



# IALA RECOMMENDATION (NORMATIVE)

## R0124 (A-124) APPENDIX 18 VDL LOAD MANAGEMENT

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# 1 INTRODUCTION

## 1.1 INDEX OF APPENDICES TO IALA RECOMMENDATION R0124 (A-124) ON THE AIS SERVICE

General:

Appendix 0 References, Glossary of terms and Abbreviations – to be developed

Deliverables of the AIS Service to the shore-based clients:

Appendix 1 Basic AIS Services, Data model & AIS Service specific MDEF sentences

Appendix 2 Intentionally blank

Architecture of the AIS Service:

Appendix 3 Distribution model – to be developed

Appendix 4 Interaction and data flow model

Appendix 5 Interfacing model

Appendix 6 Internal Time Latency model – to be developed

Appendix 7 Internal Reliability model – to be developed

Appendix 8 Test model – to be developed

Functional components of AIS Service:

Appendix 9 Functional description of the AIS Logical Shore Station – to be developed

Appendix 10 Functional description of the AIS PSS Controlling Unit – to be developed

Appendix 11 Functional description of the AIS Service Management – to be developed

Installation and life-cycle management issues of the AIS Service:

Appendix 12 Co-location issues at Physical Shore Stations (PSS) and on-site infrastructure considerations – to be developed

Appendix 13 Recommendation regarding efficient operation and maintenance – to be developed

Runtime configuration management of the VDL:

Appendix 14 FATDMA planning and operation

Appendix 15 Assigned mode operation – to be developed

Appendix 16 DGNSS broadcast via the AIS Service

Appendix 17 Channel management

Appendix 18 VDL loading management

Appendix 19 Satellite AIS considerations

## 1.2 PURPOSE OF THE APPENDIX

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This appendix presents considerations and best practices when conducting AIS VDL Loading management.

In regions with dense vessel traffic, concerns have been expressed on the overloading of the AIS VDL and should require special attention by the competent authority responsible for the VDL management during planning and operational use.

It should be noted that ship to ship transmissions will likely not be impacted by VDL over-loading due to mobile stations' ability for intentional reuse of occupied slots. Studies have demonstrated that overload results in the reduction of the AIS cell size. IMO has considered a cell size of 12 nautical miles to be the minimum operational safety margin for collision avoidance, which in turn would require a very high overload of the VDL. Therefore, this document focuses solely on shore based AIS Service's perspective.

AIS VDL loading is very complex and depends on a wide range of factors. Fortunately, AIS is fairly resilient to VDL loading in most situations. This appendix presents VDL loading and the measures that should be considered by competent authorities to prevent or correct VDL overloading. The first chapter looks at the definition and impacts of VDL Loading, then the subsequent chapter discusses the prevention of VDL Overloading, the third chapter refers to VDL Load Management, and finally the appendix concludes with Mitigation Methods for Garbling.

## 2 DEFINITION AND IMPACT OF VDL LOADING

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This section is an introduction on VDL loading, its sources and its impacts.

### 2.1 MEASURING OF THE VDL LOAD

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It is difficult to have a precise number of when the VDL is considered under load as it may vary depending on location, number and type of vessels active. It also will depend on the perspective of the type of AIS station that is measuring VDL loading. As a general guideline, it is observed that when the VDL exceeds 50% loading of its nominally available slot capacity during the last 4 minutes on both channels, it may have an impact on the mobile AIS station's ability to find free slots available for transmission.

Again, as a general guideline, considering that there are 2250 time slots available per channel, per minute and that mobile AIS stations, on average, will transmit every 10 seconds on alternating channels, the competent authority responsible for VDL management should start close monitoring of the VDL when it is approaching 50% loading on any channel (375 targets within a 50 nautical mile range of an AIS shore station).

