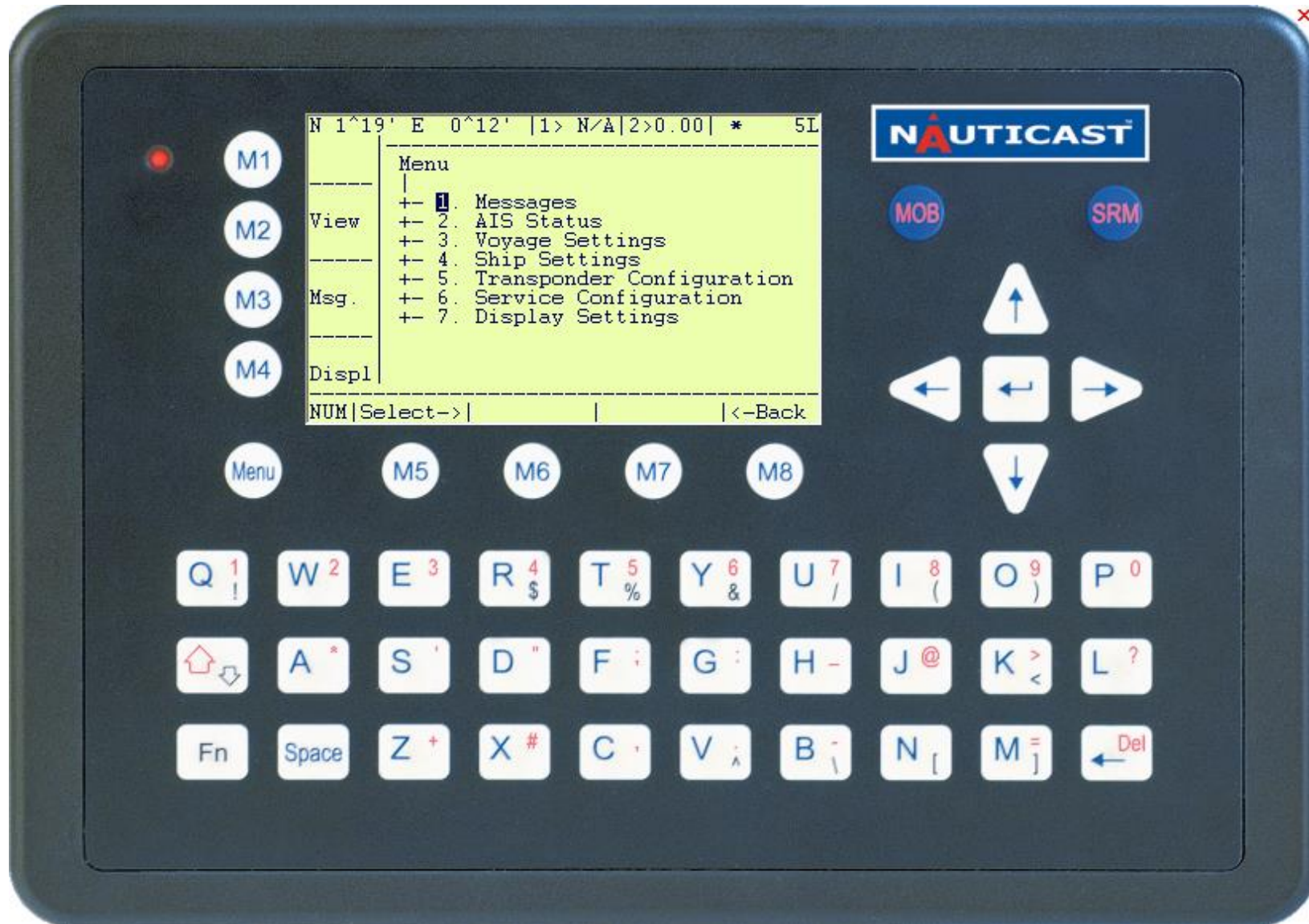
AIS components

In general, an onboard AIS (see figure 1) consists of:

- antennas;
- one VHF transmitter;
- two multi-channel VHF receivers;
- one channel 70 VHF receiver for channel management;
- a central processing unit (CPU);
- an electronic position-fixing system, Global Navigation Satellite System (GNSS) receiver for timing purposes and position redundancy;
- interfaces to heading and speed devices and to other shipborne sensors;
- interfaces to radar/Automatic Radar Plotting Aids (ARPA), Electronic Chart System/Electronic Chart Display and Information System (ECS/ECDIS) and Integrated Navigation Systems (INS);
- built-in integrity test (BIIT); and
- minimum display and keyboard to input and retrieve data.
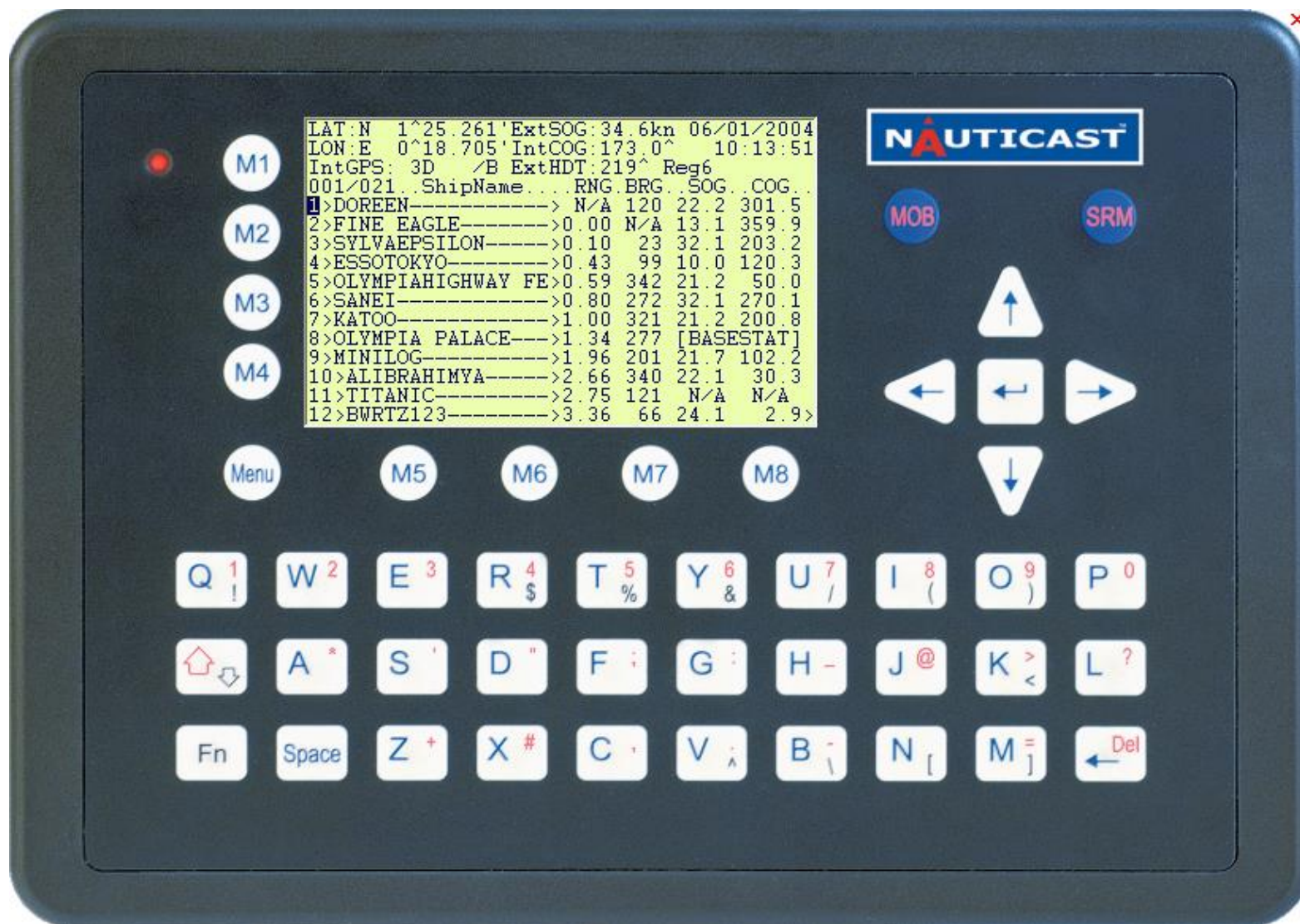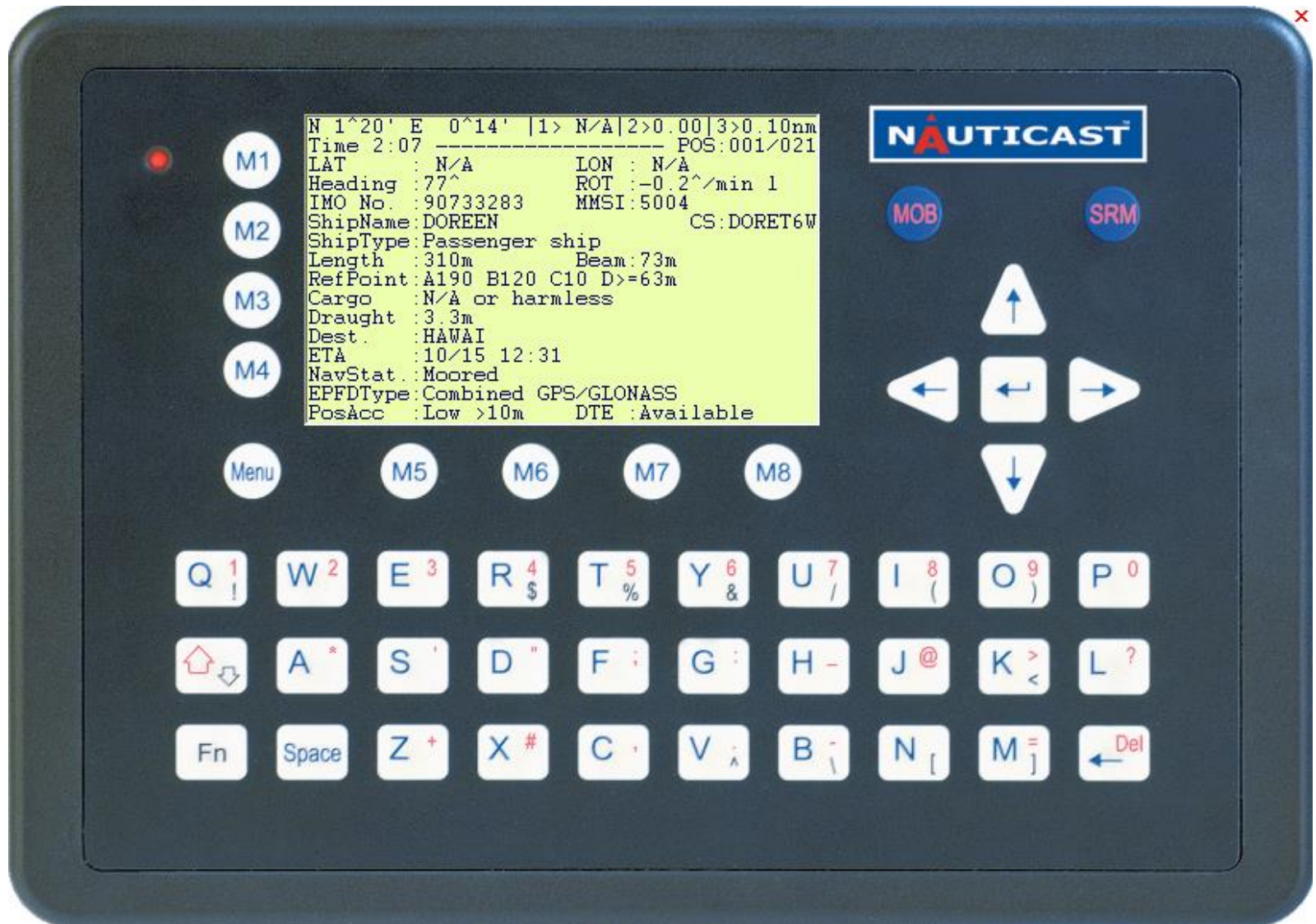
Connections to ship's systems

