IALA GUIDELINES

ON THE

UNIVERSAL AUTOMATIC

IDENTIFICATION SYSTEM

(AIS)

Volume 1, Part II – Technical Issues
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IALA AIS Guidelines, Vol. I, Part II

Table of Content – Overview

Part A: Introduction to the Technical Aspects of the AIS and Overview

1. System Architecture of the AIS

1.1 Introduction to the Technical Part of the IALA AIS Guidelines

Volume I, Part 1 concentrated on the operational aspects of the AIS, i.e. on the description of what the AIS is supposed to do under what circumstances in operational terms. This part (Volume I, Part 2) introduces a set of chapters that will deal with the technical aspects of the AIS.

This part of the IALA AIS Guidelines intends to satisfy the information need of

- anyone, in particular an interested user, who wishes to gain a better understanding of the technical aspects of the AIS. While a user of the AIS may feel that knowing the operation of AIS is sufficient he/she will discover that understanding the technical principles of AIS will lead to a greater appreciation of the benefits of AIS but also its limitations. Hence the overall effectiveness of the application can be optimised.
- integrators and application designers, both operational and technical, when seeking both a comprehensive and an accurate description of the basic services which the AIS delivers, without wishing to go into the highly technical reference documents. It should be noted, that this description was drafted from a shore-side point of view, i.e. it focuses on AIS services delivered at the shore-side interface of an AIS base station. However, many fundamental descriptions may also be of value for the AIS services delivered at the interfaces of the mobile AIS stations.
- competent authorities who wish to deploy a shore-based AIS infrastructure and seek well structured guidance in the planning and the procurement of that shore-based AIS infrastructure.

The purpose of Part A is to give a broad introductory overview of the system "AIS" as a whole. It introduces the layered structure of the AIS and the applications using the AIS derived information. This part also indicates where the different kind of AIS stations fit into the layered concept of the AIS as a whole, i.e. it maps the AIS stations to the layers of the ISO/OSI-layer model.

The large and still expanding volume of relevant international documents and standards has created the need for a reference guide. This part of the IALA AIS Guidelines refers the reader in chapter 2 to the appropriate international documents relating to the AIS function under consideration.

Chapters 3 to 10 turn to specific AIS stations. Shipborne mobile AIS stations (Chapter 4), AIS base and repeater stations (Chapter 8-10), Aids-to-Navigation AIS stations (Chapter 6), and Search-and-Rescue Aircraft AIS stations (Chapter 5), all exhibit some special features.

Part D comprises Chapters 11 thru 14 describes setting up the AIS network of a competent authority. Chapter 11 is an introduction on the topic, while Chapters 12 thru 14 describe the Logical Shore Station (LSS), the AIS Service Management (ASM), and the AIS Data Transfer Network.

After the introduction of the individual varieties of AIS stations and the higher AIS Layers, coastal-wide issues of an AIS shore infrastructure are considered. These include the planning of coastal AIS VDL coverage (Chapter 16) and re-transmission of AIS data (Chapter 17).

The AIS channel management was given a separate chapter because it is both a very powerful and very complex service, which should be carefully considered before using it. Competent authorities are responsible both for the decision to implement AIS channel management - thus drawing away from the global default AIS frequencies - and to manage the regional AIS frequencies. In that region, this service affects the AIS as a whole - for good and for worse. Therefore, detailed guidance for competent authorities that have identified a need for AIS channel management is given in Chapter 19.

Two chapters discussing co-location of AIS with other shore-based functions is also discussed in Chapters 19 and 20. Chapter 19 introduces co-location with DSC functionality while Chapter 20 introduces co-location with VHF communication assets. Long-Range Applications (Chapter 21) addresses the special consideration for long-range use of AIS. This does not make use of the AIS VDL but uses appropriate long-range communication links to provide a means for ship reporting and tracking systems which cannot use AIS VHF coverage due to the distance to the next AIS base station ashore. Chapter 22 discusses Differential GNSS correction data broadcast by the AIS shore infrastructure. Chapter 23 discusses other Aids-To-Navigation Functionality that builds upon the Aids-To-Navigation AIS station presented earlier in Chapter 6. Configuration management of AIS shore infrastructure is then discussed in Chapter 24.

