

The onboard installation of Automatic Identification System (AIS)

1. Abstract

With the implementation of AIS a substantial enhancement of maritime safety will be accomplished. Even if concerns have been raised regarding the presentation of AIS data the advantage of AIS as a complement to the radar in most situations are without doubt.

The AIS System should be considered as relatively easy to install onboard a ship. No Dry docking or hot works are required. The worldwide installation capacity may however become a problem if the US request for a worldwide carriage requirement from 1st July 2004 will be implemented. The availability of Transponders will cause no problem according to manufacturers. One challenge for AIS is not the installation onboard itself but the interoperability between transponders from different suppliers according to the standards developed for AIS since it is a new advanced technology never before implemented by IMO as a mandatory requirement.

2. General regulations and rules

Regulations and rules covering AIS are several but the major once adapted only for AIS, with references into other within them, are:

- **IMO Performance Standard for AIS (MSC.74 (69) Annex 3**
- **IMO Carriage requirements for AIS within SOLAS Chapter V, Regulation 19**
- **ITU-R.M 1371-1 Technical Recommendations on AIS**
- **IALA Technical clarification on ITU-R M 1371-1**
- **IEC 61993-2 Test Standard for Class A AIS Transponders**
- **IEC 62287 Test Standard for Class B AIS Transponders**
- **IALA Technical Guidelines for AIS**

More ITU and IEC standards referred to from the ITU 1371-1 and IEC 61993-2 Test Standard are applicable for AIS e.g. ITU R M 1084-4 (radio performance), IEC 61162-1 and 61162-2 (interfacing).

Work is ongoing to set up guidelines for onboard installation. A proposal was presented by USA and Sweden to the Sub-committee on safety of navigations 48th session agenda item 18 (Nav 48/18). Especially this proposal brings to knowledge and takes into account the following conventions, regulations, instructions and guidelines:

- **IMO Resolution MSC.90(73) Annex 7, Adoption of amendments to the international convention for the safety of life at sea, as amended.**
- **IMO Resolution MSC.74(69) Annex 3, Recommendation on performance standards for AIS.**
- **ITU Radio Regulations (RR).**
- **IEC 60092 (series), Electrical Installations on Ships.**
- **IEC 60533 Electrical and Electronic Installations in Ships - Electromagnetic Compatibility.**

Further national regulations on top of above mentioned can be applicable depending on each flag states requirement as well as requirements from classification societies, shipyards and ship owners.

3. Preparations for installation

Today several manufactures are marketing their AIS products on the market. Even if the price is an important factor for procurement of onboard AIS equipment, great concern should also be focused on that the product has a legitimate type approval. . It is therefore needed that the AIS devices are tested and approved by an independent body with "approved" test equipment and methods to ensure integrity of the AIS VHF data link (network). Also important is that the installation can be made fast and easy. Especially for the large retrofit part of the ships covered under SOLAS V, regulation 19.

Selecting the AIS on new built ships largely becomes dependent on the selection of the entire bridge system onboard. Today most manufacturers of radars and ECDIS/ECS have or are implementing AIS according to the defined interface protocol and therefore any transponder designed according to these standards could be fitted onboard. Retrofits are a little bit more complex if a solution with presentation of AIS data on other displays than the dedicated AIS Minimum Keyboard Display (MKD) is preferred. Interfacing to older radar equipment is in most cases not possible. ECDIS or ECS system will if interfacing is possible in most cases require new software and thereby approvals (ECDIS). Sensors providing information in to the AIS e.g. Gyro and Speed log, could require converters before interfacing. This means that before purchasing and installing your AIS equipment you should on new built ships demand an open AIS interface to your display systems like radar and ECDIS. On older ships you need to check the possibility for integration into existing systems. An ECS system could be a cost efficient presentation solution as a complement to the MKD. Older sensor equipment has to be checked for interoperability with the AIS unit if interfacing is required. In general all sensors installed under other carriage requirements, able to be connected to the AIS transponder, should be connected. This does however not require any new additional equipment to be installed above the carriage requirements

The positions of the AIS antennas are vital for a successful installation. Existing or planned, antenna installations have to be considered in the installation process. Normally all [antennas need](#) an as high as possible location. The perfect AIS installation should have both GPS and VHF antenna at the highest point with free line of site 360° as close as possible to the transponder itself so that unnecessary cabling can be avoided. Unfortunately several other equipment requiring antennas has the same rule so the position planning is as already mentioned crucial to avoid interference.