Smart Antenna — **MX420** — **Smart Antenna** — **MX420**

VHS Antenna
GPS Antenna
MX423 Transponder

- SatCom
- Gyro
- Pilot's PC
- Speed Log
- ARPA
- ECDIS/GMDSS

Data from GPS/DGPS
- Time in UTC
- Position
- Course
- Speed

Data from other ship sources
- Gyrocompass
- Speed log

Data programmed into unit
- IMO number
- Call sign
- Ship Name
- Ship type
- Location of GPS antenna

Data entered by Master
- Ship's draft
- Ship/Cargo Type
- Destination
- ETA
- Route plan

MX420/AIS

Control & Display Unit

AIS Transponder

AIS Reports
AIS Reports from other stations

Special Port for Pilot Hook-up

Interface with ECDIS, ARPA or other ship systems
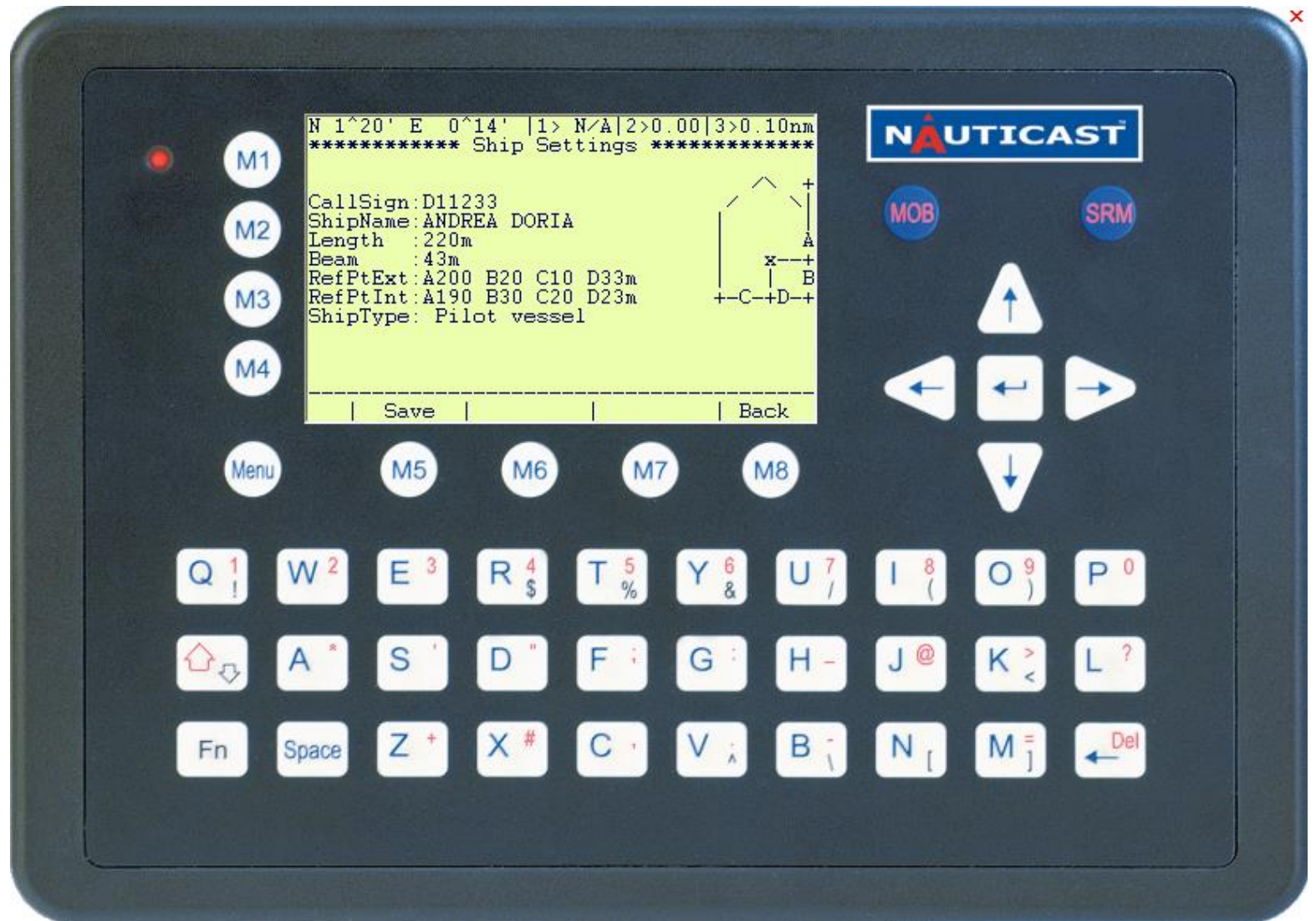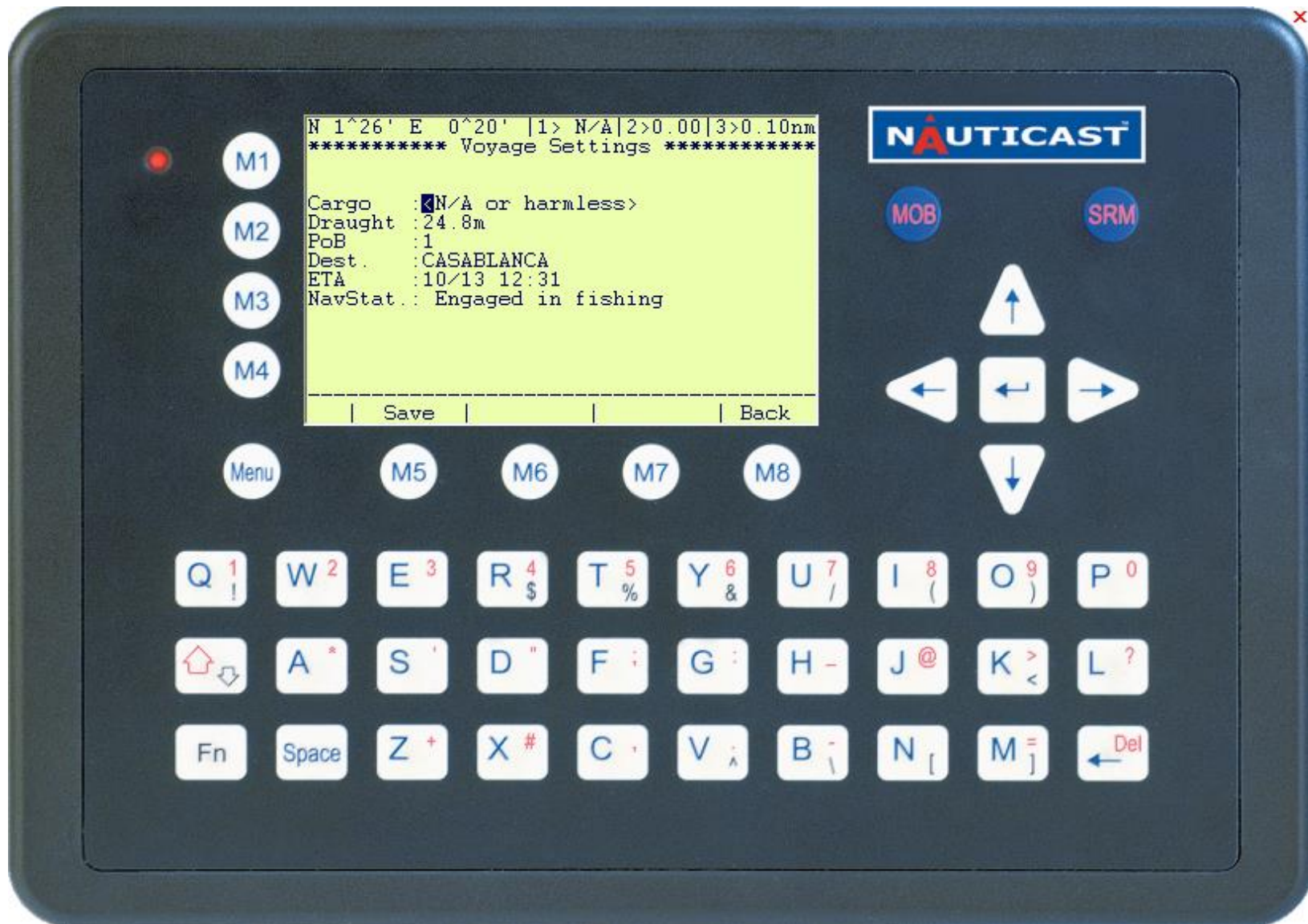
MD&K - Menu
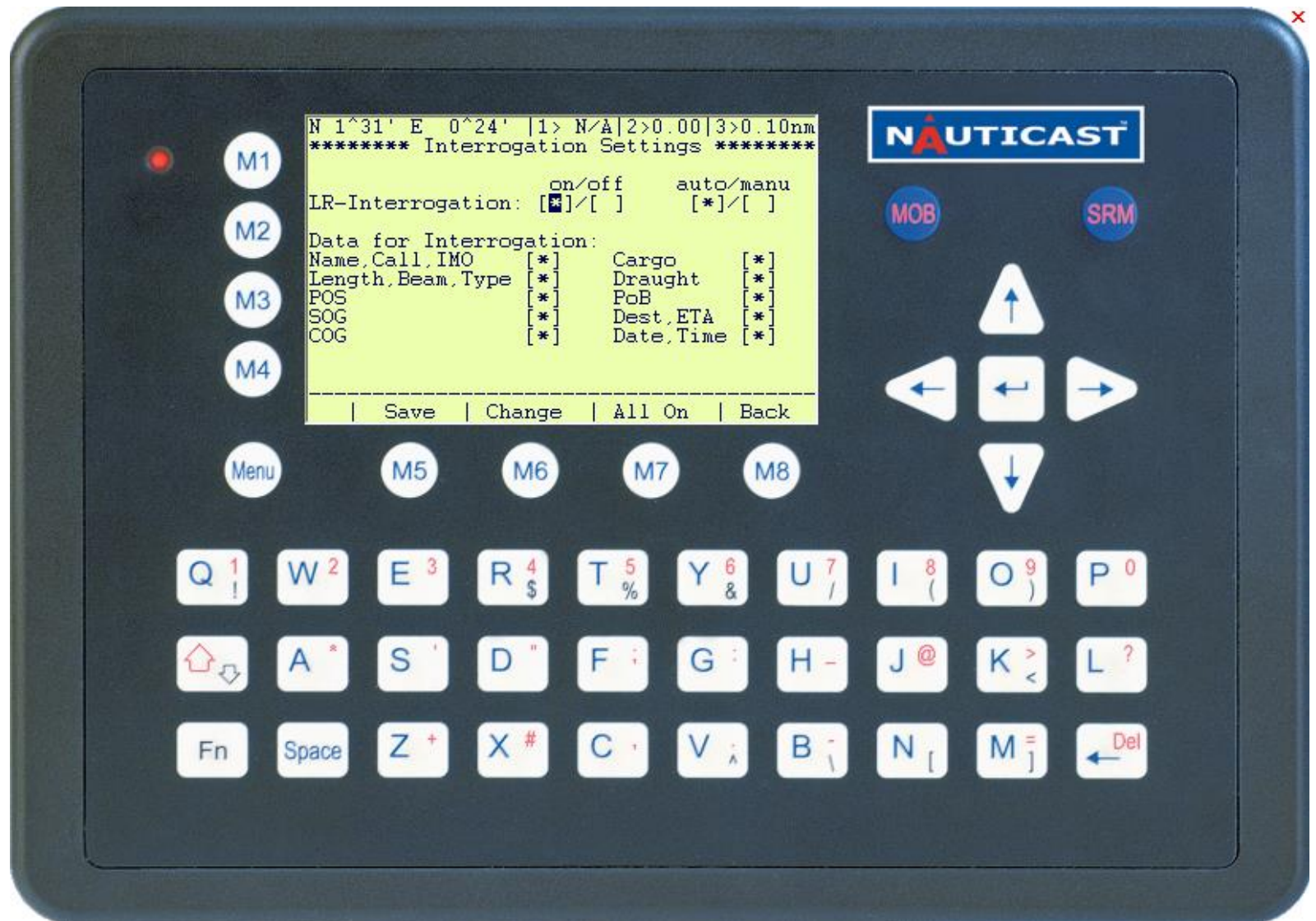
MD&K – VHF status

