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Use of AIS Binary Messages

Submitted by Germany and Sweden

SUMMARY

Executive summary:	This document describes the technical limitations for the use of AIS binary messages and presents the results of a study of the existing usage of the AIS VFH Data Link. Further work to develop guidelines for the use of AIS Binary Messages is proposed
Action to be taken:	Paragraph 31
Related documents:	MSC 82/21/13 and MSC 82/24, paragraph 21.41

Introduction

1 The AIS system has since its introduction proven to be quite useful for its main purposes although there are some technical limitations. The occurrence of inferior installations and incorrect/incomplete handling has also been frequently observed.

2 IMO has given guidance on the application of AIS binary messages in SN/Circ.236, developed by the Sub-Committee on Safety of Navigation at its forty-ninth session (30 June to 4 July 2003). SN/Circ.236 states that after a four year trial period "all SOLAS ships and a large number of non-SOLAS vessels are expected to be equipped with AIS, allowing IMO to evaluate the benefit and practicability of AIS binary messages, as well as the loading of the AIS frequencies". For vessels where SOLAS don't require AIS have the implementation been delayed because of delayed standards but is now starting.

Background

3 In addition to the guidance given by IMO, ITU has in Recommendation ITU-R M.1371-3 Annex 5 given guidance for the design of the application specific part of the binary message, called "function messages". The function messages are divided into "International Function Messages" and "Regional Function Messages" with the intention to allow regional development of messages in addition to the messages that are internationally agreed.

4 Proposals have been made to use AIS binary messages to cater for the developing need for digital communication between shore and ships since no other relevant system is in place.

5 The increasing number of shipborne AIS units and the establishment of shorebased AIS infrastructure have in some areas lead to a high utilization of the limited capacity of the AIS Data Link (VDL) and a further increase can be expected. Therefore, it is important that IMO gives guidance for the use of AIS binary messages so that the main functions of AIS will not be impaired.

6 When the use of binary messages is discussed it is important to focus on the main functions of the whole AIS system. The technical characteristics, the loading of VDL, the man-machine interface and other available or emerging communication methods must be taken into account.

Technical limitations

7 The principle of operation of AIS is based on the use of well defined time slots. Under steady-state conditions, each unit preannounces its planned transmissions in order to give other units, within its coverage area, the possibility to avoid transmissions in the same timeslot. (Self Organized Time Division Multiple Access - STDMA) Each ship makes up a “cell” together with other ships in its coverage area. Ships normally participate in several cells which partly overlap each other and receive transmissions that are not co-ordinated in time. Weaker signals are discriminated in the receiver if there is a sufficient difference in signal strength.

8 The resulting effect is that there is a high probability of successful reception of an AIS message from ships close to own ship and that the probability decreases with increasing distance and load on the VDL. The throughput, the percentage of messages that are succefully received, will vary. Three throughput zones can be identified:

.1 the Aloha Zone,
.2 the Discrimination Zone, and
.3 the Protected Zone.

9 The coverage area of a ship in position R can be estimated as a circular area with the radius r.

10 The Aloha Zone stretches from r to r/2. Any time stations within this zone attempts to reuse the same time slot, garbling will occur at R. With an increase in required capacity, the time slot reuse is increased. Since this results in garble, the net throughput is decreased proportionally.

11 The Discrimination Zone stretches from r/2 to r/3. Within this zone, transmissions, in reused time slots, may result in garble or discrimination. The net throughput is increased, at R, as a transmitting station moves from r/2 towards r/3. Stations within the Discrimination Zone are able to receive each other, and are thus STDMA organized. Slot reuse then only occurs in time slots used by stations in the Aloha Zone

12 The Protected Zone stretches from r/3 to 0 (zero). Within this zone, all stations are STDMA organized. Slot reuse will occur in slots used by stations in the Aloha Zone. Each time slot reuse occurs, it will result in discrimination, thus allowing closer stations to have 100% net throughput. The protected zone ensures good throughput between stations which are close to each other.

13 Shore-based AIS stations normally have coverage areas which are much larger than the coverage areas of ships. The shore-based stations therefore receive transmissions from multiple different uncoordinated cells which may cause garbling.