The purpose and functions of the AIS can be expressed in terms of services provided. The most fundamental services of the AIS are called Basic AIS Services (BAS) presented in Part F. They make use of the diverse features of the AIS VHF Data Link (as described in Recommendation ITU-R M.1371-1 in connection with the IALA Recommendation on Technical Clarifications of Recommendation ITU-R M.1371-1) and the diverse features of the different AIS stations (as described e.g. in the appropriate IEC standards and the before mentioned IALA Recommendation). They can be described in a common format. Part F of this document provided an introduction to the idea of BAS. The full description will be given in Volume II of the IALA Guidelines on AIS.

This description of the BAS does not make redundant the referenced documents, i.e. the appropriate international standards nor introduce new system features. However, this description of the BAS binds together - in a comprehensive and highly accurate manner - all information items from various sources that are essential to understand what is being delivered in functional terms on a given interface on the recipient's side. It is also the basis for an assessment of the usefulness of a particular AIS service for a particular intended application in terms of accuracy, frequency, reliability etc.

1.2 IMO's provisions for AIS shore infrastructure

IMO's SOLAS Convention, as revised, Regulation 19, §2.4.5, states with regard to the purpose of the AIS:

"AIS shall

provide automatically to appropriately e quipped shore stations, other ships and aircraft information, including ship's identity, type, position, course, speed, navigational status and other safety-related information;

receive automatically such information from similarly fitted ships;

monitor and track ships; and

exchange data with shore-based facilities."

In addition, the IMO Performance Standards for the AIS state:

"1.2 The AIS should improve the safety of navigation by assisting in the efficient navigation of ships, protection of the environment, and operation of Vessel Traffic Services (VTS), by satisfying the following functional requirements:

.1 in a ship-to-ship mode for collision avoidance;

.2 as a means for littoral States to obtain information about a ship and its cargo; and

.3 as a VTS tool, i. e. ship-to-shore (traffic management).

1.3 The AIS should be capable of providing to ships and to competent authorities, information from the ship, automatically and with the required accuracy and frequency, to facilitate accurate tracking. Transmission of the data should be with the minimum involvement of ship's personnel and with a high level of availability.

1.4 The installation, in addition to meeting the requirements of the Radio Regulations, applicable ITU-R Recommendations and the general requirements as set out in resolution A.694(17), should comply with the following performance standards [the details follow in the original IMO document]."

From this the provision of IMO for AIS, the AIS shore infrastructure can be inferred. It should be noted however, that there is neither a stipulation of IMO to any competent authority to implement a VTS nor to implement AIS into existing VTS. However, since IMO stated, that AIS improves the safety of navigation and operation of VTS, competent authorities should consider implementing AIS into VTS.

IMO's provision for AIS shore infrastructure was taken up by ITU-R when creating Recommendation ITU-R M.1371, which included a so-called AIS base station. When drafting a test standard for Class A and Class B shipborne AIS stations, IEC also took the existence and specific role of AIS base and repeater stations into consideration.

1.3 ITU's additional operational requirements for AIS shore infrastructure

As a peer organisation to IMO, ITU recognised the potential of the AIS also for areas of shore-based application, other than ship reporting and VTS, namely maritime, safety-related information services, Aids-to-Navigation and Search and Rescue:

"The ITU Radiocommunication Assembly considering (...)

d) that such a system should be used primarily for surveillance and safety of navigation purposes in ship to ship use, ship reporting and vessel traffic services (VTS) applications. It could also be used for other maritime safety related communications, provided that the primary functions were not impaired;

e) that such a system would be capable of expansion to accommodate future expansion in the numbers of users and diversification of applications, including vessels which are not subject to IMO AIS carriage requirement, Aids-to-Navigation and Search and Rescue." (Recommendation ITU-R M.1371-1)

Hence, the VTS would not be the only shore-based application to which the AIS would be of relevance. Hence, the design of the technical AIS shore infrastructure, in order that it may be used universally, should be designed such that it would not limit the use of AIS information to VTS's needs, only. This statement does not reduce the prominent role of the VTS as the primary shore-based user of the AIS information. It imposes a fundamental technical design philosophy, however, which will be explained in more detail below.

