e-NAV13 Input paper

Agenda item 9.6

Task Number 32

Author(s) / Submitter(s) N Ward

Reliability of AIS Data

# Summary

This paper contains a technical analysis of the reliability of AIS data, drawing on work already carried out on failure modes of AIS aids to navigation. It is provided in response to a question posed by the IALA Legal Advisory Panel (LAP).

## Purpose of the document

The Committee is invited to consider the contents of this paper when preparing an answer to the question from the LAP on the reliability of AIS data.

## Related documents

References given in paper.

# Background

This technical analysis on the reliability of AIS data arises from a request by the IALA Legal Advisory Panel to the e-Navigation Committee. This in turn arose from the increasing use of AIS data in court cases. The analysis draws on work already carried out on failure modes of AIS aids to navigation.

It should be noted that AIS was originally provided for safety reasons, not for security purposes, so it was never designed to be resistant to malicious interference.

# Discussion

**3.1 Causes of failure**

A Failure Mode and Effect Analysis was carried out on AIS AtoNs in 2011 (1) and this identified the following potential causes of failure:

* Incorrect data input to AIS unit
* Failure of AIS unit
* Disruption to GNSS (GPS)
* Degradation of VHF propagation
* Loss of VHF reception
* Control system malfunction

These overall headings can be used in a general way to analyse causes of AIS data loss or corruption and thereby to assess the reliability of AIS data.

The categories can be broken down further into sub-systems, as follows, with comments on the probabilities of each cause, where data is available.

**3.2 Data Input**

Data input to an AIS device can be divided into Static, Dynamic and Voyage related. Static data in the case of a ship will include MMSI, name and type (e.g. cargo, tanker, fishing, sailing vessel, other). Dynamic data will include position, heading, COG, SOG. Voyage related information includes draft, destination and ETA.

Static information is input either at installation, or when some change is made, such as during a refit. This information would generally be correct, unless manipulated for the purposes of deception (2).

Dynamic information is derived from onboard sensors, such as a GPS receiver, compass or log. There are three ways in which this information can become erroneous: sensor failure, deliberate manipulation (e.g. jamming) and incorrect interfacing. Interfacing problems should be detected and corrected during initial trials, but sensor failure or manipulation could occur at any time.

Voyage related information may be the commonest source of error, since the task of changing the information for each leg of a voyage can be overlooked. Destination information from ferries, for example, is often not changed for the return leg after completing the outward leg.

**3.3 Failure of AIS unit**

Failure of the AIS unit was calculated to be the most likely cause in the case of an AIS AtoN – contributing roughly three-quarters of the overall probability of failure, based on manufacturer’s MTBF figures. Reliability figures may have improved for newer units, with better design and components, but the original equipment is still installed on many vessels, so this figure is still appropriate.

**3.4 Disruption to GNSS (GPS)**

There are two components to this source of failure: the GPS receiver and the system itself. GPS receiver failure, again based on manufacturer’s data, contributes about a quarter of the total, whereas the probability of an *undetected* satellite or ground station fault is relatively small. However, this assumes that Receiver Autonomous Integrity Monitoring or differential corrections are available. If not, then this becomes a much more significant contributor.

**3.5 Platform and Power Supply failure**

This might be expected to be much more significant for an unattended floating platform such as a buoy than for a vessel, but the contribution is very small, even for a buoy and the causes (mooring breakage or dragging) would not apply to a vessel.

Power supplies on a buoy might be expected to be less reliable than on a ship, but the overall contribution is again quite small.

**3.6 Effects of VHF propagation**

Atmospheric noise is not a significant problem at VHF. Stratification causing anomalous propagation can extend ranges to as much as five times the normal 20-40 M. However, this phenomenon is related to particular weather conditions, mainly dependent on season and location, therefore it is difficult to apply a realistic probability to it.

**3.7 Loss of VHF reception**

The likelihood of interference to VHF is significant, either from other authorised stations, or from faulty equipment. However, it is again dependent on location, seasonal and diurnal factors, so that the confidence of any prediction of probability would be very low.

**3.8 Control system malfunction**

National AIS networks would normally have backup systems. Communication links in remote areas could be a single point of failure, but would only affect very limited areas.

**3.9 Malicious interference**

AIS was introduced as a safety system and has no inherent protection against malicious interference. False transmissions, or transmission containing false information can often be detected by suitably aware and trained operations personnel. However, procedures for this purpose are not generally publicised or standardised, partly because that would alert the perpetrators and make it easier for them to circumvent these measures.

Jamming and spoofing of GPS have been demonstrated on many occasions (3) and false AIS data can certainly result. It would be technically possible to create false AIS transmissions by setting up a base station and programming it appropriately. However, input of false information to existing AIS units is much simpler and more difficult to detect. There have been many examples of this approach.

Corroboration of AIS information, by radar for example, would be needed to ensure that it is correct.

# Conclusions

The main, predictable contributors to the probability of AIS AtoN failure are the reliability of the AIS unit itself and the reliability of the GPS unit. This assumes that some form of GPS integrity monitoring is in place. Both these factors could be expected to make similar contributions to the overall reliability of AIS onboard ship.

Other causes are relatively insignificant, or difficult to predict. Further work would be required to establish an overall probability of erroneous data, probably drawing on records collected over long periods.

The probability of disruption, particularly malicious interference such as jamming or spoofing is impossible to predict. However, such disruption is certainly possible. Procedures and training can detect and mitigate this disruption to some extent, but cannot eliminate it.

The overall conclusion is that the correctness of AIS data cannot be relied upon, in the absence of competent monitoring, or corroborative information.

# References

5.1 GLA 2011. AIS AtoN FMEA, Report No: RPT-49-NW-11.

5.2 Reuters 2012. www.reuters.com/article/2012.

5.3 GLA 2010. GPS Jamming Demonstrations, Report No: RPT-AJG-10.