### 2.2 SOURCES OF VDL LOADING

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VDL loading can be caused by the following conditions:

- 1 High amount of AIS messaging:
  - a Ship traffic - This is the most common cause of VDL loading. Currently only the busiest ports would see enough traffic to cause VDL loading, but this might change rapidly with the increase of other AIS mobile stations, especially class B AIS mobile stations.
  - b Use of repeaters - Repeaters effectively double the amount of traffic on the VDL for a particular geographical area. The use of repeaters in high traffic areas is not recommended.
  - c Use of Application Specific Messages.
  - d Use of additional AIS stations – AIS AtoN station, AIS Airborne stations, etc.

- 2 Abnormally high propagation

Some atmospheric conditions may drastically increase AIS propagation for periods lasting from a few minutes to a few days. This abnormally high propagation can increase VDL loading in a matter of minutes.

### 3 Faulty or misconfiguration of AIS stations.

AIS stations can be misconfigured or become faulty and transmit additional messages that would increase the load on the VDL.

### 4 Extensive broadcast or use of timeslot reservations by AIS shore stations.

AIS shore stations can, through extensive broadcasts (and the use of FATDMA slot reservations to protect own transmissions from interference), make part of the VDL capacity unavailable for mobile AIS stations.

## 2.3 IMPACTS OF VDL LOADING ON AIS MOBILE STATIONS

Under high VDL loading, the range of reception of the AIS mobile station is reduced. This is explained by the AIS mobile station free slot selection process<sup>1</sup> described below:

Mobile stations within VHF operational range organize themselves autonomously by taking into account the current and future use of time slots by other AIS stations. Consequently, mobile stations attempt to avoid the simultaneous use of the same time slot. If all time slots within their VHF operational range are occupied, they will use time slots of the most distant stations. This process is re-evaluated dynamically by the AIS station but the range of reception is effectively reduced by this process. To avoid losing targets that may pose a danger, a mobile AIS station limits its simultaneous use of the time slot of a particular distant station to once per minute. Consequently, complete suppression of targets is unlikely. This process respects the fundamental collision avoidance requirement for AIS, for which it is more important to receive the reports of nearby mobile AIS stations than the most distant mobile AIS stations.

## 2.4 IMPACTS OF VDL LOADING ON THE SHORE BASED AIS SERVICE

Under high VDL loading, the AIS shore stations may miss a higher percentage of messages from AIS mobile stations. This is explained by the process described below:

Within the reception area of an AIS shore station, there will be mobile AIS stations that can-not receive each other's AIS messages. Hence, the broadcast schedule will not be exchanged among these mobile stations. For this reason, these mobile stations will, at times, transmit their reports using the same time slot – a random occurrence. During this event, the shore station may receive only one, or none of the reports sent during the conflicting time slot. There are shore station design measures that can reduce the effect of these events. In some cases, the distance between the mobile stations and a shore station may result in only the stronger mobile AIS station's signal being received (capture effect). When the received signals are approximately equal, a shore station will not be able to discriminate either of the two mobile stations' messages. This phenomenon is called garbling. The probability of data transmission collisions or garbling increases with the number of mobile AIS stations inside the coverage range of a shore station.

## 3 VDL MONITORING

The most important task of competent authorities to prevent VDL loading is to monitor the VDL usage by AIS units. The following sections discuss the different types of VDL monitoring that should be performed by competent authorities to ensure the availability and integrity of the VDL.

### 3.1 AUTOMATED TOOLS FOR VDL MONITORING

VDL monitoring can become a resource intensive activity. Some automated monitoring tools exist to facilitate the task of competent authorities. The importance of these tools should not be underestimated when procuring an AIS system. Automated monitoring tools with advanced reporting capabilities are essential to help proper VDL monitoring.