1.4 AIS to be considered a maritime, safety-related information service

From a VTS or, more generally speaking, from the point of view of a competent authority the AIS provides an information service for shore-based VTS, traffic management schemes, ship reporting systems and other shore-based safety-related services.

This service consists of information delivery between ships and shore and vice versa. Thus the service of information exchange between ships and maritime, safety-related shore services, such as VTS, is one important part of the AIS (refer to SOLAS Regulation 19, §2.4.5, Nr. 4, as cited above). This information comprises, amongst others, the maritime, safety-related data items listed in IMO SOLAS Regulation 19 (see above).

Consequently, approaching the AIS from any shore-based application's point of view, there will be an AIS Service delivered at a functional interface, which will be defined in more detail below.

1.5 The AIS Service: its place within the shore-based technical environment

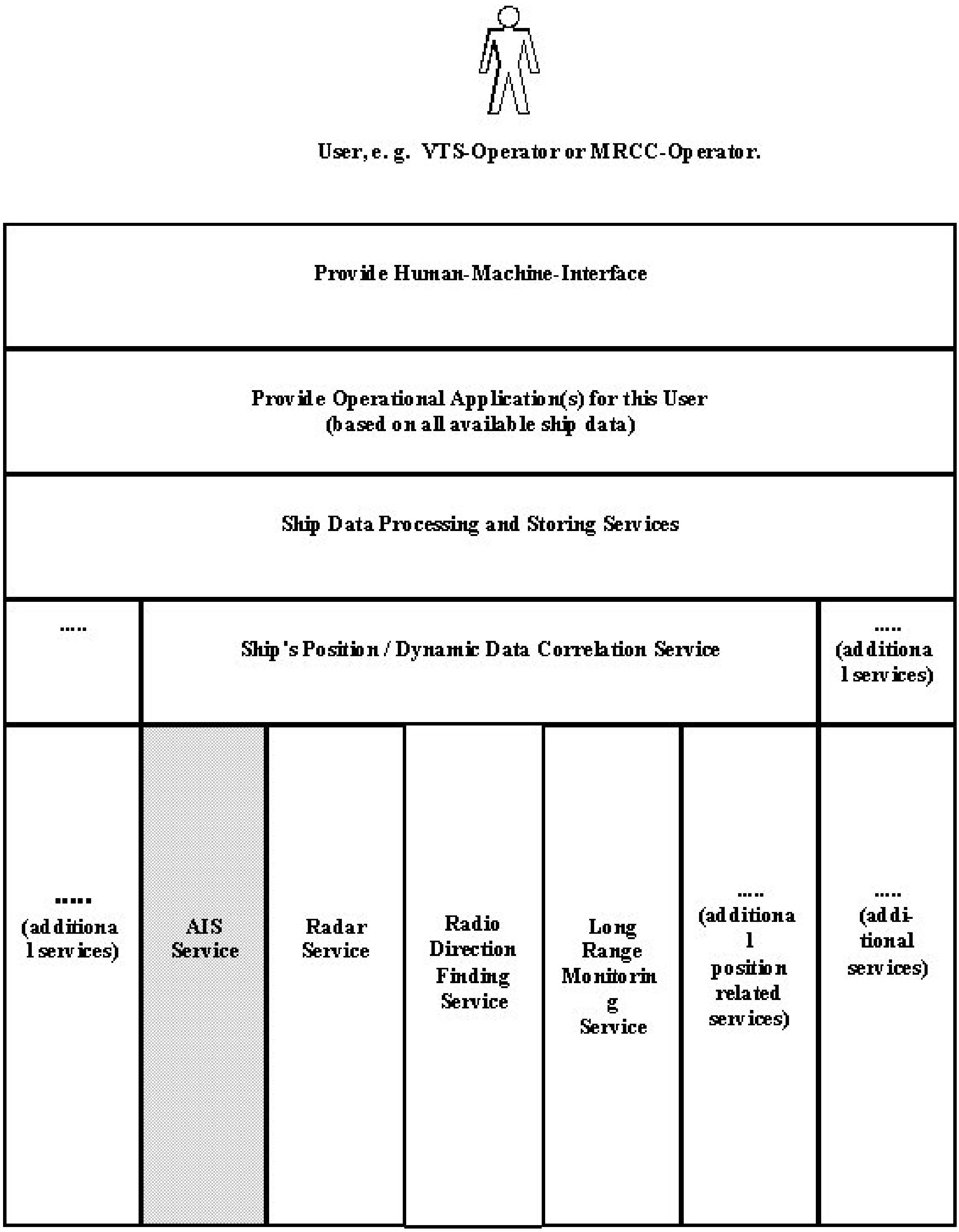
Figure 1.1 shows an overview of the functional technical layers needed to process data derived from various shore-based sensor services to present the traffic image to the user. These layers above the different services will be dependent on user requirements and complexity of the infrastructure. This will not be described herein.