14 Slots may also be reserved for use by the shore based AIS stations. These slots are "protected" up to 120 NM from the transmitting stations by all mobile units that have received the reservation message. (ships approaching the station normally do not receive the message at such a long distance). Such slots may also be used by ship stations when interrogated from a shore station. Mobile stations may be interrogated for dynamic and static data – other messages must be transmitted in slots reserved by own unit.

15 The resulting effect of the reservations from shore based stations is that a number of slots can be made unavailable for use by ships in large areas without making the slots free from interference. The probability of receiving transmissions from shore stations decreases with increasing distance between ship and shore station and with increasing load on the VDL.

16 The mechanism for transmission of unscheduled messages, for example when a ship increases its update rate due to a change of course, involves an increased risk of collision with other transmissions. The probability for a successful reception of such messages decreases with increasing load on the VDL and with distance.

17 For broadcasted AIS message there is no function available to check if and by whom the message is successfully received. This problem is normally mitigated by repeated transmissions which increase the probability for successful reception but increases the VDL load. For addressed messages an acknowledgement can be requested from the receiving part, which also creates a load on the VDL.

Present situation on the VDL

18 To complement earlier theoretical studies and simulations a number of recordings of received AIS transmissions have been made and used for off-line analysis of the VDL with a specialized software. The recording was performed using a special AIS receiver able to measure both the time domain of the received data as well as the signal level domain. The results are summarized below.

19 The Rotterdam area

The average load in the AIS system measured (2007-03-06) from the VTS at Rotterdam is approximately 20% with load peaks of up to 40%.
The receptions from a few vessels which were studied in detail vary from 36% to 100%.
Two vessels on mid range provides lower throughput than the others, 36% and 58% compared to almost 100% for the others. The reason for that may be installation or equipment related or caused by the fact that the AIS antenna on board is shaded from the reception point.

20 The Dover area

The average load in the AIS system measured (2007-03-07) from the VTS at Dover is approximately 20% with load peaks of up to 36%.

21 The Hamburg area

The average load in the AIS system measured (2007-03-05) from a building close to the port area (Hotel Hafen) is approximately 10%. The receiving range was however limited to 10 Nm, presumably due to high background noise level in the area.
The receptions from a few vessels which were studied in detail vary from 57% to 100%.

22 The Gothenburg area

The average load in the AIS system measured (2007-03-10) from the ferry Stena Germanica at the approach to Gothenburg was approximately 10 % with load peaks up to 40 %.
The receptions from a few vessels which were studied in detail vary from 86% to 100%.

23 The Trelleborg area (south Sweden)

The average load in the AIS system measured (2007-04-16) from the AIS basestation was approximately 32 %.

24 Other observations

- Only 25% of the analysed AIS units did transmit all messages within the stipulated timeframe. Several units transmitted with an offset of several hundred µs.

- The load of the VDL varies strongly from second to second which indicates that the randomization process of the transmitting units don't work as expected.

- A higher load was observed on Channel A compared to Channel B. Some AIS units transmitted up to 90% on channel A.

Expected developments

25 The mandatory carriage of AIS for ships not engaged in international voyages comes into force on 1st of July 2008.

26 The introduction of AIS Class B intended for ships with no carriage requirement for AIS has started and is expected to give a considerable voluntary implementation in many areas.

27 In some regions a mandatory carriage of AIS on fishing vessels is under consideration.

28 The establishment of shore based AIS stations continues and in many areas multiple stations are overlapping each other, each of them reserving slots for own transmissions. Many administrations are considering using AIS for distribution of information and to require information from ships via AIS. In some areas is distribution of differential corrections for GNSS via AIS (Message 17) planned.

29 As a result the requirements for capacity on the VDL will increase both from mobile AIS units and from shore stations. The utilization of AIS for data communication which has begun shows the need for a separate data communication channel. The AIS VDL could then be used to redirect such traffic to other frequencies.

Conclusions

30 There is a need to consider many factors when making guidelines for the use of AIS binary messages. One way of doing this is to establish a correspondence group with a task to develop AIS binary messages and guidelines for their use, taking, among others, the following factors into consideration:

.1 The operational need

.2 The expected load on the VDL

.3 Expected throughput to basestations in high VDL load situations

.4 Available man – machine interface onboard

.5 Emerging other digital communication systems

Action requested by the Sub-Committee

31 The Sub-Committee is invited to note the comments and information provided above and to decide as appropriate.

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