Since one of the most time and cost consuming process of the installation is running the cables a carefully planning is recommended. On new built ships it is obviously easier since the work can be planned already at the drawing desk. In many cases the retrofits, cabling will probably be handled by the crew, to reduce cost and time in port. Guidelines to the crew and solutions from the manufactures that provides as short cable distances as possible are important.. Short cable distances are also important to avoid losses in the feeders.

It is important to not only remember cabling for the antenna feeders also the connections to other sensors, equipment, power and displays should not be forgotten.

The table below gives recommendation on cables that can be used for the GPS-antenna connections. Due to the high frequency it's important that the attenuation in the cable is low for the specific frequency (1.5 GHz).

Type	Attenuation @ 1.5 GHz (dB/100m)	outer Diam.(mm)	Weight (kg/100m)
RG 400	60	4,95	6,3
RG 223	60	5,40	5,5
RG 214	35	10,8	18,5
RG 225	30	10.9	23,3

For optimum performance of the transponder approximately +10dB gain should be available when the cable attenuation has been subtracted from the GPS-antenna preamplifier gain.

Example:

Cable type	Preamplifier Gain (dB)	Recommended min cable length (m)	Recommended max. cable length (m)
RG 223	12	0	20
RG 223	26	20	45
RG 223	36	45	60
RG 214	12	0	35
RG 214	26	35	70
RG 214	36	70	100

Min. length = (Preamp. Gain – 10 dB)/Cable attenuation per meter

Max length = Preamp. Gain/Cable attenuation per meter

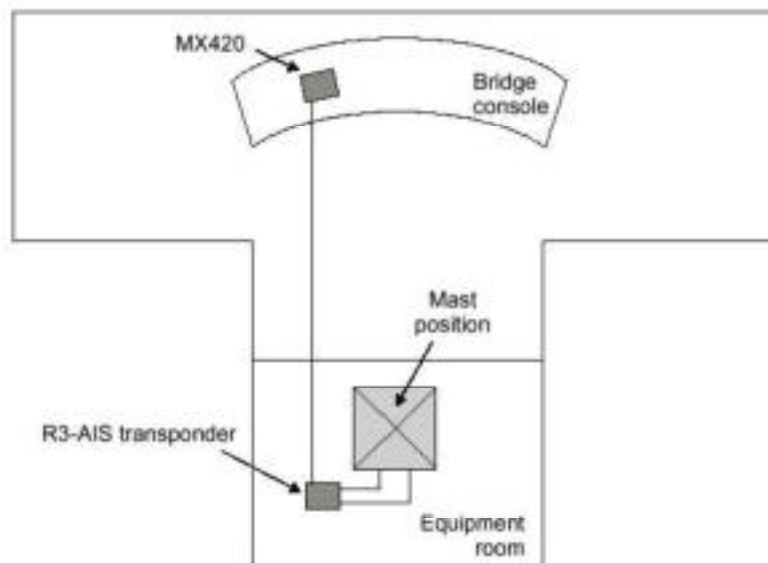
The table below gives recommendation on cables that can be used for the VHF-antenna connections. The cable attenuation shall be kept as low as possible, a 3 dB loss is the same as a reduction of the input and output signal power to a half.

Type	Attenuation @ 150 MHz (dB/100m)	Ø(mm)	Weight (kg/100m)
RG 214	7	10,8	18,5
RG 217	5	13,8	30,1
RG 225	8	10,9	23,3

Example: A cable of 40 meter RG 214 attenuates has a cable attenuation of 2,8dB.

4. Installation

The transponder is preferably mounted in cabinets or the equipment room as close to the antenna location as possible to avoid long cables. The AIS dedicated display should be mounted at the coning position so that the information can be easily accessed by the OOW and compared with other sensors if not integrated into other display functionality e.g. radar or ECDIS.



Choosing a Safe Physical Environment

Select a location away from heat sources, such as heating vents or equipment heat exhausts. Avoid areas where there are a high flow of humid salt air (e.g. port holes/windows, and hatches that are open to the outside) and high levels of vibrations and shocks.