The AIS Service of a competent authority comprises all AIS-related functionality below the integration level of AIS-derived information with other information sources or sinks. In a VTS environment the AIS-derived information of the AIS Service would be integrated with other services e.g. with the Radar Service, the Direction Finding Service, Ship Data Processing Services, etc.

According to need, the competent authority may define more than one AIS Service, e.g. East Coast AIS Service and West Coast AIS Service, which may have different properties. When defining more than one AIS Service within one competent authority, it is beneficial to have complete operational, geographical, physical, and data separation between these services to avoid interference. Should a complete separation of different AIS Services, also of different neighbouring competent authorities, not be possible, the competent authority or authorities should take any measure to minimise the potentially harmful interference of their AIS Services.

For simplicity's sake, this document, in its present edition, confines itself to the treatment of one AIS Service in one competent authority, only.

Figure 1.1: Functional technical layers



1.6 The functional interface between the shore-based applications and the AIS Service

The requirements for the interface between shore-based applications and the AIS Service can be defined in functional terms as follows:
A) This functional interface should provide the AIS Service to shore-based applications as a set of Basic AIS Services (BAS).
B) The functional interface should facilitate the integration of the AIS Service shore-based applications, such as radar-based VTS environments.
C) The functional interface encapsulates the technical details of both the AIS technology and of the layout and local configuration of shore-based AIS. (This is a state-of-the-art engineering principle. It protects application software from unnecessary changes due to configuration or technology improvements within the AIS Service.)

The interface between the AIS Service and its clients e.g. the VTS environment would also comprise a list of available Basic AIS Services (selection or all) and would consist of a definition of all Logical AIS Shore Stations (LSS) set up in this particular VTS environment.

1.6.1 Basic AIS Services

The purpose and functions of the AIS can be expressed in terms of services provided to the recipient. The most fundamental services of the AIS are called Basic AIS Services (BAS). They make use of the diverse features of the AIS VHF Data Link (VDL; as described in Recommendation ITU-R M.1371-1 in connection with the IALA Recommendation on Technical Clarifications of Recommendation ITU-R M.1371-1) and the diverse features of the different AIS stations. The BAS are described in a common format.

This description of the BAS does not make redundant the referenced documents, i.e. the appropriate international standards, nor do they introduce new system features. However, each description of a BAS integrates, in a comprehensive and highly accurate manner, all information items from various sources into functional terms that are essential to understand what this BAS is delivering. Therefore, the BAS are also the basis for an assessment of the usefulness of the AIS Service for a particular intended application in terms of accuracy, frequency, reliability etc.

The BAS are subdivided into "external" and "internal". The "external" BAS are those BAS which deliver net information about ships and shipboard applications. The "internal" BAS are those which are needed to make use of the special capabilities of the AIS base station with regard to the AIS VDL.

The BAS are the services the AIS delivers to *the recipient's side ashore* at the interface between the AIS Service and "higher", application-oriented levels. Therefore, their description also takes into account the processing at the fixed AIS stations, the Physical AIS Shore Station (PSS), and the LSS.

1.6.2 BAS Overview

The following list provides an overview of all defined BAS. The "internal" BAS are contained and managed within the AIS Service and may be triggered and / or configured by higher levels of shore-based infrastructure. All available BAS will be described in detail in the IALA AIS Guidelines (Vol. II, from Edition 1.2).

