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R0124 (A-124) APPENDIX 16
DGNSS BROADCASTS FROM AN AIS SERVICE

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DOCUMENT REVISION

Revisions to this document are to be noted in the table prior to the issue of a revised document.

Date	Details	Approval
30 May 2005	Added comments, and cleaned up document	
1 June 2007	Reorganised into newer template	
5 December 2007	Further editing of the document	
18 September 2008	Editions introduced at e-NAV5, A-124 Edition 1.3 Annex B have been included in this annex	
3 July 2009	References, term and abbreviations removed	
15 March 2011	Comments from e-NAV9 incorporated	
December 2011	Format aligned towards the new IALA document template and minor amendments of contents. Updated in accordance with IALA recommendation to amend the primary document to become an annex resulting in this document becoming an appendix	
September 2020	Ed. 2.1 Editorial corrections.	

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1 INTRODUCTION

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1.2 PURPOSE OF THE APPENDIX

The purpose of Differential GNSS (DGNSS) is to increase accuracy and integrity of position reports from vessel. A base station may transmit DGNSS corrections via AIS VDL if it is connected to a DGNSS reference station. This service can be provided automatically and may be considered a back-up service for the radiobeacon DGNSS service. Unfortunately, the DGNSS corrections are generally not available to a vessel's own EPFS.

This appendix describes how a base station may transmit DGNSS corrections and ensure that a consistent approach is taken whilst implementing a DGNSS service over AIS. In particular, this appendix covers the use of Message 17 for the broadcast of differential corrections. Appendix 14 provides guidance on how to reserve slots for Message 17. This appendix does not define how the differential corrections are generated.

There are currently no mandated requirements to provide DGNSS corrections via AIS. Distributing DGNSS corrections via AIS is an added value service, which may improve the accuracy of AIS position reports, but which is unlikely to affect the positional accuracy of the external GNSS devices.

Concerns have been raised on the effectiveness of using AIS for providing GNSS corrections, primarily due to the restricted update rate, issues of VDL loading and potential for conflict with corrections provided through other augmentation services. It is up to National Competent Authorities to evaluate the appropriateness of providing DGNSS corrections through AIS.

2 PERFORMANCE REQUIREMENTS FOR A DGNSS SERVICE

2.1 ACCURACY, AVAILABILITY AND CONTINUITY

An AIS-based DGNSS service should comply with the current IMO requirements for the accuracy, availability and continuity for a World-wide Radionavigation System. A summary of the requirements at the time of the publication of this document are given in Table 1. Also in the table is the number of stations needed to meet the IMO requirements based on IALA Recommendation R-121 on the Performance and Monitoring of DGNSS Services in the Frequency Band 283.5 – 325 kHz_Dec2004.

Table 1 Accuracy, availability and continuity requirements for GNSS by IMO

Area	Absolute horizontal accuracy (95%)	Availability	Continuity	Augmentation
Ocean	≤ 100 m	>99.8% over 30 days	N/A	None
Harbour entrances, Harbour approaches and coastal waters	≤ 10 m	>99.8% over 2 years	>99.97% over 15 minutes	2 or more stations

At the time of writing, the definition of Availability and Continuity for an AIS service has not been defined. The definition of continuity is currently being discussed at IMO. The competent authority should define these criteria locally and ensure that their AIS DGNSS service complies with the IMO requirements using these definitions.

2.2 INTEGRITY

The competent authority should refer to IALA Recommendation R-121 for recommendations of implementing integrity checks of the DGNSS system. This should include a separate integrity check of the contents of the transmitted Message 17.

It should be noted that, in addition to the requirements highlighted above, the time for broadcasting an integrity warning to the user, from the time the integrity problem is identified, should not be greater than 10 seconds. When it has been determined that the error condition no longer exists, there may be a delay, similar to that used for initially identifying the error before the error warning is withdrawn.