Ensure that there is enough airflow to avoid high ambient temperatures.

Allowing for Proper Distances

Select a location that will minimize cable lengths between components. Install the transponder as close as possible to VHF/GPS antennas to avoid unnecessary attenuation of the RF-signal.

You should try to leave space of clearance around the transponder to facilitate service and installation. The display and data input unit if not integrated in other bridge system functionality should be easy accessed and visible for the OOW.

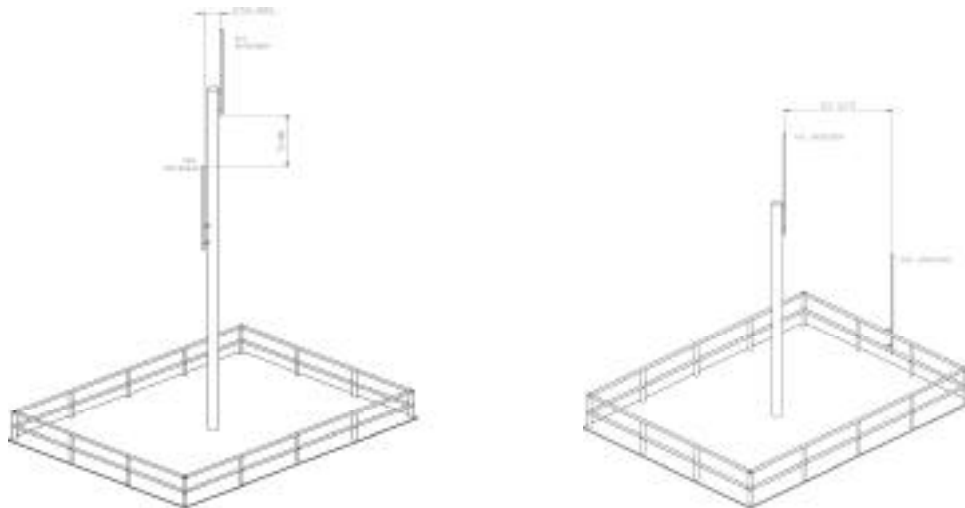
IMO proposed guidelines states the following about the MKD:

“The functionality of the “Minimum Keyboard and Display (MKD)” shall be available to the mariner at the position from which the ship is normally operated. This can be by means of the AIS internal MKD (integrated or remote) or through the equivalent functionality on a separate display system. In the case of a separate display, the internal MKD does not need to be installed.

External display systems which provide MKD functionality, are acceptable.”

The transponder is a low noise device, but as it transmits short bursts of energy on a continuous basis, the possibility of interference to other VHF radios must be minimised by following the guidelines provided by IMO below.

The following picture illustrates vertical and horizontal separation:



Proposed IMO Guidelines

The proposed Guidelines from IMO recommends the following about the antenna installation.

2.1 Interference to the Ship's VHF Radiotelephone

The AIS ship borne transponders, like any other ship borne transmitting equipment operating in the VHF maritime band, may cause interference to a ship's VHF radiotelephone. Because of the burst transmission nature of the AIS, this interference may be heard as a periodic (e.g. every 20 second) soft clicking noise on a ship's radiotelephone. Normally the squelch circuit will mask this effect and the noise will only be noticed during reception of a signal. This problem may become more noticeable when the VHF radiotelephone antenna is located near the AIS VHF antenna and when the radiotelephone is operating on channels close to the AIS operating channels (e.g. duplex channels 27, 28 and 86).

Attention should be paid to the location and installation of different antennas in order to obtain the best possible efficiency and suppress noise. Special attention should be paid to the installation of mandatory equipment like the AIS antennas.

2.2 VHF Antenna Installation

2.2.1 Location

Location of the mandatory AIS VHF-antenna should be carefully considered. Digital communication is more sensitive than analogue/voice communication to multipath interference created by reflections from obstructions like masts structures etc. It may also be necessary to relocate the VHF radiotelephone antenna to minimize interference effects.