1.6.2.1 External BAS

A_STAT Static ship data from Class A shipborne mobile AIS stations
A_DYN Dynamic ship data from Class A shipborne mobile AIS stations
A_VOY Voyage related ship data from Class A shipborne mobile AIS stations
SAFE_AD Safety related addressed message
SAFE_BR Safety related broadcast message
INT_TDMA interrogation via AIS VDL
INT_DSC [1] interrogation via DSC Ch 70
B_DAT Ship data from Class B shipborne mobile AIS stations
SAR_DAT Data from SAR airborne AIS stations
ATON_DAT Data from AtoN AIS stations
TRANS_IAI Transparent transmission within the International Application Identifier branch
TRANS_RAI Transparent transmission within the Regional Application Identifier branch

1.6.2.2 Internal BAS

BASE_DAT Data on base station (base station's own data)
ASGN_RATE Assignment of reporting rate to mobile station(s)
ASGN_SLOT Assignment of transmission slots to mobile station(s)
DGNS_COR DGNSS corrections to mobiles
CH_TDMA Channel management by TDMA
CH_DSC Channel management by DSC
PWR_LEV Power level setting to mobiles
FATDMA (announce) configuration of FATDMA reservations of base station(s)

1.7 The Layered Structure of the AIS Service

1.7.1 The functional layers for the AIS Service and the AIS shore infrastructure

The geographical coverage requirement introduces at least five hierarchical, functional layers with different tasks (from top to bottom):

- The **Logical Shore Station (LSS) layer** processes the data derived from the different physical AIS shore stations and provides the Basic AIS Services to the applications during run-time.
- the **AIS shore station layer**; an AIS shore station may house more than one fixed AIS station;
- the **fixed AIS station layer** (AIS repeater stations are also located on this layer);
- the **layer of VHF-/RF-domain equipment** for fixed AIS stations, which comprises antenna(s) and other pieces of on-site infrastructure;
- the **AIS VHF Data Link (VDL)**, which can only be accessed by the VHF-/RF-domain equipment.

Each of these layers may consist of different entities, which in total must deliver the complete functionality of the layer. On the AIS base station layer, for example, the entities may be AIS base stations proper, AIS simplex repeater stations, and / or AIS duplex repeater stations.

In addition, one uppermost logical layer is required, which would be responsible of managing the whole of the AIS Service. This highest logical layer of the AIS Service is called AIS Service Management (ASM).

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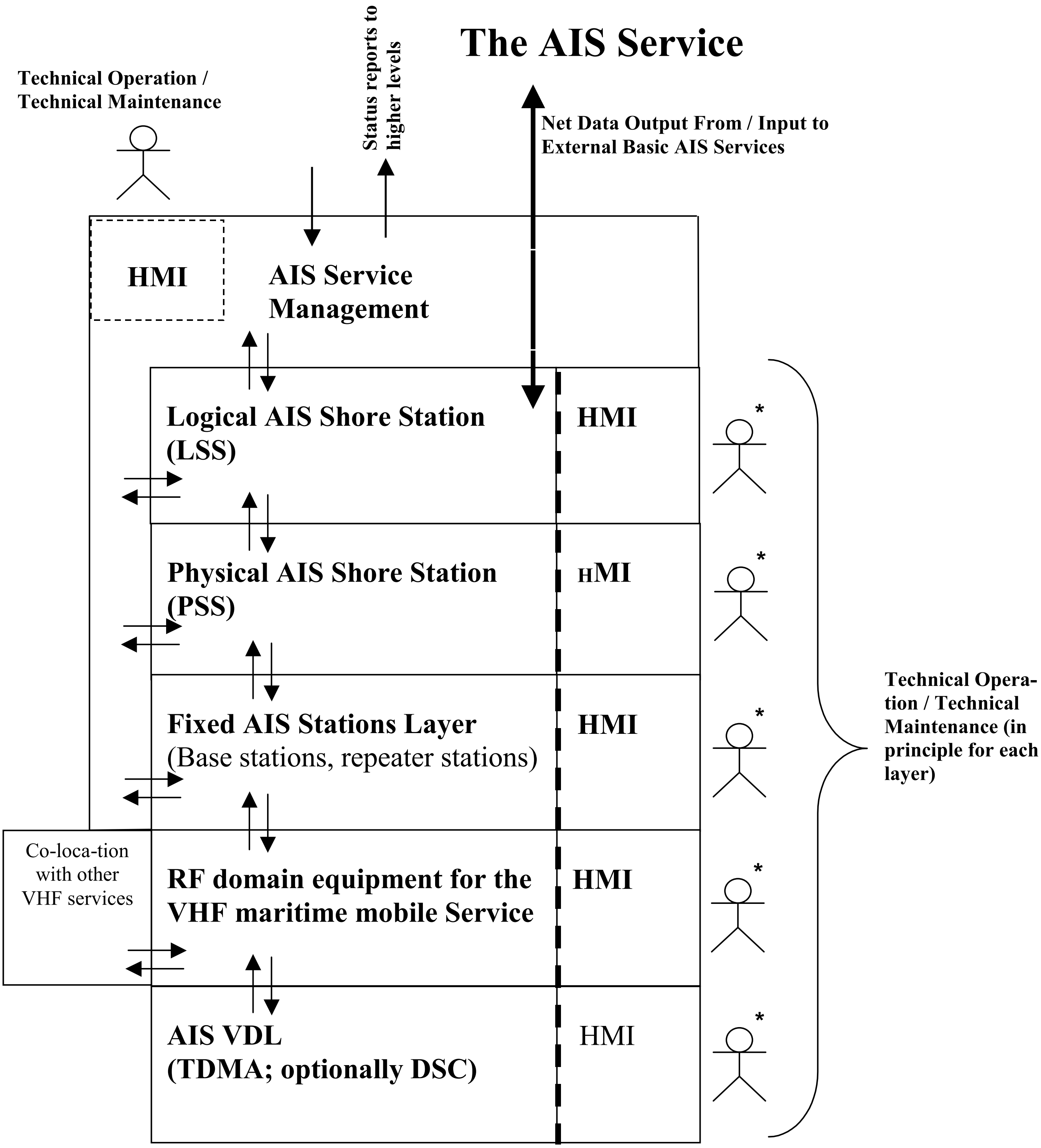
[1] If DSC has been implemented as part of the AIS service