2.3 AIS REQUIREMENTS

DGNSS Corrections should be transmitted over the AIS VDL using Message 17 only. In accordance with ITU-R M.1371, the surveyed position of the DGNSS reference station must be given in Message 17. In accordance with IALA Recommendation R0121 (R-121), the reference station antenna should be surveyed to a 3-D accuracy of 0.2m. Corrections may be given for GPS, GLONASS, and any other future operational GNSS services (e.g. Galileo, Compass). Recommended RTCM messages to be transmitted in AIS Message 17 are:

- RTCM Messages 1 or 9[1] for GPS corrections;
- RTCM Message 31 or 34[2] for GLONASS corrections;

At the time of writing, it is recommended that no other RTCM Message Types be used as these will use valuable bandwidth. Future RTCM Messages Type may be relevant for transmission, although consideration must be given to legacy mobile users.

Message 17 should preferably be transmitted using FATDMA (Usage category 2 – Appendix 14) with a transmission scheme that allows the system to meet the 10-second TTA requirement. It is recommended that RATDMA is not used for Message 17 transmissions due to the possibility of the message not being broadcast in time to meet the TTA requirement. The probability of a slot collision is also increased with the use of RATDMA, particularly in busy areas.

2.3.1 VDL Loading Requirements

With regular, high volume data being broadcast on the AIS VDL, the potential issues regarding the loading of the VDL must be considered. The slots allocated to the service should comply with the FATDMA Plan (see Appendix 14). Through trials, it has been found that most Class A stations will revert to an uncorrected position state after the age of the corrections exceed 30 seconds, and therefore, a new set of corrections should be made available every 30 seconds or less. This should not affect the 10-second TTA requirement.

3 FUNCTIONAL DESCRIPTIONS

3.1 OVERALL SYSTEM DESCRIPTION

The AIS shore-based infrastructure allows for DGNSS corrections to be broadcast to AIS users in the vicinity of the AIS PSS Controlling Units. Figure 1 shows how DGNSS corrections enter the AIS shore-based infrastructure, and that the information flows down to the VDL. The majority of the AIS shore-based infrastructure remains identical to the general structure of the AIS Service, with the ASM controlling the configuration of the AIS-LSS and AIS-PCU, and reporting back the status of the AIS Service back to the External Services.

[1] Concern has been raised that RTCM message 9 only contains corrections for 3 SV, and that nowhere is it described how AIS Base Stations should handle buffering of correction data from different RTCM messages to compile an AIS Message 17.

[2] Concern has been raised that RTCM message 34 only contains corrections for 3 SV, and that nowhere is it described how AIS Base Stations should handle buffering of correction data from different RTCM messages to compile an AIS Message 17.