To minimize interference effects, the following guidelines should apply:

- The AIS VHF antenna should have omni directional vertical polarization providing 3 to 5 dBi gain.
- The AIS VHF antenna should be placed in an elevated position, which is clear from obstructing conductive materials. The antenna should not be installed close to any large vertical obstruction. The objective for the AIS VHF antenna is to have a clear view of the horizon.
- The AIS VHF antenna should be installed safely away from interfering high power energy sources such as radar and other transmitting radio antennas, preferably at least 3 meters away from and out of the transmitting main beam.
- There should not be more than one antenna on the same level. The AIS VHF antenna should be mounted directly above or below the ship's primary VHF radiotelephone antenna, with no horizontal separation and with a minimum of 2 meters of vertical separation. If it is located on the same level as other antennas, the distance apart should be more than 10 meters.

2.2.2 Cabling

The cable should be kept as short as possible to minimize attenuation of the signal. Double shielded coaxial cables equal or better than RG214 are recommended.

All outdoor installed connectors on the coaxial cables should be fitted with preventive isolation such as shrink stocking with silicone to protect against water penetration into the antenna cable. Coaxial cables should be installed in separate signal cable channels/tubes and at least 10 cm away from power supply cables. Crossing of cables should be done at right angles (90°). Coaxial cables should not be exposed to sharp bends, which may lead to change the characteristic impedance of the cable. The minimum bend radius should be 5 times the cable's outside diameter or in according to manufacturer recommendation.

2.2.3 Grounding

Coaxial down-leads must be used for all receiving antennas, and the coaxial screen should be connected to ground at one end.

2.3 GNSS Antenna installation

A Class A AIS shall be connected to a GNSS antenna.

2.3.1 Location

The GNSS antenna must be installed where it has a clear view of the sky. The objective is to have a clear view of the horizon with a vertical view of 5 to 90 degrees above the horizon. Small diameter obstructions, such as masts and structures, do not seriously degrade signal reception, however such objects must not eclipse more than a few degrees of any given bearing. Locate the antenna at least three meters away from and out of the transmitting beam of high-power transmitters (S-Band Radar and/or Inmarsat systems). This also includes the ship's own AIS VHF antenna if it is designed and installed separately.

If a DGNSS system is included or connected to the AIS system, the installation of the antenna shall be in accordance with IEC 61108-4, Ed 1, annex D.

2.3.2 Cabling

To achieve optimum performance, the gain of the antenna pre-amplifier should match the cable attenuation. The resulting installation gain (pre-amplifier gain - cable attenuation) should be between 0 and 10 dB. The coaxial cable between the antenna and the AIS transponder connector should be routed directly in order to reduce electromagnetic interference effects. The cable should not be installed close to high-power lines, such as radar or radio-transmitter lines or the AIS VHF antenna cable. Crossing of antenna cables should be done at 90 degrees to minimize magnetic field coupling.

2.4 Power source

The AIS shall be connected to an emergency power source¹

The AIS transponder should normally be connected to the ships 24 VDC supply.

¹ A further requirement to connect AIS to the reserve power source of the GMDSS is under review by IMO.

Connectors

Not mentioned in the IMO guidelines are suggestions for connectors to use for the antenna installation. The marine environment requires the installations to be waterproof and corrosion resistant. Type N connectors are well suited for this type of installations and meet these requirements.



Pilot plug

According to the AIS standard a pilot plug connection should be available to provide connection for embarked pilots. This allows easy access for the pilots using their own equipment to access the data available from the transponder and thereby avoiding interference with the OOW tunings etc.

The proposed IMO guidelines state about this the following:

“A pilot input/output port is part of an AIS Class A station. A plug connected to this port should be installed on the bridge near the pilot’s operating position so that a pilot can connect a Personal Pilot Unit (PPU).

The pilot plug should be configured as follows:

•AMP/Receptacle (Square Flanged (-1) or Free-Hanging (-2)), Shell size 11, 9-pin, Std. Sex 206486-1/2 or equivalent with the following terminations:

- TX A is connected to Pin 1
- TX B is connected to Pin 4
- RX A is connected to Pin 5
- RX B is connected to Pin 6
- Shield is connected to Pin 9”

Long Range AIS

The AIS transponder also has a predefined connection for long range communication over e.g. Inmarsat C. This requires a connection to the onboard equipment of possible according to the requirement for interfaces as described in IEC 61162-2. IMO proposed guidelines states the following:

“).