1.7.2 Overview on the layered structure of the AIS Service

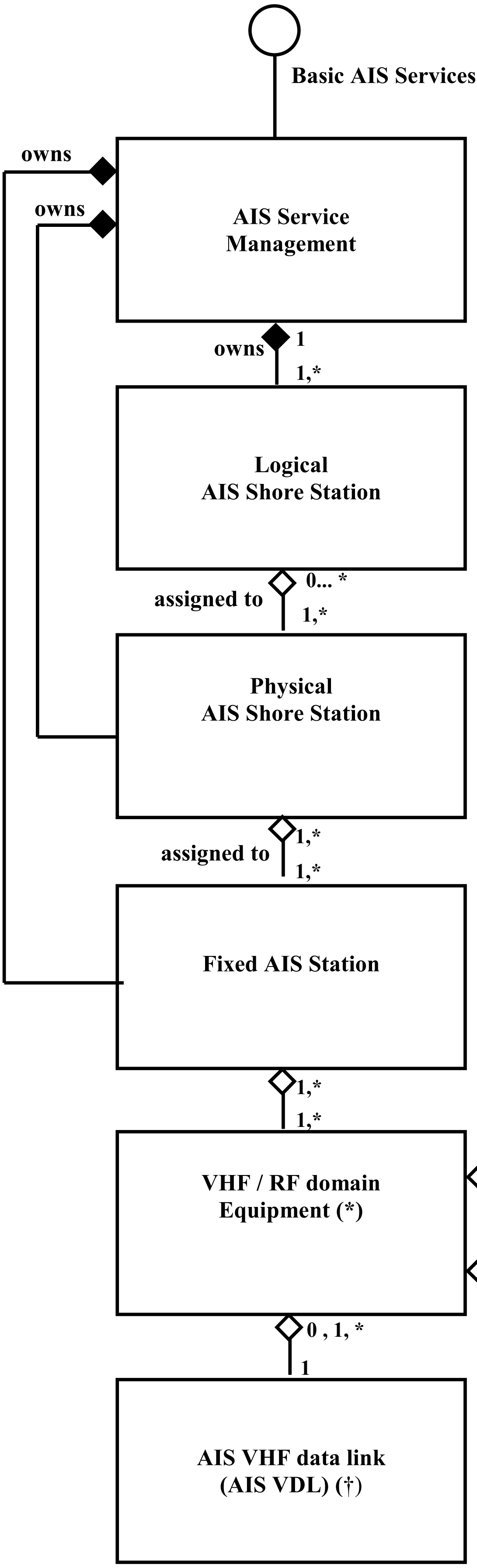
Figure 1.2 provides an overview on the layered structure of the AIS Service. This figure may be useful to understand the principle of the layered structure of the AIS Service. A Human-Machine-Interface (HMI) is needed to make data available to technical personnel operating and maintaining the AIS Service. In principle, a HMI would be needed for every layer (refer also to footnote below).