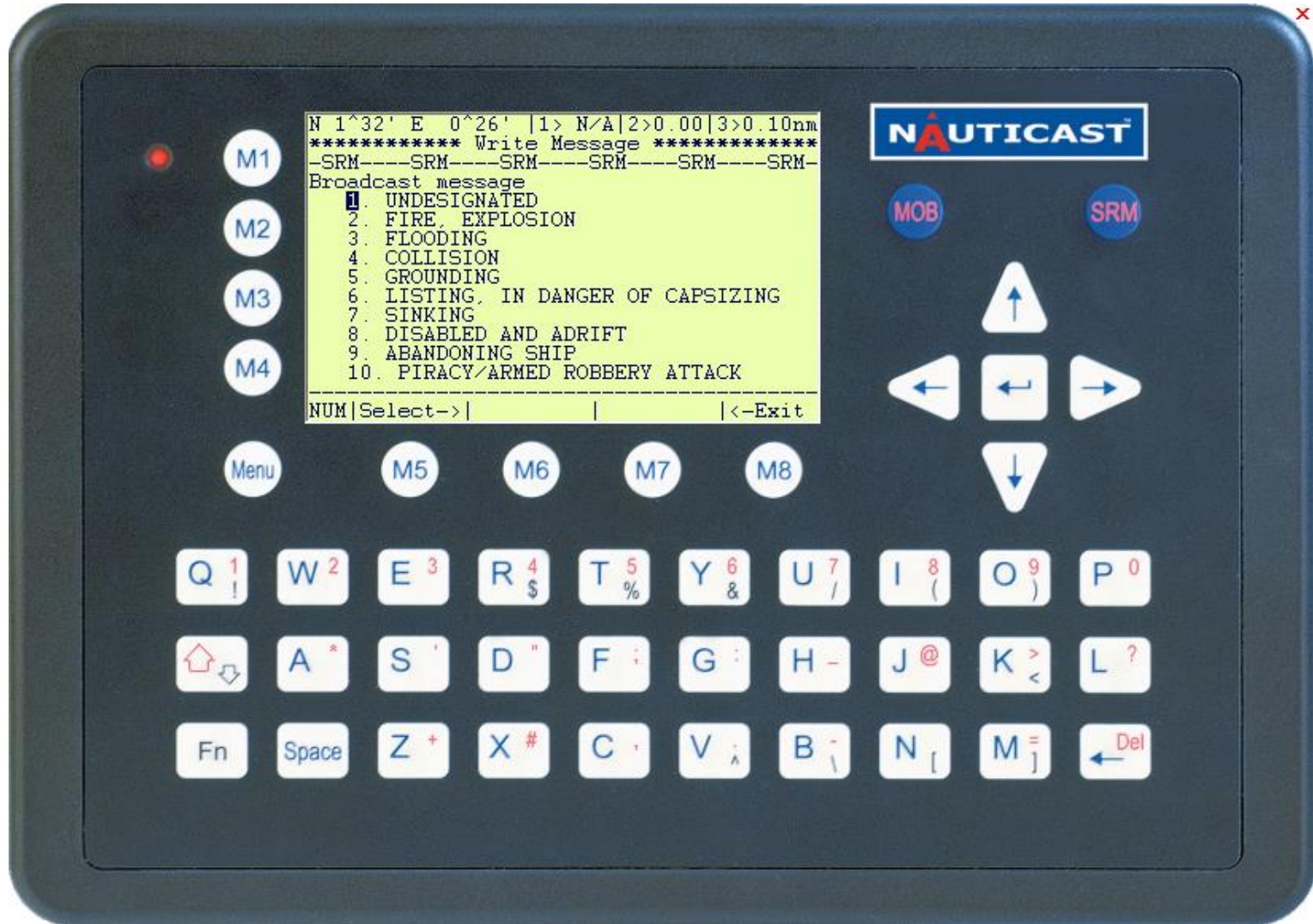# MD&K – vessels' list

MD&K – detailed info

MD&K – ship settings

MD&K – voyage settings

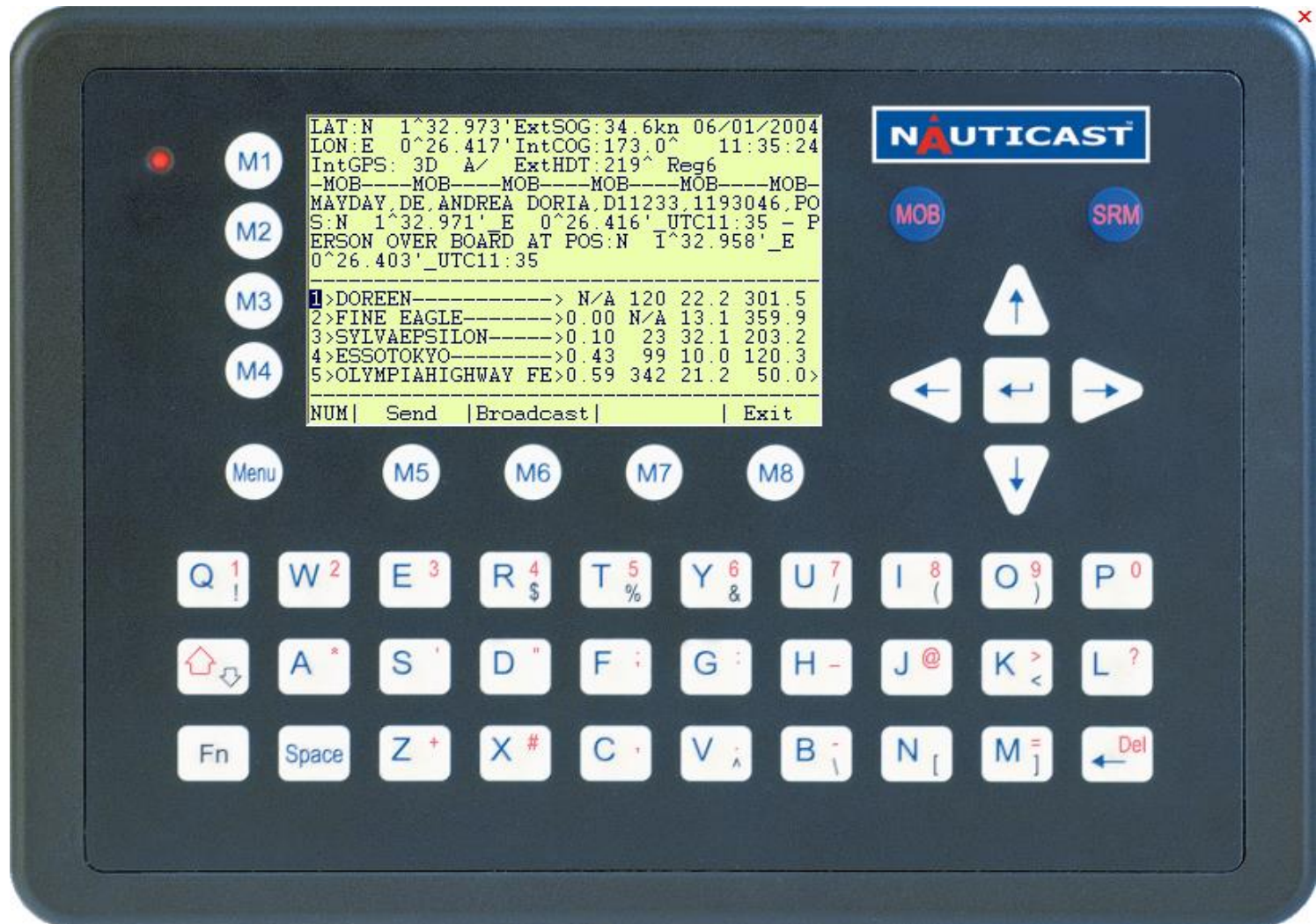# MD&K – interrogation settings

MD&K – broadcast message

MD&K – SAR message

MD&K - plot

MD&K - plot

AIS on ECDIS

MERCANDIA IV
MMSI: 219000368
Updated: 12:18:42
Call Sign: OXIE2
IMO Nr: 8611685
Lat: 56 02.0800 N
Lon: 012 37.2330 E
5,6 kn
COG: 269,0 deg
HDG: 263,0 deg
ROT: PORT > 5 deg / 30 s
Pos Accuracy: High
Passenger Ship - No

Draught: 3,5 m
Dest: HELSINGOR
ETA: --/-- 00:00
Ship size: 96 m x 15 m
Under Way Using Engine