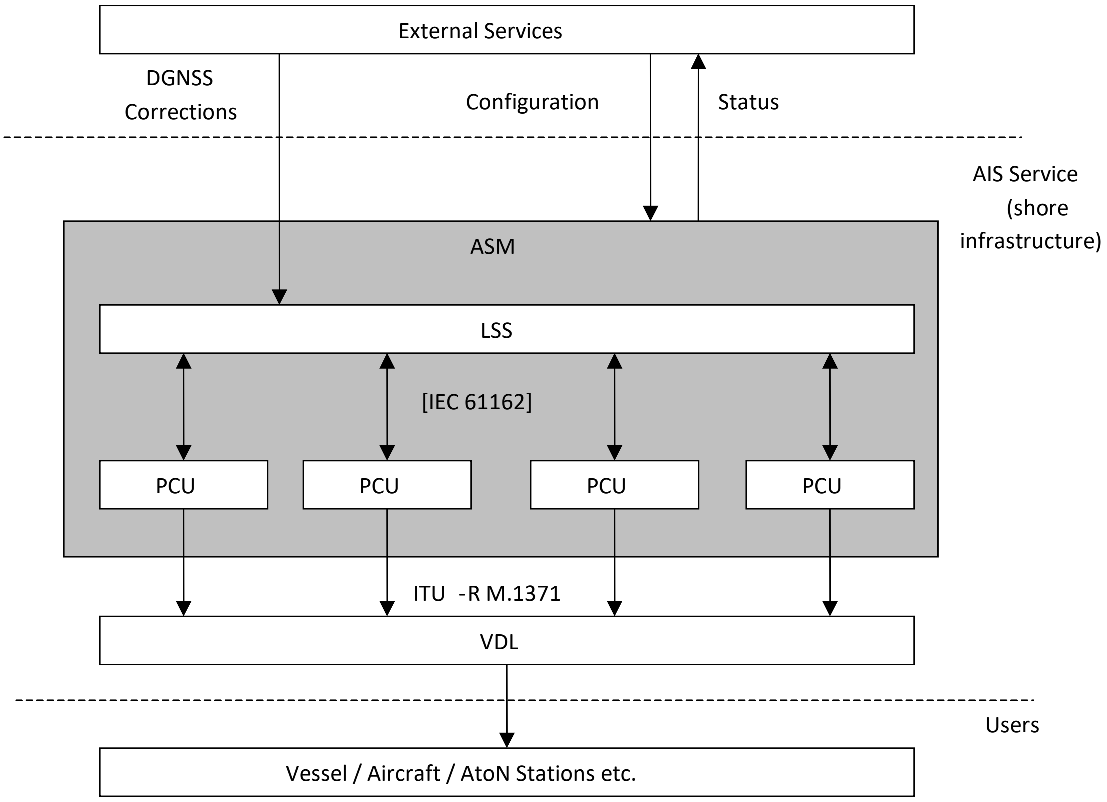

Figure 1 DGNSS Corrections within the AIS shore-based infrastructure

3.1.1 DGNSS Corrections

The DGNSS corrections are always provided by an External Service and are not generated by the AIS service. Section 3.2 considers the options in terms of suitable sources of DGNSS corrections.

3.1.2 DGNSS Corrections within the AIS Logical Shore Station

The DGNSS corrections being provided to the AIS Service are in a data format defined by RTCM SC-104. The information can also be provided by the DGNSS_COR object defined in this document. The DGNSS correction data from the External Service is encapsulated in an IEC 61162 VDM sentence by the AIS Logical Shore Station (AIS-LSS) for processing by the AIS PSS Controlling Unit (AIS-PCU). The AIS-LSS ensures that the latest full set of corrections is used, and that they are transmitted at the correct time. The AIS-LSS also prioritises the DGNSS corrections so that any new integrity alarms that have been identified by the DGNSS corrections source are transmitted in the next Message 17 slot(s).

When AIS Base station is in independent mode it may broadcast DGNSS corrections receiving RTCM corrections via special RTCM dedicated port (It is in compliance with IEC 62320-1). Preamble and parity shall be discarded by AIS Base station before transmitting Message 17.

3.1.3 Service Planning

The competent authority should consider the impact of providing an AIS DGNSS service on the VDL. It is not recommended that an AIS DGNSS service be deployed over a wide area (it is better to deploy a radiobeacon DGNSS service for this purpose). However, an AIS DGNSS service could be considered where it is necessary to obtain high accuracy and high integrity position reports from vessels.

The competent authority should minimise the number of base stations providing the AIS DGNSS service. This may require careful planning using any available terrain information.

3.1.4 Service Limitations

At the time of writing, a DGNSS service over AIS has several limitations in the service it is capable of providing.

On most vessels, the external GNSS is not capable of switching between an external radiobeacon DGNSS receiver and an output provided by AIS. The implication of this is that an AIS DGNSS service cannot be considered as the backup to an existing radiobeacon service for the EPFS. It should be noted that a Class A and B stations has the ability to switch between an external DGNSS receiver and a Message 17 source (refer to position sensor fall-back conditions specified in IEC 61993-2 or latest revision), although this can only be used to differentially correct the internal GNSS receiver.