Figure 1.2: Layered structure of AIS Service



* Note: This symbolic representation does not imply any inference as to the amount of required personel for the technical operation / technical maintenance of the AIS service. This symbolic representation aims at indicating that human interaction with the largely automated AIS Service is required as the last resort - and in some cases possibly on a regular basis - on all layers of the AIS Service.

Figure 1.3 also provides a representation of the layered structure of the AIS Service. This figure may be helpful to understand the relationship between the pluralities of the different layers.



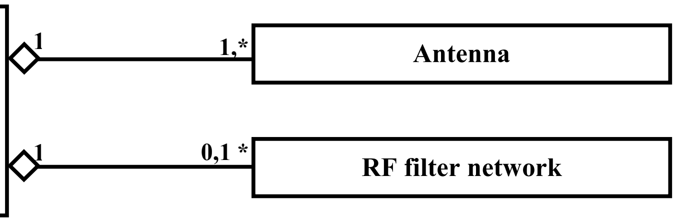


Figure 1.3: Description of the AIS Service using the internationally standardised UML (Unified Modelling Language)

The UML provides a powerful, internationally standardised and widely distributed notation to convey logical structures and relationships between abstract and concrete objects, it can be used to describe the functionality of the AIS Service. Since it is novel to IALA Recommendations a legend and some explanation are given.

The **numbers**

denote the multiplicity of possible relationships between the different entities. For example, a logical AIS shore station must have at least one physical AIS shore station associated with it but will have as many as are needed (indicated by the asterisk *). Also, in most cases, a physical AIS station will be used by more than one logical AIS shore station, hence *. However, in very simple AIS Service layouts the logical AIS shore station may be omitted in the AIS Service (but needs to be provided by higher levels or applications instead), so that a physical AIS shore station would not be unrelated to any logical AIS shore station, hence '0'.

The **composition indications**

—◇

indicates, that the higher level comprises, at least, the items given. For example, the physical AIS shore station comprises (amongst other devices *which may not be of relevance for the discussion at hand*) at least one AIS base station. A black square indicates, that the existence of the part of the whole is dependent on the whole for its existence or making sense.

Notes:

* The VHF / RF domain equipment may be "owned" by a different service, such as VHF radio communications and is provided to the AIS Service on a co-location basis (while fulfilling the requirements of the AIS Service).

† The AIS VDL also exists without any AIS shore installation.

1.7.2.1 The AIS VHF Data Link

VHF data link (VDL) is understood as the medium for exchange of data between different AIS stations; by default, using ITU-assigned channels AIS1 and AIS2 in the VHF maritime mobile service band. The channels AIS1 and AIS2 are divided in time slots, 1 minute consists of 2250 slots per channel, giving in total 4500 slots.

In addition, DSC Channel 70 can be used for DSC-based AIS channel management and DSC polling. DSC polling can result in the utilisation of other DSC channels in the VHF maritime mobile band, but its use affects the operation of the mobile AIS station's VDL monitoring and utilization capabilities.

1.7.2.2 RF-/VHF domain Equipment

RF-/VHF domain equipment consists of the means to establish the VDL between the different AIS stations. Antennas, cables and filters are components of the RF-/VHF-equipment.

1.7.2.3 Fixed AIS Stations Layer

1.7.2.3.1 AIS Base Station

The AIS base station is the most basic AIS-related entity of any AIS shore infrastructure. Conceptually, it is a "bare bones" black-box like device defined by the functional description and interface definitions given in the following chapters. It cannot operate on its own, since it does not have the supporting infrastructure of a physical AIS shore station.