Name of ship
Radio call sign
Speed Vector
COG
Heading
Rate of Turn
Type of ship
Dimensions
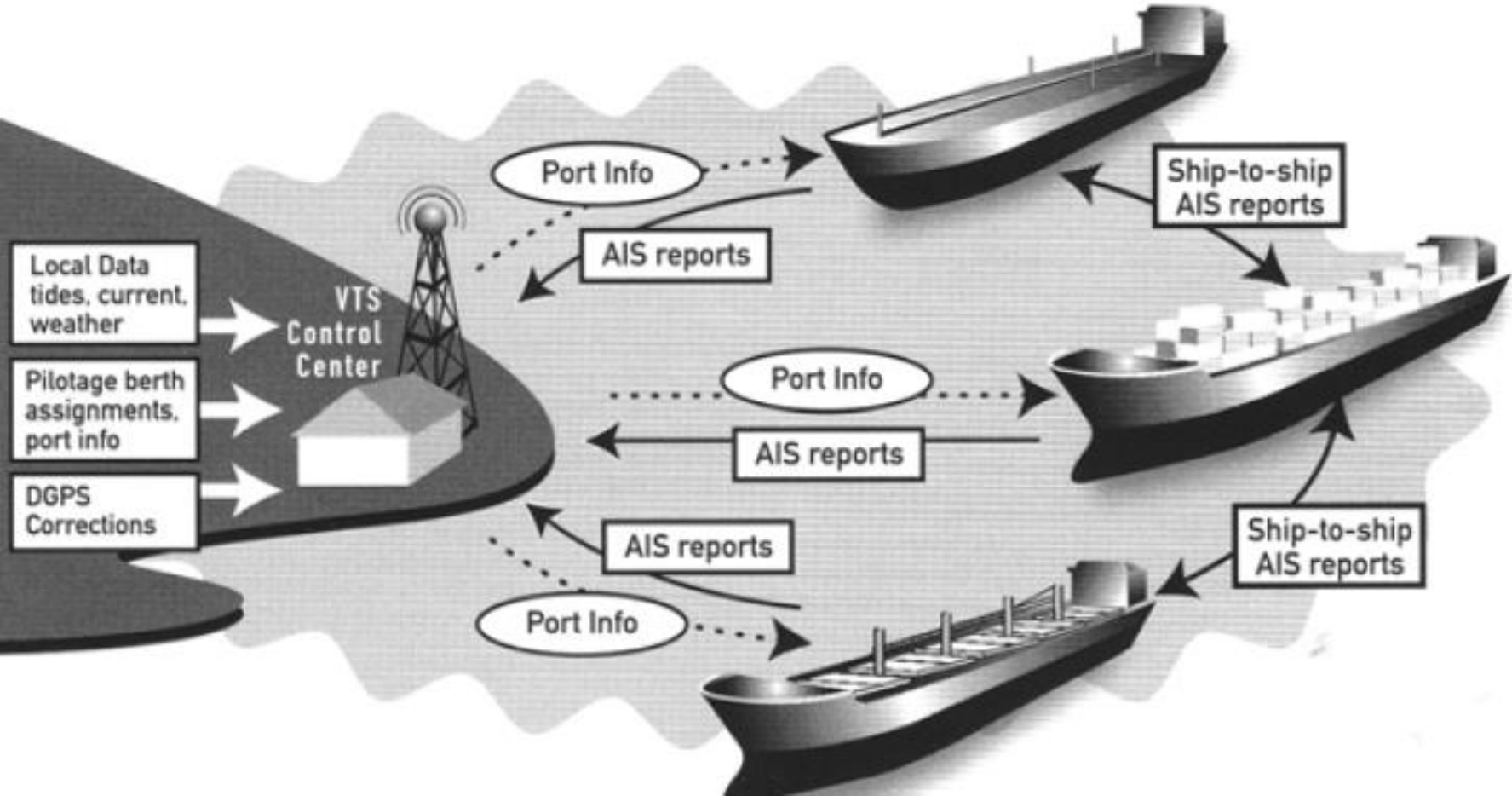Navigational Status

AIS on RADAR

AIS information
- Position, ship's scaled outline
- COG/SOG vector
- Heading, ROT indication

Radar information
- Raw radar
- Centre of reflection
- Vector

AIS within VTS

AIS in VTS operations

- Pseudo Targets broadcast by VTS
  VTS centres may send information about vessels which are not carrying AIS and which are tracked only by VTS radar via the AIS to vessels equipped with AIS. Any VTS/generated/synthetic target broadcast by VTS should be clearly identified as such. Particular care should always be taken when using information which has been relayed by a third party. Accuracy of these targets may not be as complete as actual directly-received targets, and the information content may not be as extensive.

- Text messages
  VTS centres may also send short messages either to one ship, all ships, or ships within a certain range or in a special area, e.g.:
  - (local) navigational warnings;
  - traffic management information; and
  - port management information.

Display of AIS data – recommended symbols

- Sleeping target
  A sleeping target indicates only the presence of a vessel equipped with AIS in a certain location. No additional information is presented until activated, thus avoiding information overload.

- Activated target
  If the user wants to know more about a vessel's motion, the target (sleeping) may be activated so that the display shows immediately:
  - a vector (speed and course over ground);
  - the heading; and
  - ROT indication (if available) to display actually initiated course changes.

Display of AIS data

- Selected target
  If the user wants detailed information on a target (activated or sleeping), it may be selected. Then the data received, as well as the calculated CPA and TCPA values, will be shown in an alpha-numeric window.

The special navigation status will also be indicated in the alpha numeric data field and not together with the target directly.

- Dangerous target
  If an AIS target (activated or not) is calculated to pass preset CPA and TCPA limits, it will be classified and displayed as a dangerous target and an alarm will be given.

Display of AIS data

- Lost target
  If a signal of any AIS target at a distance of less than a preset value is not received, a lost target symbol will appear at the latest position and an alarm will be given.

- Other targets
  Other targets such as AIS-SART, AIS-AToN, may be displayed with special symbol

AIS Search and Rescue Transmitter (AIS-SART)	⊗	A circle containing a cross drawn with solid lines.

Information and identification

The information which is sent within AIS system can be divided into 4 groups:

1. Static data

2. Dynamic data

3. Voyage related data

4. Safety related data

For the purpose of ship and message identification, the appropriate **Maritime Mobile Service Identity** (MMSI) number should be used.

Information – Static

Information item	Information generation, type and quality of information
Static	
MMSI	Set on installation Note that this might need amending if the ship changes ownership
Call sign and name	Set on installation Note that this might need amending if the ship changes ownership
IMO Number	Set on installation
Length and beam	Set on installation or if changed
Type of ship	Select from pre-installed list
Location of electronic position fixing system (EPFS) antenna	Set on installation or may be changed for bi-directional vessels or those fitted with multiple antennas

Information – Dynamic

Ship's position with accuracy indication and integrity status	Automatically updated from the position sensor connected to AIS The accuracy indication is approximately 10 m.
Position Time stamp in UTC	Automatically updated from ship's main position sensor connected to AIS
Course over ground (COG)	Automatically updated from ship's main position sensor connected to AIS, if that sensor calculates COG This information might not be available
Speed over ground (SOG)	Automatically updated from the position sensor connected to AIS. This information might not be available
Heading	Automatically updated from the ship's heading sensor connected to AIS
Navigational status	Navigational status information has to be manually entered by the OOW and changed as necessary, for example: - underway by engines - at anchor - not under command (NUC) - restricted in ability to manoeuvre (RIATM) - moored - constrained by draught - aground - engaged in fishing - underway by sail In practice , since all these relate to the COLREGs, any change that is needed could be undertaken at the same time that the lights or shapes were changed
Rate of turn (ROT)	Automatically updated from the ship's ROT sensor or derived from the gyro. This information might not be available

Information voyage related

Voyage-related	
Ship's draught	To be manually entered at the start of the voyage using the maximum draft for the voyage and amended as required (e.g. – result of de-ballasting prior to port entry)
Hazardous cargo (type)	To be manually entered at the start of the voyage confirming whether or not hazardous cargo is being carried, namely: - DG (Dangerous goods) - HS (Harmful substances) - MP (Marine pollutants) Indications of quantities are not required
Destination and ETA	To be manually entered at the start of the voyage and kept up to date as necessary
Route plan (waypoints)	To be manually entered at the start of the voyage, at the discretion of the master, and updated when required

Safety-related	
Short safety-related messages	Free format short text messages would be manually entered, addressed either a specific addressee or broadcast to all ships and shore stations

Hazardous cargo

Due to the amendment of MARPOL categorization of hazardous cargo by resolution MEPC.118(52), cargo type may be categorized as A, B, C or D, rather than X, Y, Z or OS on older AIS equipment, as described in SN.1/Circ.227 and SN.1/Circ.227/Corr.1.

The table below indicates the equivalence of the old and new category indications:

Current MARPOL category	Equivalent category on older AIS units
X	A
Y	B
Z	C
OS	D

Information safety related

This category can be sent to a particular vessel or distributed to all within the VHF range and comprises information like:

- navigational and meteorological warnings,
- communications within search and rescue operations,
- DGPS corrections
- …

AIS types of messages

The AIS standard consists of 22 types of messages:

Msg. ID	Name	Description	Cat ego ry	Prio rity	Operati on mode	Access Schemes	Communi cation State
1.	Position Report	Scheduled position report	F/S	1	AU	SOTDMA, RATDMA, ITDMA (1)	SOTDMA
2	Position Report	Assigned Scheduled position report	F/S	1	AS	SOTDMA	SOTDMA
3.	Position Report	Special position report, response to interrogation	F/S	1	AU	RATDMA	ITDMA
4.	Base Station Report	Position, UTC, Date and current slot number of base station	F/S	1	AS	FATDMA	SOTDMA
5.	Static and Voyage Related Data	Scheduled static vessel data report / Aids-to-Navigation data	F	4 (5)	AU, AS	RATDMA, ITDMA (2)	N/A
6.	Binary Addressed Message	Binary data for addressed communication	F	4	AU, AS, IN	RATDMA, ITDMA (2)	N/A
7.	Binary Acknowledgement	Acknowledgement of received addressed binary data	S	1	AU, AS, IN	RATDMA, ITDMA (2)	N/A
8.	Binary broadcast Message	Binary data for broadcast communication	F	4	AU, AS, IN	RATDMA, ITDMA (2)	N/A
9.	Special Position Report	Position Report for stations other than ship stations only	F/S	1	AU, AS	SOTDMA RATDMA, ITDMA (1)	SOTDMA,
10.	UTC/Date inquiry	Request UTC and date	F/S	3	AU, AS, IN	RATDMA, ITDMA (2)	N/A
11.	UTC/Date Response	Current UTC and date if available	F/S	3	AU, AS, IN	RATDMA, ITDMA (2)	SOTDMA
12.	Addressed Safety Related Message	Safety related data for addressed communication	F	2	AU, AS, IN	RATDMA, ITDMA (2)	N/A
13.	Safety Related Acknowledgement	Acknowledgement of received addressed safety related message	S	1	AU, AS, IN	RATDMA, ITDMA (2)	N/A
14.	Safety Related broadcast Message	Safety related data for broadcast communication	F	2	AU, AS, IN	RATDMA, ITDMA (2)	N/A
15.	Interrogation	Request for a specific message type (can result in multiple responses from one or several stations) (4)	F	3	AU, AS, IN	RATDMA, ITDMA (2)	N/A
16.	Assigned Mode Command	Assignment of a specific report behaviour by competent authority using a base station	F/S	1	AS (3)	RATDMA ITDMA (2)	N/A
17.	DGNSS Broadcast Binary Message	DGNSS corrections provided by a base station	F	2	AS (3)	FATDMA, ITDMA, RATDMA	N/A
18	not used	not used	-	-	-	-	-
19.	VTS Targets	VTS derived target	F	2	AS (3)	FATDMA, ITDMA, RATDMA	N/A
20.	Data Link Manage-ment Message	Reserve slots for base station(s).	S	1	AS(3)	FATDMA	N/A
21.	Test/Evaluation Message	Reserved for Proprietary and/or local use.	F	4	AU, AS, IN	FATDMA, ITDMA, RATDMA	N/A
22.	Channel Management	Management of channels and transceiver modes by a base station.	S	1	AS (3)	FATDMA, ITDMA, RATDMA	N/A

AIS message	Name of Message	Description
1,2,3	Position report (ship)	Dynamic data
4	Base station report	Position, UTC, Date and current slot of base station
5	Identification report (ship)	Static and voyage related data
11	UTC/Date Response (ship)	Current UTC and date if available

Messages' rates

- static and voyage-related data (the identification report): <u>every 6 minutes</u> or on request (AIS responds automatically without user action); and

- safety-related text message: as required.

Messages' rates – the position report

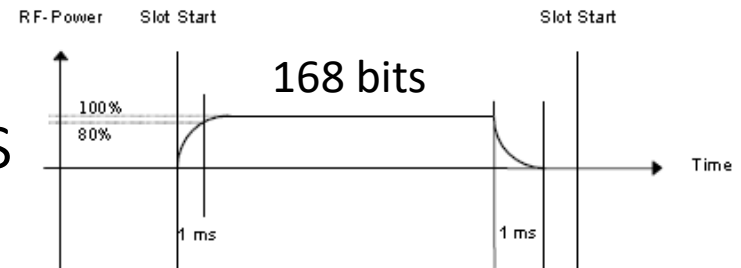- **Class A shipborne equipment reporting intervals**

Type of ship	General reporting interval
Ship at anchor or moored and not moving faster than 3 knots	3 min
Ship at anchor or moored and moving faster than 3 knots	10 s
Ship 0-14 knots	10 s
Ship 0-14 knots and changing course	3 1/3 s
Ship 14-23 knots	6 s
Ship 14-23 knots and changing course	2 s
Ship >23 knots	2 s
Ship >23 knots and changing course	2 s

Messages' rates – the position report

- **Class B shipborne equipment reporting intervals**

Crafts not subject to SOLAS	Nominal reporting interval
Class B "SO" shipborne equipment not moving faster than 2 knots	3 min
Class B "SO" shipborne equipment moving 2-14 knots	30 s
Class B "SO" shipborne equipment moving 14-23 knots	15 s
Class B "SO" shipborne equipment moving > 23 knots	5 s
Class B "CS" shipborne equipment not moving faster than 2 knots	3 min
Class B "CS" shipborne equipment moving faster than 2 knots	30 s

Access to the radio channels

168 bits

- In order to obtain the maximum bandwidth of the data link transmitted by many system users on a common channels, a communication scheme, synchronized according to the GNSS time pattern was designed.

- It is called SOTDMA (self-organizing time-division multiple access)
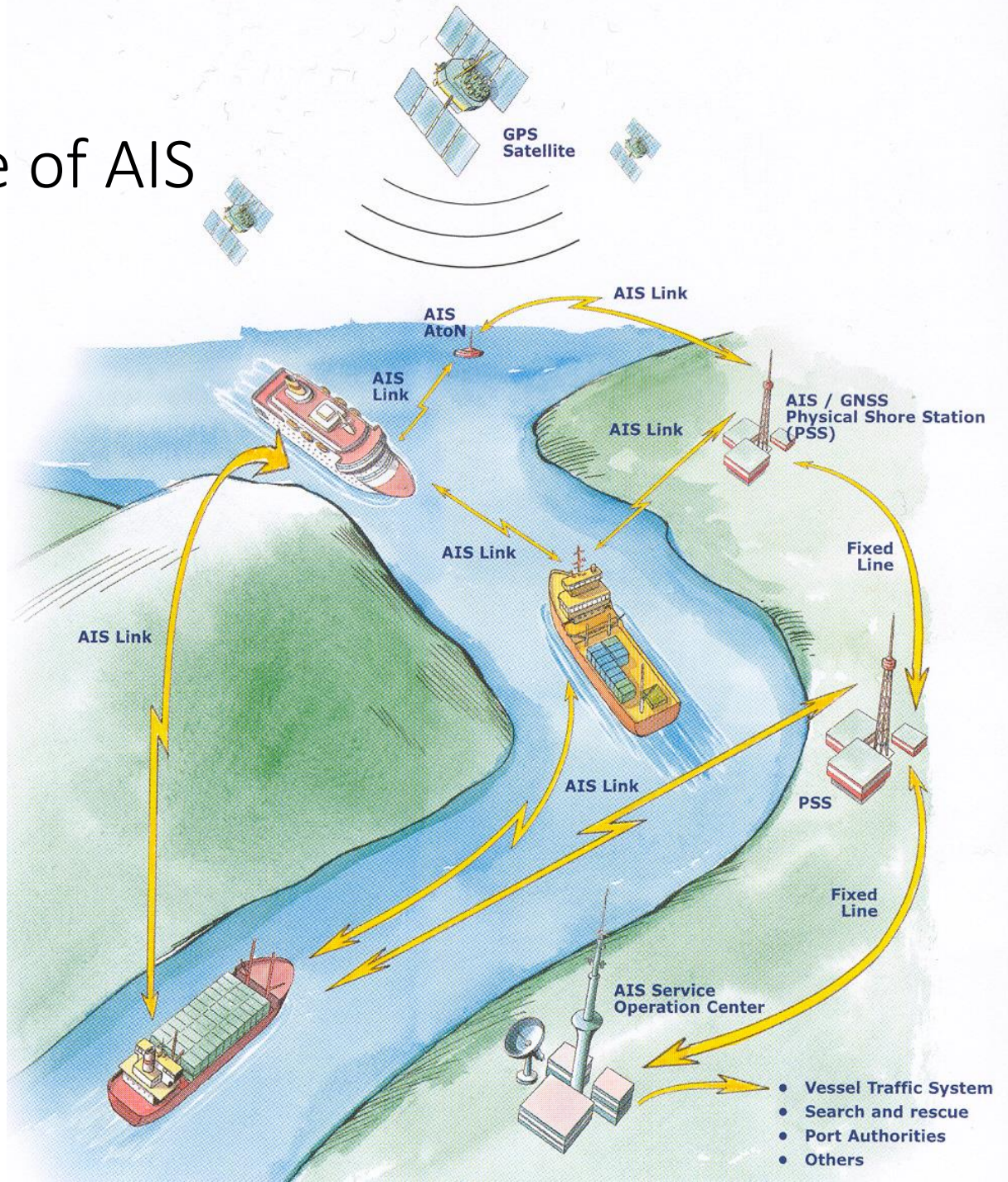

60 Seconds
2250 Slots

AIS 1   A   B   C   A   C   B

AIS 2   B   C   A   C

26.67 ms
1 Slot = 256 Bits

- Identity
- Postition
- Speed Over Ground
- Course Over Ground
- Heading
- Rate of Turn
- Navigation Status
- Time Stamp

SOTDMA

- An algorithm used as a part of TDMA scheme, used within AIS, in order to access the communications channels and solve all radio traffic conflicts in continuous and autonomous mode.