If a radiobeacon DGNSS receiver is absent on board the vessel and GNSS receiver has RTCM input port then GNSS receiver input port may be connected to RTCM output of Class A (B) station (optional mode of AIS class A).

There is also concern on the difference between the position being broadcast by the vessel over AIS and the position being used by the vessel's commander. The IEC standard for Class A and B stations asks that the position being broadcast is prioritised based on the status of the internal and external position fixing systems (EPFS). If the external EPFS is differentially corrected, then this is the position broadcast and used by the vessel's commander. However, for many vessels, the external EPFS is not differentially corrected (and may not be capable of do so in its current configuration), and so the AIS will broadcast its internal differentially corrected (by Message 17) GNSS position. The vessel's master will continue to use the external GNSS, and a situation will occur where other vessels are more confident of a ship's position than the master of the vessel.

Note that uncorrected external EPFS (GNSS receiver) will typically have accuracy less than 13 m p=95% according to IEC 61108-1 (practically about 5-7 m) but corrected less than 10 m p=95% (practically about 2-3 m).

The Reference point for position is defined in the vessel dimensions in message 5. It is necessary to remember that position of internal AIS GNSS receiver has reference point as its own antenna position on the vessel. The change in reference point is announced in a new Message 5, when changing from internal to external EPFD and vice versa. A vessel transiting from a region outside into a region inside coverage of a DGNSS service based on AIS message 17 is therefore likely to switch reference points frequently in the transition zone. Since version 4 of ITU 1371, an indication that coordinates belong to internal GNSS receiver (Type of EPFD indicator = 15 in Message 5) has been introduced.

A competent authority should be satisfied with the benefits of providing a DGNSS corrections service over AIS given the potential limitations above.

3.2 INTERFACING A DGNSS REFERENCE STATION AND INTEGRITY MONITOR

3.2.1 Overall Description

In order to provide the correction data to the AIS base station, a DGNSS Reference Station and Integrity Monitor (RSIM) is required. The purpose of the RSIM is to generate pseudo-range corrections for the Satellite Vehicles (SV) (note: SV is usually an abbreviation for Space Vehicle) in view and ensure that the corrected position is within limits. When the position is out-of-tolerance, the Integrity Monitor raises an alarm for the appropriate SV and notifies users not to use it in their navigation solutions. Different possibilities of providing RSIM are further described in IALA Recommendation R-121.

The AIS shore stations should be capable of using such a data stream to provide a DGNSS service over AIS. There are many ways this is possible, some of which are highlighted below. It should be noted that where the RSIM and the AIS transmitting station are physically separated, the integrity and reliability of the intermediate communications structure should be given careful consideration since any failure will cause the DGNSS service to be disrupted.

3.2.2 Correction Sources

3.2.2.1 Independent RSIM

It is recommended that an AIS DGNSS Service relies on a dedicated RSIM that provides corrections for transmission by AIS only. This provides an independent DGNSS service which can be used as a back-up to other DGNSS services (e.g. radiobeacon DGNSS).

It should be noted that the cost to implement and operate an independent RSIM for an AIS DGNSS Service will be greater than to utilise an existing RSIM as described in the MF radiobeacon option below. It may be possible to use one central RSIM for multiple AIS base stations, although care should be taken to ensure that spatial decorrelation is considered.

3.2.2.2 MF Radiobeacon

If the AIS base station is in an area covered by an MF radiobeacon service, it may be possible to use this to provide the RTCM data stream required to generate Message 17. A suitable MF receiver will be required. The output from this receiver would be passed through the RTCM interface of the AIS-LSS for further processing.