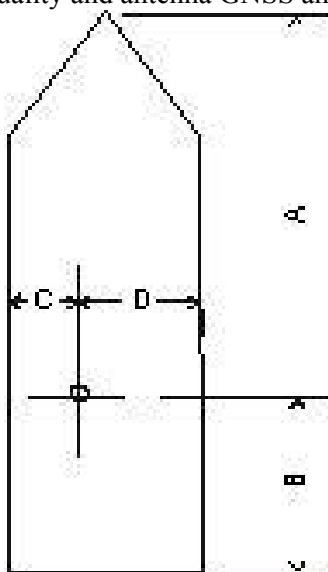
If this is available, a connection between that communication system and the Class A mobile unit can be made. This connection is needed to activate the LR function of AIS. Its I input/output port must meet the requirement of IEC 61162-2.”

5. Commissioning

The commissioning of the AIS system should of course verify that the installation has been properly done. Recommended a certified Service Engineer for the installation and the commissioning to secure proper installation and functionality

If no other ships are available at the commissioning an extra portable transponders can be a good tool to verify the AIS installation. A thorough test procedure has to be performed according to a checklist containing at least the following items:

- Optical inspection of installation
- Verify antenna installation quality and antenna GNSS antenna positions



- Run Built in test functionality
- Check static data input (See also IMO proposed installation guidelines that states the following:

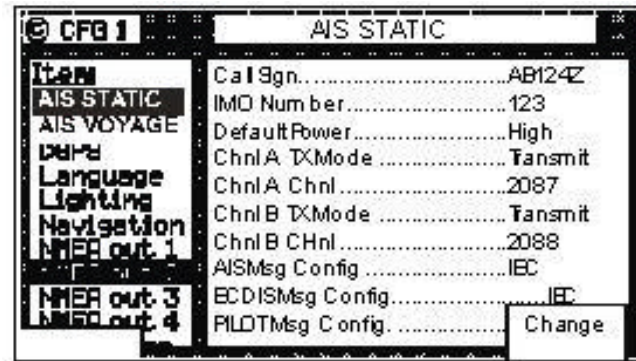
“Information that should be entered at the initial installation of the AIS includes:

- Maritime Mobile Service Identity (MMSI) number
- IMO vessel number
- Radio call sign
- Name of ship
- Type of ship
- Dimension/reference for position of the electronic position fixing device (EPFD) antenna (see paragraph 5.2)

Access to **MMSI, IMO number** and other AIS controls (like power and channel settings) will be controlled, e.g. by password.

The **Call Sign, Name of Ship** and **Type of Ship** must be input to the AIS, either manually using the MKD or by means of IEC 61162 sentences “SSD” and “VSD” via the PI. Type of Ship information shall be in accordance with the table given in Annex 2 (Table 18 from Rec. ITU-R M.1371-1).

For example, a cargo ship not carrying dangerous goods, harmful substances, or marine pollutants; would use identifier “70”. Pleasure craft would use identifier “37”. Note that ships who’s type identifier begins with a “3” must use the fourth column of the table. Depending on the vessel, cargo and/or the navigational conditions, this information may be voyage related and would therefore be changed before beginning or at some time during the voyage. This is defined by the “second digit” in the fourth column of the table.”



EXAMPLE OF STATIC DATA INPUT MENY IN MKD

- Verify connection and input to display systems. This should be done together with the supplier of those systems.
- Verify connections and data from other sensors.
- Verify system operation (against other transponders available or test unit)