Infrastructure of AIS

Infrastructure of AIS: AIS-SART activated

The AIS-SART should be capable of transmitting messages that indicate the position, static and safety information of a unit in distress. The transmitted messages should be compatible with existing AIS installations. The transmitted messages should be recognized and displayed by assisting units in the reception range of AIS-SART, and clearly distinguish the AIS-SART from an AIS installation.

Inherent limitations of AIS

- The OOW should always be aware that other ships, in particular leisure craft, fishing boats and warships, and some coastal shore stations including VTS centres, might not be fitted with AIS.

- The OOW should always be aware that other ships fitted with AIS as a mandatory carriage requirement might switch off AIS under certain circumstances by professional judgement of the master.

- In other words, the information given by the AIS may not be a complete picture of the situation around the ship.

Inherent limitations of AIS

- The users must be aware that transmission of erroneous information implies a risk to other ships as well as their own. The users remain responsible for all information entered into the system and the information added by the sensors.

- The accuracy of AIS information received is only as good as the accuracy of the AIS information transmitted.

- The OOW should be aware that poorly configured or calibrated ship sensors (position, speed and heading sensors) might lead to incorrect information being transmitted. Incorrect information about one ship displayed on the bridge of another could be dangerously confusing.

Inherent limitations of AIS

- If no sensor is installed or if the sensor (e.g. the gyro) fails to provide data, the AIS automatically transmits the "not available" data value. However, the built-in integrity check cannot validate the contents of the data processed by the AIS.

- It would not be prudent for the OOW to assume that the information received from other ships is of a comparable quality and accuracy to that which might be available on its own ship.
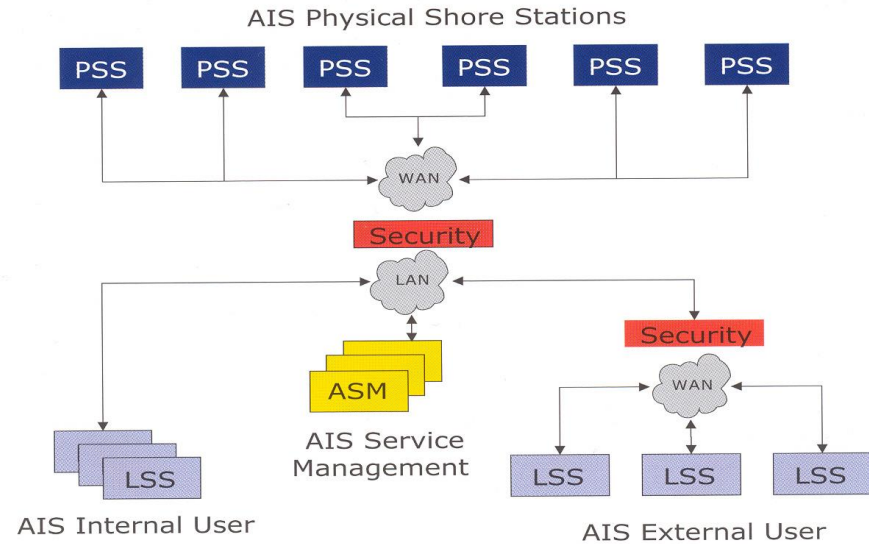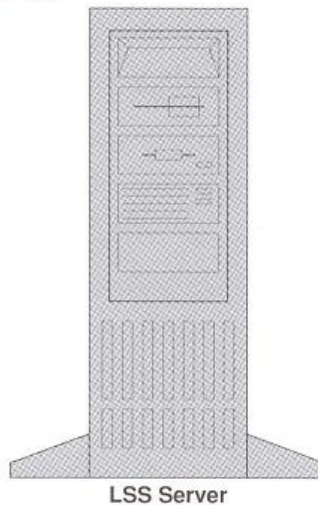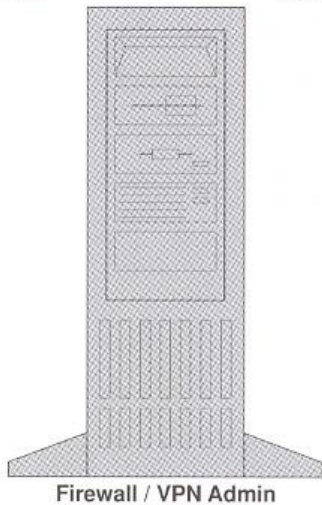
AIS in HELCOM

After the collision in the Baltic Sea east of the Danish island of Moen, ministers from the Baltic states as signatories of the HELCOM Convention adopted the Copenhagen Declaration dated 10 September 2001.
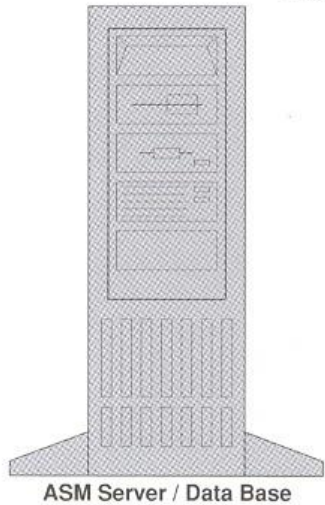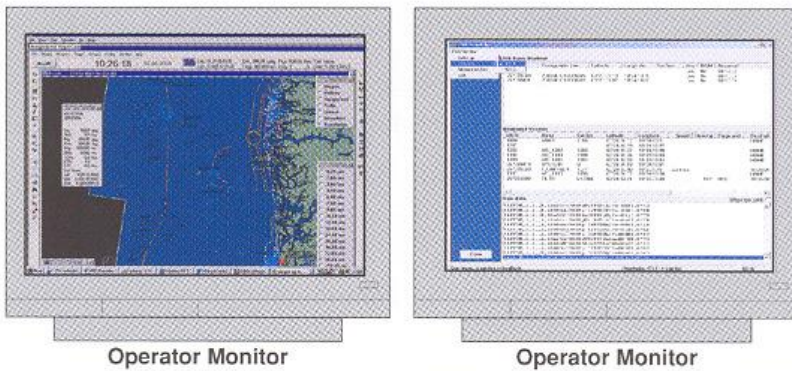
- Helsinki Commission is the administrator of the Helsinki Convention on the Protection of Biotopes (Marine Environment) of the Baltic Sea (since January 17, 2000).

- The aim of the HELCOM work is to protect the Baltic marine environment as part of the international cooperation of the European Union, Finland and Russia.

- On September 10, 2001 HELCOM issued the Copenhagen Declaration "On safety of navigation and rescue potential in the area of the Baltic Sea". It includes an obligatory program for the construction of a land-based AIS network, the completion of which was agreed on July 1, 2005. The basic task of the system is to increase the safety of navigation through automatic monitoring of passenger ships and vessels which carrying dangerous or polluting goods.
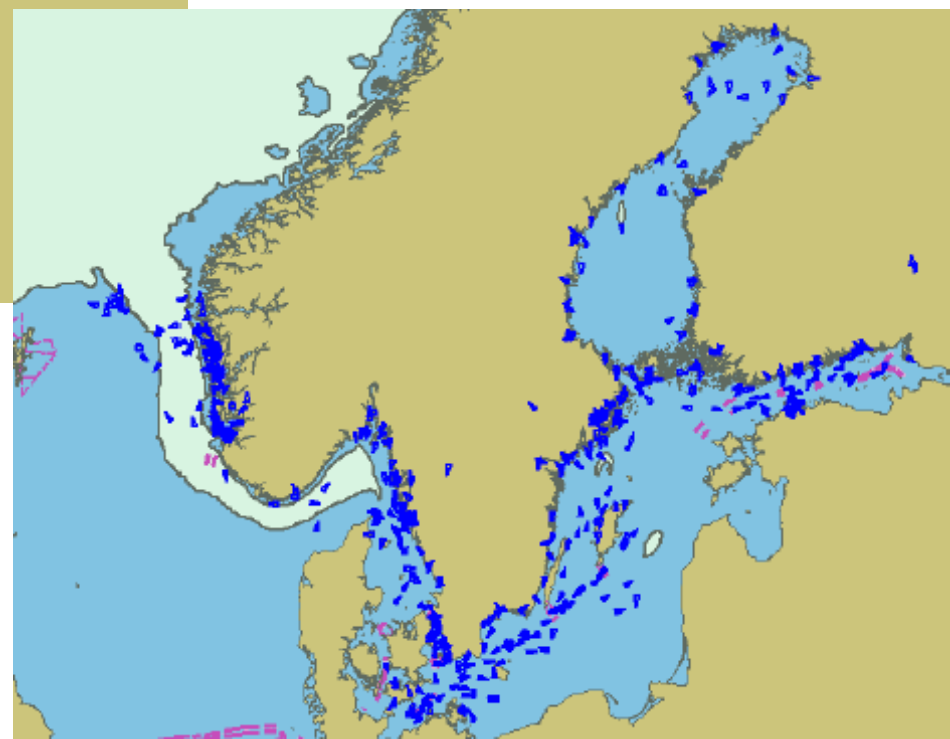
AIS in HELCOM Data Exchange system

