



Report ITU-R M.2169
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Improved satellite detection of AIS

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1 Introduction

Satellite detection of AIS messages has been requested by administrations. In response, studies were made that were documented in Report ITU-R M.2084 – Satellite detection of automatic identification system messages. The report considered the operational and technical characteristics of the shipborne AIS and the requirements and limitations of reception of AIS messages from satellites. Further studies were proposed to deal with the technical limitations that hinder detection of AIS-equipped target ships in high-traffic areas (e.g. the Dover Straits, Singapore, North East United States of America, and the northern Gulf of Mexico) on the designated AIS VDL (VHF Data Link). The technical limitations specifically cited were:

- 1 the length of the AIS message in the time slot (insufficient time buffer for the satellite detection range);
- 2 the large number of messages in the satellite antenna footprint (excess reuse of the time slots in the VDL as detected by the satellite);
- 3 the difficulty satellite AIS has in distinguishing signals between AIS messages and communications from terrestrial services within the satellite antenna footprint (coverage pattern).

This report on further studies shows the need for a special AIS message that is shortened in length and can be transmitted on a special reporting schedule on two other frequencies when those frequencies are designated. Accordingly, a new Recommendation ITU-R M.1371 AIS message (Message 27) and new Radio Regulations (RR) Appendix 18 (AP18) frequencies for this service are proposed.

2 Solving the problem of overlapping messages (blurred reception)

The differences in propagation delay between vessels and the satellite causes the AIS messages to overlap. Thus, the slot composition must be adjusted to increase the time buffer so that the AIS transmissions can be received by the satellite in separate slots without a time overlap. Table 1 serves as the basis for the proposed new Message 27 slot composition shown in Table 5 based on an allowance for the “propagation time delay difference (bits)”. Tables 2 to 4 show the technical parameters, reporting intervals and data packet structure of the AIS messages that are currently approved.

TABLE 1
Satellite AIS reception technical parameters

AIS satellite propagation calculations			
Constants:			
Speed of light (m/s)	299 792 458		
AIS bit-time @ 9 600 bit/s (ms)	0.1041667		
Nautical mile (km/nm)	1.852		
Calculations:	Orbit No. 1	Orbit No. 2	Orbit No. 3
Satellite orbital altitude (km/nm)	600/324	948/512	1 000/540
Slant range to horizon (km/nm)	2 831/1 529	3 604/1 946	3 709/2 003
Ground range to horizon (km/nm)	2 664/1 438	3 281/1 772	3 359/1 814
Difference in propagation distance (km/nm)	2 231/1 205	2 656/1 434	2 709/1 463
Propagation time delay difference (ms)	7.44	8.86	9.04
Propagation time delay difference (bits)	71	85	87
Typical satellite visibility (min) ⁽¹⁾	10.2	13.6	14.0

- ⁽¹⁾ These satellite visibility periods are for a typical overhead pass of the satellite based on a circular, polar-orbiting satellite for the indicated satellite altitudes and a target ship located at 40° latitude. Typical visibility periods will vary depending on a number of factors including satellite inclination angle and target ship latitude.

TABLE 2
Overview of shipboard AIS technical parameters

AIS parameters	Values
Frequencies	161.975 and 162.025 MHz
Channel bandwidth	25 kHz
Platforms	Class A ships, Class B ships, coast stations, navigation aids
Power	12.5 W (Class A); 2 W (Class B)
Antenna type ⁽¹⁾	1/2 λ dipole
Antenna gain ⁽¹⁾	2 dBi with cosine-squared vertical elevation pattern; Minimum gain = –10 dBi
Cable loss ⁽¹⁾	3 dB (estimated)
Receiver sensitivity	–107 dBm for 20% packet error rate (PER) (minimum) –109 dBm for $\leq$ 20% PER (typical)
Modulation	9 600 bits/s GMSK
Multiple access mode	TDMA (self-organizing, random, fixed and incremental)
TDMA frame length	1 min; 2 250 time-slots

TABLE 2 (*end*)

AIS parameters	Values
TDMA slot length	26.7 ms; 256 bits (see Table 4)
Message types	26 types
Message length	1 to 5 slots with 1 slot being the dominant type
Periodic message interval	2 s to 6 min transmit intervals (see Table 3)
Required D/U protection ratio	10 dB at PER = 20% ⁽²⁾

⁽¹⁾ Typical parameters not defined in Recommendation ITU-R M.1371.

⁽²⁾ Parameter specified in IEC 61993-2.

TABLE 3

Reporting intervals for AIS messages

AIS platform	Reporting interval
Dynamic information:	
Coast station	3 1/3 to 10 s interval (10 s nominal)
Class A ship	2 s to 3 min interval (approximately 7 s average) (see Table 4)
Class B ship	5 s to 3 min interval (30 s nominal)
Search and rescue aircraft	10 s interval
Aid to navigation	3 min interval
Static and voyage information	6 min interval
Safety and administrative messages	As required
Data message	As required

TABLE 4

Default AIS data packet bit structure

Power ramp up	8 bits	
Training sequence	24 bits	Necessary for synchronization
Start flag	8 bits	
Data field	168 bits	Default length
Cyclic redundancy code	16 bits	Necessary for error detection
End flag	8 bits	
Buffer	24 bits (typically, the last 20-bit positions are empty)	Necessary to accommodate bit stuffing, propagation and repeater delays, and jitter
Total	256 bits	