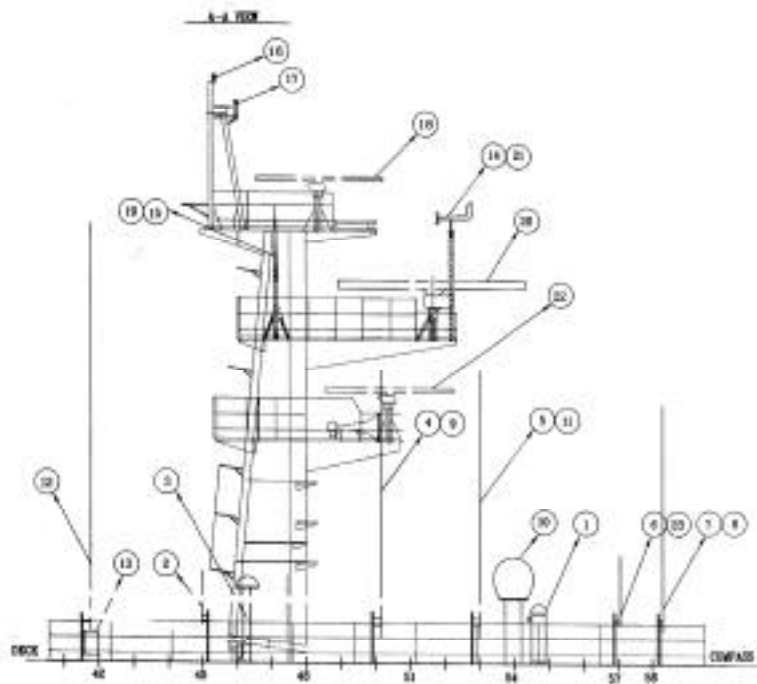
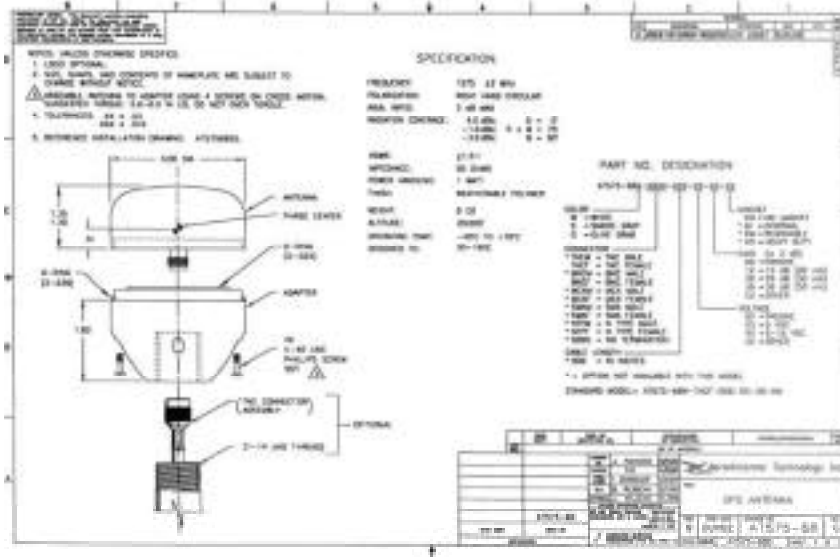
System security

It is important that static data configured in the transponder cannot be tampered with. Therefore some kind of access level is required to input this data in to the AIS transponder, to avoid fraud in e.g. actions of piracy. It should be up to the competent authority or maybe also in the guidelines for AIS to provide a solution to a logistic chain that can secure easy availability for changing the data if required. At the same time changing the data should only be possible for a reliable and trusted source of competence. Maybe an international register like the once used in mobile telephony to avoid abuse of stolen or wrongly programmed transponders could be an idea for IMO to consider. This register should then at least contain information about equipment type, serial number related to what MMSI number as well as IMO number, maybe also ship name and owner. The MMSI number is the most sensitive data.