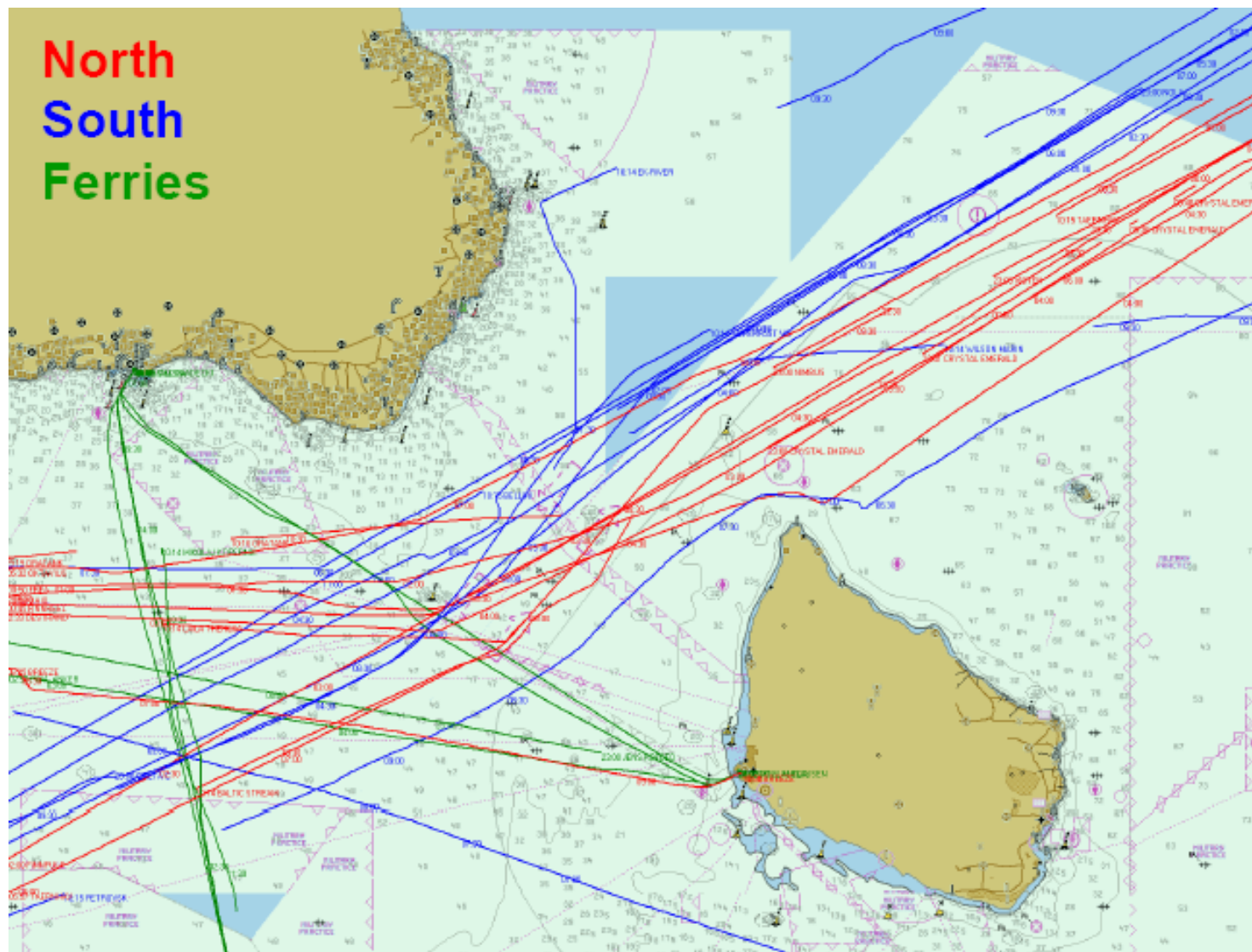# AIS in HELCOM Data Exchange system
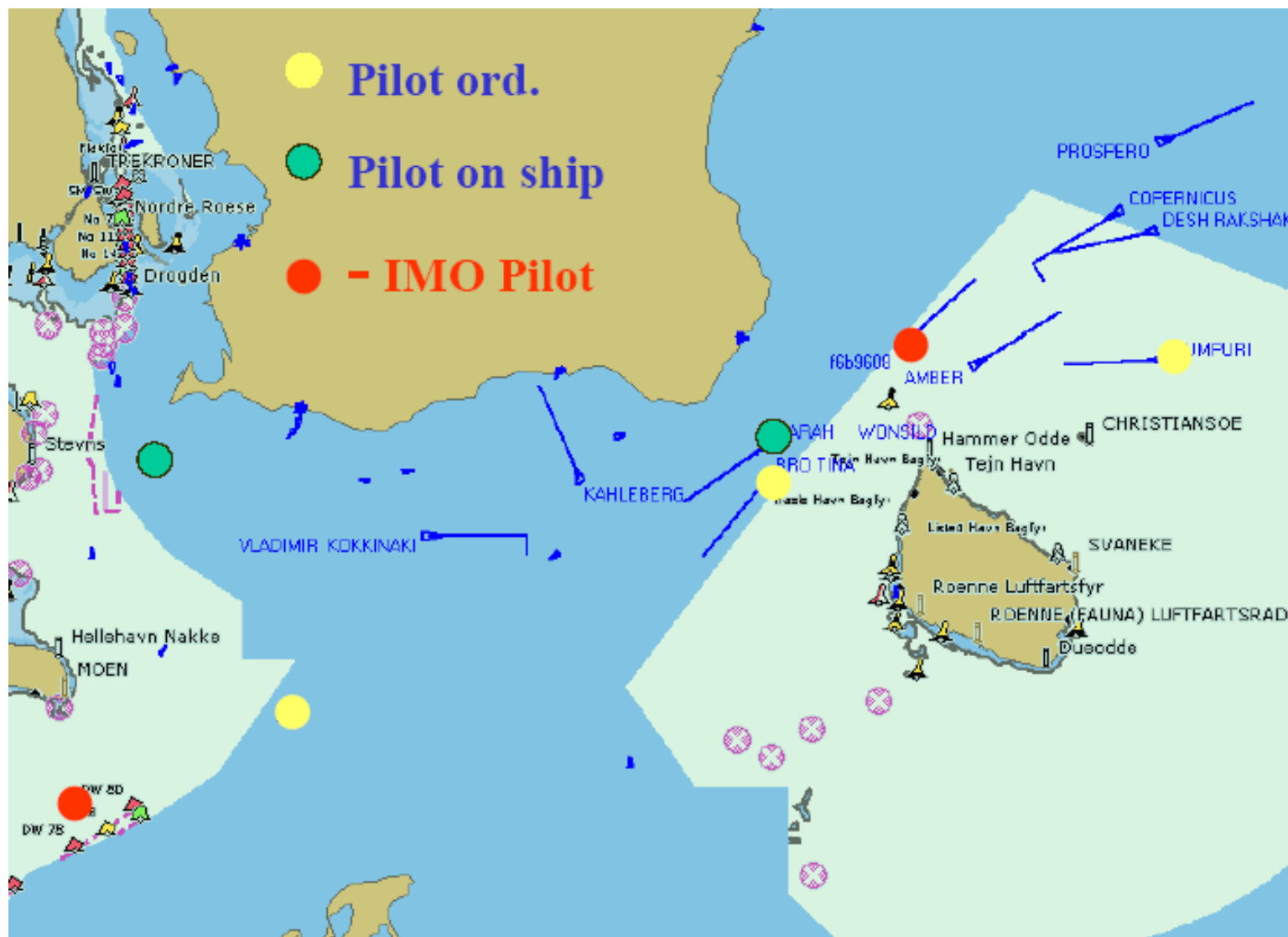
AIS in HELCOM Data Exchange system

AIS in HELCOM Data Exchange system

AIS in HELCOM Data Exchange system

AIS in HELCOM Data Exchange system

The end