### 3.2 AIS SHORE-SIDE NETWORK MONITORING

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AIS shore-side network monitoring includes all activities related to the monitoring of the AIS network deployed by the competent authority. The following is a list of recommended things to monitor to ensure availability of the VDL and proper function of the AIS network:

- Number of AIS units received by each station;
- Number of time slots occupied in the last frame (1 min);
- Average number of time slots occupied in each frame of the last epoch (6 min);
- PSS coverage;
- PSS transmissions;
- PSS faults;
- PSS configuration.

### 3.3 AIS VDL INTEGRITY MONITORING

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Integrity monitoring refers to proper usage of the VDL by AIS units. The following aspects should be monitored:

- Are all transmitters licensed?
- Any defective or non-standard units?
- Any invalid MMSIs being used?
- Any targets over land (Marine electronic workshops, tests, etc.)?
- Legitimacy of messages being transmitted by AIS units (configuration errors);
- Top most active MMSIs in last frame and in last epoch and messages they have been transmitting, with report rate.

Competent authorities should take appropriate steps to ensure that detected anomalies are corrected within the local legal process.

### 3.4 AIS DATA INTEGRITY

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AIS data integrity refers to the validity of the actual data being transmitted from AIS units. This data should be monitored by competent authorities and reported to the AIS unit operator if found to be not valid or inappropriate. As with the VDL integrity monitoring, local legal process might be necessary to ensure corrective actions are taken by concerned parties.

- AIS unit dynamic data (position, speed, COG, etc);
- AIS unit static data (MMSI, IMO number, name, antenna position, etc.);
- AIS unit voyage data (status, destination, ETA, etc.).

## 4 VDL LOAD MANAGEMENT

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In order to minimize the loading of the VDL, the following options should be considered by the competent authority responsible for the VDL management. There are also options available to mitigate the effects of garbling for the reception of an AIS Service. These options are discussed in the next Chapter.

Of the alternatives listed below, only those listed in section 6.1 have no effect on the technical operation of the mobile stations.

## 4.1 DESIGN CONSIDERATIONS TO AVOID VDL OVERLOADING

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In areas with dense vessel traffic, the operational transmission range of the AIS shore stations must be designed such that the traffic volume remains below the theoretical system capacity within the coverage area. This can be achieved as follows:

### 4.1.1 Adjust the transmission range of the AIS shore station

Adjust the transmission range of the AIS shore stations by adjusting the height of the antenna. Locate the adjacent AIS shore stations for the desired transmission ranges. Reducing the transmission range will require a larger number of AIS shore stations to achieve the desired transmission coverage area.

### 4.1.2 Creation of sectorised transmission coverage areas

Transmission sectorisation establishes, at a single site, several transmission coverage areas for an AIS shore station. This approach requires the installation of additional AIS transmission equipment. Antenna systems with directional properties and a variety of heights can be used to create these sectors. Each transmission coverage sector must be monitored. With proper design and control, the geographic transmission coverage of sectors can be changed during operations as needed for a variety of traffic loading conditions. Note that sectorisation of an AIS shore station's reception coverage area does not require that the AIS shore station's broadcasting capabilities also be sectorised and vice versa. That is an independent design issue.

## 4.2 MANAGING THE VDL LOADING OF AIS MOBILE STATIONS BY AN AIS SERVICE

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### 4.2.1 Using Assignment commands for temporary VDL loading management

Within its service coverage area, an AIS Service can designate the transmission mode of a mobile station. To do this, the AIS Service broadcasts a command that switches each, or a designated group, or individual AIS mobile station(s) to the assigned mode using AIS messages 16 and 23. The reporting rate and time slot assignments can be specified by this command.

For example, an AIS command could be given to instruct all class B vessels to go silent for a number of minutes in order to make sure other more important transmissions can be received.

Note: The hard assignment method does not reduce VDL loading. Hard assignment uses message 16 to assign specific class A vessels to time slots that are reserved, but not used, by the AIS shore station to ensure that these vessels cannot be interfered with.

Without a refreshment of the assignment command, the assignment will expire automatically after up to 8 minutes. Hence these assignments only constitute temporary VDL loading measures.