Documentation

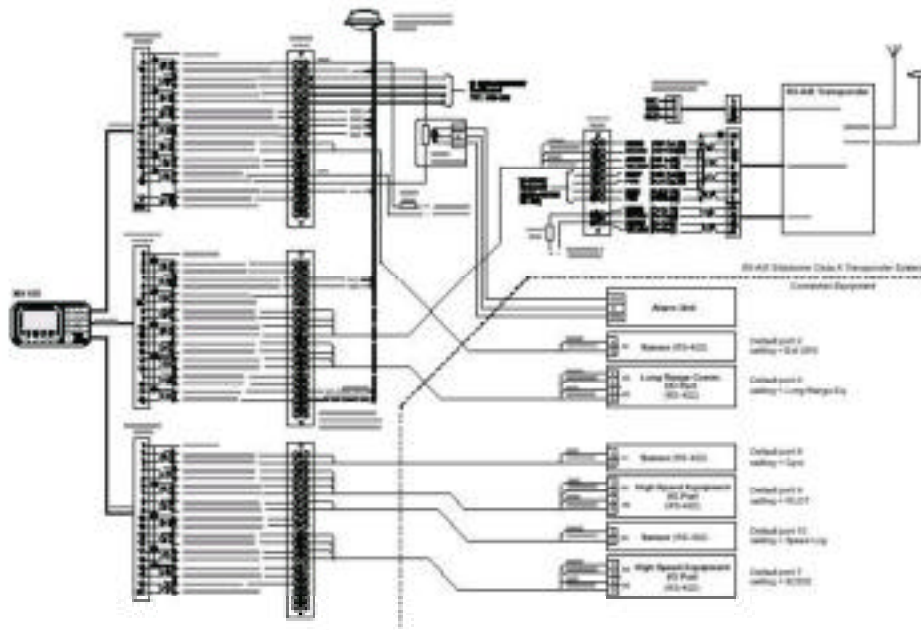
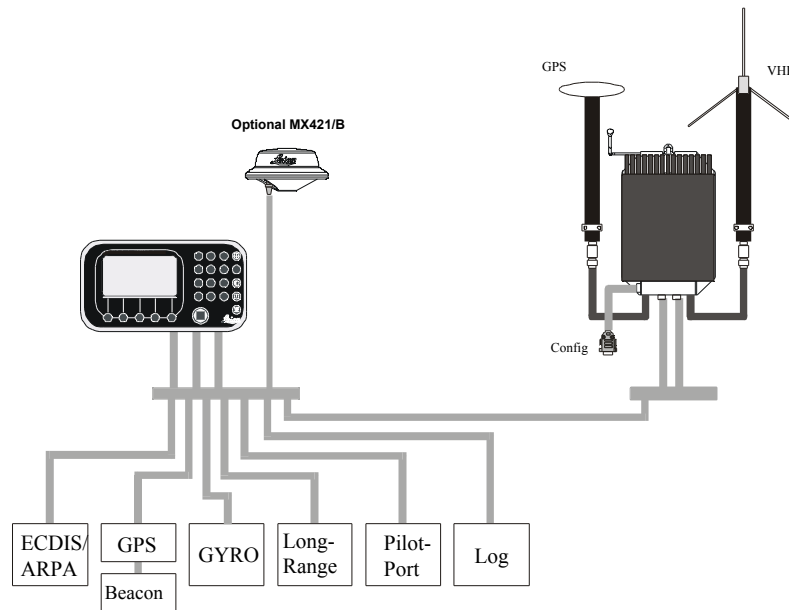
The AIS transponder should be delivered with installation manuals and operator’s manual (user) further IMO installation guidelines will also recommend that drawings of the following shall be submitted:

•Antenna layout



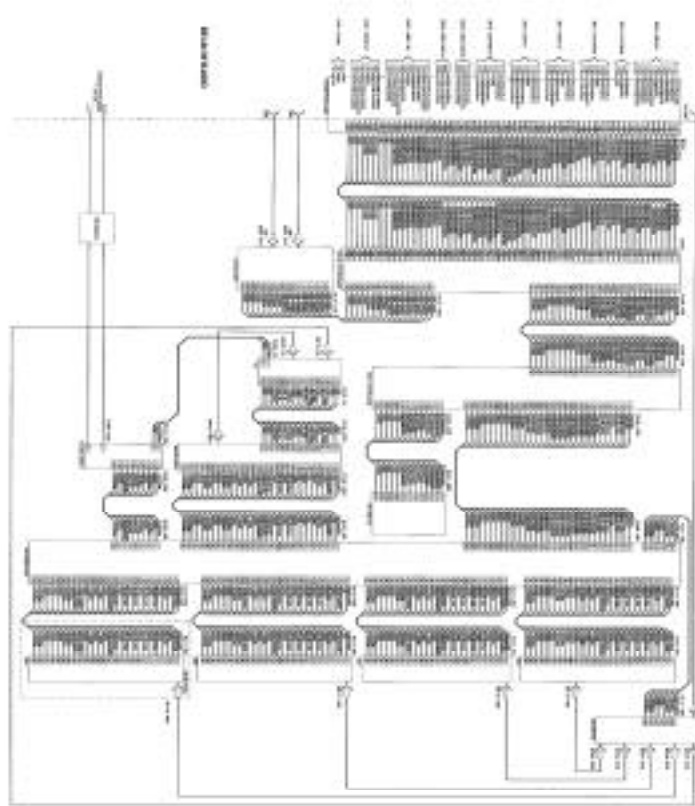
EXAMPLE OF ANTENNA LAYOUT

•AIS arrangement drawing



EXAMPLE OF INSTALLATION DRAWING

- Block diagram (interconnection diagram)