Care should be taken when utilising such a system to provide a DGNSS service over AIS because it is reliant on an external system to provide the differential data. Any failures of the radiobeacon service will be reflected almost immediately in the DGNSS service over AIS. If two or more radiobeacon services operate in the area, it may be possible to utilise them to increase availability of the AIS service. The competent authority should also ensure that the MF signal can be received reliably 24 hours a day (it is affected by sky wave propagation during night hours that can cause fading). If the MF radiobeacon receiver is installed at a distance from the transmitting AIS base station, then care should be taken to ensure that spatial decorrelation of the corrections is considered. Furthermore the TimeToAlarm aspect should be taken into account. Transmission of Integrity Alerts via the beacons may delay the correction data stream about 3-5 seconds. A much better solution would be a direct datalink to the RSIM at the beacon station location.

3.2.2.3 Data interface Guidance RTCM Input / Output in Binary Format

The AIS-LSS interface for the input of DGNSS corrections should comply with the Data Interface Specification defined in the latest revision of ITU-R M.823. The information enters through a dedicated input port. The competent authority should also refer to RTCM Recommended Standards for Differential GNSS Service Version 2.3

3.2.3 Processing Multiple Sources of DGNSS Corrections

In some locations, the system may have access to more than one reference station. In this case, a decision on how to deal with them must be made in order to provide a single set of corrections for each navigation system. The base station may be configured to transmit the data for the nearest reference station. However, a more sophisticated solution would be to receive data from all sources and interpolate according to distance from 'Virtual RSIM' position. This will provide a more accurate set of corrections for vessels near the transmitting AIS base station.

3.2.4 Processing Correction Data

ITU-R M.1371 provides the standard Message 17 format to be transmitted by the AIS base station. The data for the fields are generated by the AIS-LSS and directly from the data stream. Table 2 shows the data source for each field in Message 17. It should be noted that the preamble and parity bits are discarded and will be replaced by the receiving AIS mobile stations. The header contains the Station Health message. This should NOT be discarded.

Table 2 Data source for fields in Message 17. Differential data to be transmitted are Words 3 onwards without the parity bits

AIS Message 17		Data source
Static data		
Parameter	**Number of Bits**	
Message ID	6	Set by AIS shore-based Service
Repeat Indicator	2	Set by AIS shore station
Source ID	30	MMSI of AIS shore station
Spare	2	-
Longitude	18	Position of DGNSS reference station (refer to remark below)
Latitude	17	Position of DGNSS reference station (refer to remark below)
Spare	5	-
Differential Correction data (header)		
Parameter	**Number of Bits**	
Message Type	6	RTCM Header, Word 1, d_9-d_{14}
Reference Station ID	10	RTCM Header, Word 1, d_{15}-d_{24}
Z count	13	RTCM Header, Word 2, d_1-d_{13}
Sequence number	3	RTCM Header, Word 2, d_{14}-d_{16}
N	5	RTCM Header, Word 2, (d_{17}-d_{21}) - 2 [1)]
Health	3	RTCM Header, Word 2, d_{22}-d_{24}
Differential Correction data		
Correction Data	Up to 696	RTCM Data, Word 3 onwards [2)]

Notes

[1)] The frame length in RTCM header is two more than the number of words (N) following the header

[2)]16 fill bits are used for RTCM word $_{(N+2)}$ if number of satellites Ni = 2, 5, 8 or 11

The reference station position fields should be filled with the position of the differential correction source, and not the position of the transmitting AIS base station. This information is either manually configured into the transmitting Base Station or is determined by the evaluation of the RTCM Message Type 3. If a virtual RSIM has been defined, then its position should be transmitted in Message 17.

3.3 TRANSMISSION SCHEMES

When selecting a transmission scheme to provide a DGNSS service over AIS, it is important to consider the potential loading on the VDL. For reasons of ensuring reliable reception of DGNSS broadcasts, it is recommended not to transmit messages larger than 3 consecutive slots. The FATDMA planning allows the possibility to transmit a full set of corrections (containing up to 19 SV data in a 3-slot message) approximately every 15 seconds (see Appendix 14).