These control methods can become very complex and require constant attention to the movement of each vessel subject to these commands if permanent VDL loading management is desired. Effective management of this capability may require automation and / or co-operation between adjacent AIS Services. Since this control mechanism by itself already results in an additional VDL loading, it should be used with appropriate precaution.

### 4.2.2 Persistent VDL Loading Management

The following section present methods to achieve persistent VDL loading management within the coverage area of the AIS Service of the competent authority responsible for VDL management.

It is to be noted that these measures should be taken as early as the planning stages of the AIS Service.

It should also be noted that the number of AIS shore stations in a given area is not directly correlated to the VDL loading. On the contrary, a higher number of shore stations may result in a decrease of VDL loading.



#### 4.2.2.1 Careful planning of broadcast services and FATDMA reservations for shore stations

Any broadcast service will add to the load of the VDL. Therefore, careful planning of broadcast services must be observed in regions with high VDL loading or extensive use of broadcast services. In particular, FATDMA reservations may affect the AIS mobile stations availability of VDL capacity well beyond normal coverage ranges (up to 120 nautical miles), especially during periods of abnormal propagation. FATDMA reservations are only recommended to be used by the competent authority responsible for VDL management for protecting regularly occurring transmissions. Please refer to appendix 14 on FATDMA planning and operation for further details.

#### 4.2.2.2 Channel management

The Channel Management (AIS message 22) command can command the VHF data link parameters to instruct all AIS mobile stations within a defined coverage area to broadcast on alternative VHF channels. For further details on Channel Management, refer to appendix 17.

With regard to VDL loading, the transition period and the transition region will need to be considered:

- When using Channel Management via the AIS VDL (as opposed to DSC Channel Management capability), it creates persistent additional VDL loading for refreshing these commands;
- In the transition region, VDL load increases as a result of additional transmissions from mobile stations.

Channel Management may have positive effects on VDL loading if it is used to overcome interference from external sources.

## 5 ADDITIONAL DESIGN CONSIDERATIONS

Since the receiving AIS shore stations will typically be affected by VDL loading sooner than the mobile AIS stations, the main issue remains slot garbling for receiving AIS shore stations. If the distances between receiving AIS shore stations are chosen such that the operational cells overlap significantly, then AIS messages from vessels within the overlapping nominal coverage areas from several receiving AIS shore stations will be received simultaneously. This results in a redundancy of reception routes, namely from two or more receiving AIS shore stations from different directions. Each of the receiving AIS shore station experiences different conditions with respect to the distribution of time slots, such that the probability of garbling for the same time slot in both nominal coverage areas is reduced. Interference of reception at one receiving AIS shore station could be compensated for by another receiving AIS shore station. The probability of reception in the case of overlapping nominal coverage areas is higher.

Simply increasing the number of shore stations or the addition of receive only stations with smaller reception coverage areas can reduce the number of garbled slots per individual shore station as explained below.

This section considers only the reception portion of the AIS Service and therefore, it is not required to discriminate between transceiver and pure receive only stations.

It should be noted that installing more receiving AIS shore stations as a mitigation method for garbling will result in an increased redundancy for un-garbled time slots however, will not increase redundancy for garbled time slots.

### 5.1.1 Adjust the reception range of the receiving AIS shore station

One preferred method is by adjusting the reception range of the receiving AIS shore stations by adjusting the height of the antenna. Another method to adjust the reception range is by introducing attenuation for the receivers to remove the most distant received AIS transmissions only. Locate the adjacent receiving AIS shore stations for the desired reception ranges. Reducing the range will require a larger number of receiving AIS shore stations to achieve the desired coverage area.



## 5.1.2 Creation of sectorised coverage areas

Sectorisation establishes, at a single site, several coverage areas for a receiving AIS shore station. This approach requires the installation of additional AIS equipment. Antenna systems with directional properties and a variety of heights can be used to create these sectors.