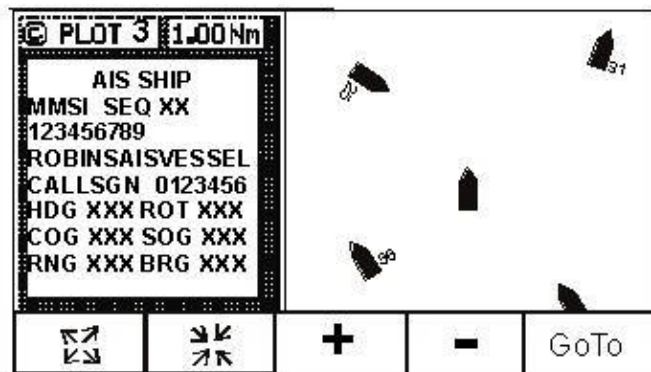
EXAMPLE OF INTERCONNECTION DIAGRAM

An initial installation configuration report should be produced during installation and kept on board.

6. Operation

Running the system after installation will not be covered by this presentation but some operational matters related to the installation process needs to be addressed.

It is important that the crew as part of preventive maintenance check that the transponder is providing correct position information since not doing so will provide data that could create confusing situation pictures for other ships.



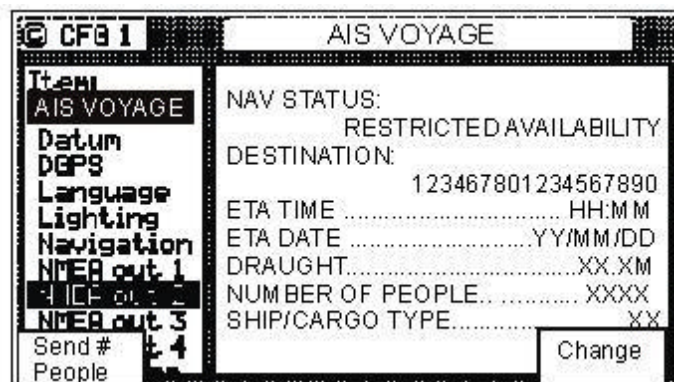
CORRECT POSITION IS ESSENTIAL FOR THE CORRECT DISPLAY

Preventive maintenance also requires regular control of radio coverage. US Coast Guard has provided figures that set 20 nautical miles as a normal range for onboard installation. It is however highly dependent on the height of the VHF antennas. Regularly controlling the antenna connections for corrosion should be part of the maintenance.

Normally AIS transponders are not repaired onboard and could be considered as LRU (Line Replaceable Units) but some fuse and other details according to the manufacturer could be kept as spare parts onboard.

Finally learning to handle the equipment is essential so that this new technology can provide the enhancement of safety as expected. This means e.g. to input correct data into the transponder. The AIS Transponder with the MKD should however with its manuals be considered as relatively easy to learn. Manufacturers might also provide interactive teaching programs to faster and easier train on their equipment.

EXAMPLE OF INPUT
OF VOYAGE RELATED
DATA



7. Summary

The AIS transponder can be installed relatively easy onboard both new built ships and retrofit ships. If compared to other equipment in complexity it could be a VHF radio installation with some added complexity for the integration of other sensors and displays. If cabling (cabling requires 1-2 days with two persons) is done the actual installation should not take more than 4-6 hours by a skilled engineer. Good preparations are of course vital for the success. The problems described above are normal and easily handled by the many skilled installation engineers around the world. This means therefore that the worries about installation as a narrow point at an accelerated AIS implementation can be reduced so that the tool for enhanced safety at sea and coastal security can be provided in line with the proposed timetables.