Table 3 *Maximum number of SV corrections expected to be contained in one Message 17 transmission, taking bitstuffing into account*

Corrections for number of SV (maximum)	Number of slots
1	1
10	2
19	3
29	4

Note: ECB sentence (IEC 62320-1) does not support planning for two-three satellite systems simultaneously.

This easily meets the 30-second correction age requirement but does not meet the 10-second TTA requirement. This requirement is met by reserving a single slot every 3 1/3 seconds (increment of 250 slots per channel) that will enable a message to be sent for a single SV. This message will simply disable the use of the SV in the navigational solution. The transmission scheme is summarised in Figure 2.

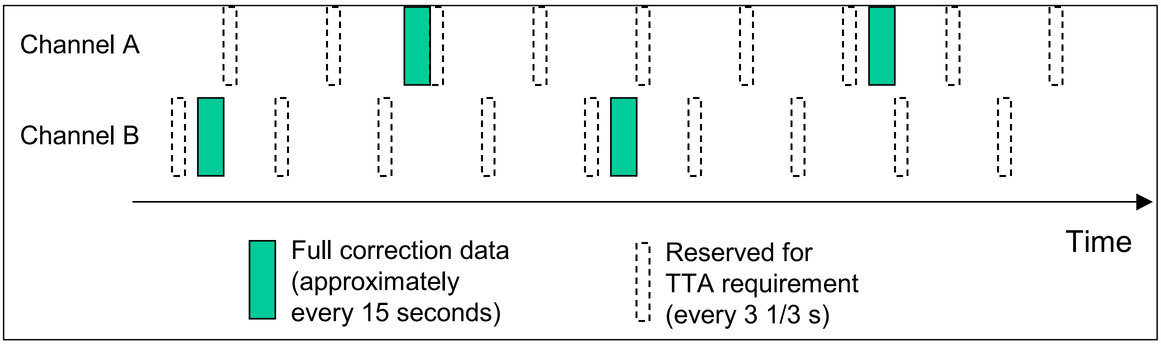

Figure 2 Proposed FATDMA transmission scheme for transmitting DGNSS corrections over AIS for one GNSS system.

Note: The diagram shows the sequence for one frame and is not to scale.

The advantage of this scheme is that a number of GNSS systems could be serviced with the minimum additional loading on the VDL. The regular 1-slot reservations could be shared for all the GNSS systems.

It is unlikely that multiple GNSS failures will occur at the same time, and therefore, the regular 1-slot reservations could be used for all the GNSS systems. This practice will substantially reduce the VDL loading when providing a DGNSS service for more than one GNSS system. Table 4 provides a brief summary of the VDL loading for a number of GNSS systems.

Table 4 *Loading on the VDL when one base station provides DGNSS service for multiple GNSS systems*

Number of GNSS Systems	Slots per frame required for full constellation data	Slots per frame required for the TTA slots	Total number of slots	VDL Loading (over two channels)
1	12	18	30	0.67%
2	24	18	42	0.93%
3	36	18	54	1.20%

3.3.1 Multiple Base Stations

It is envisaged that in some areas, the RF coverage of base stations providing DGNSS over AIS would overlap. From a time-slot reservation point of view, independently operated base stations will require their own TTA slot reservations, using different time slots. The implication of this is that the VDL loading will increase linearly with the amount of base stations in the local area. Coordinating several base stations in the dependent mode may reduce the need for timeslot reservations; this will be further discussed in the future Appendix 3, on distribution of the AIS service, and Appendix 14, on FATDMA planning. It is up to the competent authority to ensure that the loading of the VDL is not adversely affected.

If Base Stations are transmitting different sets of corrections (from different Reference Stations) for the same GNSS system, then the competent authority should be aware that vessel positions may shift slightly due to spatial decorrelation as different sets of corrections are applied to the GNSS unit.