1.7.2.3.2 AIS Repeaters

The AIS essentially is a simplex system, and the AIS easily provides for a simplex repeater or simplex repeating process. *Duplex repeaters may be built, but it may be difficult to fulfil physical layer and link layer requirements of Recommendation ITU-R M.1371-1 with respect to the TDMA AIS VDL.*

The main application of simplex repeating is to extend the coverage, or to overcome local obstacles to radio propagation. The main application of duplex repeating is to extend the coverage.

Within the AIS Service simplex and duplex AIS repeaters are located on the same layer as AIS base stations, i. e. they have direct access to the VHF/RF domain equipment for reception and transmission of VDL messages.

This document describes the simplex repeater station or the simplex repeating process proper, and the duplex repeater station proper. More detailed planning considerations and application notes for both simplex and duplex repeating are given in the IALA Recommendation of AIS Shore Stations and Networking Aspects Related to the AIS Service Edition 1.0, Part II-B and II-C.

1.7.2.4 Physical AIS Shore Station (PSS)

The PSS is the most basic AIS-related entity, which can exist on its own in a real physical environment, as opposed to an AIS base station or AIS repeater station.

A PSS is physically fixed or is considered to be "fixed"[2]. A PSS may be theoretically mounted on a flying or floating platform, however. The latter cases are excluded from the scope of this document for simplicity's sake.

A PSS consists at least of the following components or functions:
- one AIS base station or one AIS repeater station;
- power supply;
- VHF-/RF-domain equipment, at minimum simply a cable and a VHF antenna;
- if the PSS houses an AIS base station: a means to transport data to and from the AIS base station is required; (an AIS repeater may operate without this data transport means);
- a means to protect the above component against environmental influence and damage, e.g. a shelter building or a housing case. Thus, a PSS does not necessarily need to be considered large physically.

In addition, a PSS will generally have a UTC source of its own (there may be cases during which the AIS base station may be set up using only the synchronisation provided by the AIS VDL itself, i.e. UTC indirect or even slot synchronisation). This UTC source may be internal to the AIS base station such as a GNSS receiver, or just internal to the PSS, such as an atomic clock or a Loran timing receiver.

In addition, there may be optional AIS-related functions added to the PSS' set-up, e.g. DGNSS correction source, AtoN station's functionality source, remote control equipment, or logging devices. Also, the PSS will, in most cases, comprise a control device, which, for instance, monitors the integrity of operation of some or all devices of that PSS, or which performs filtering functions for those AIS base and repeater stations housed by this PSS.

Co-location issues: From a conceptual point of view, one shelter or housing case may house more than just AIS-related services. Yet, the term "Physical AIS shore station" is used to indicate that the shore station has AIS capability regardless of any non-AIS capability it may have.

1.7.2.5 Logical AIS Shore Station (LSS)

A LSS is a software process, which transforms the AIS data flow associated with one or more PSS into a different AIS-related data flow. Every individual transformation process takes into consideration
- operational aspects of the applications using the AIS service, and
- technical aspects which arise when operating a network of PSS.

Details are described in the appropriate Part below.

The software process of a logical AIS shore station can run on any appropriate computer at any appropriate place. It is required, however, that there are reliable data transportation means to and from all associated physical AIS shore stations and to the AIS Service, which interfaces with the applications.

1.7.2.6 The AIS Service Management (ASM)

Since the AIS Service of a competent authority will, in most cases, comprise more than one LSS, PSS, and fixed AIS station, there is a need for a top layer, which acts as a controlling entity for the whole of the AIS Service. In particular:

[2] As is the case when mounted on an AtoN; the point here is, that the physical AIS shore station has a fixed geographical position. If it is mounted on an AtoN the area in which the AtoN is allowed to swing is very small compared to the coverage area of this physical AIS shore station.

The ASM "owns" all the logical and physical shore stations, i. e. it invokes, initialises, configures and terminates the logical and physical shore station software processes at run-time;
it determines the network communication relationships between physical shore station and their associated logical shore stations for them to use during run-time;
the ASM determines the communication relationships between the logical shore stations and the applications associated with them, i.e. this top level acts as a "switch-board" for the data exchange relationships between the different processes.
A more detailed description is given in Chapter 13 below.

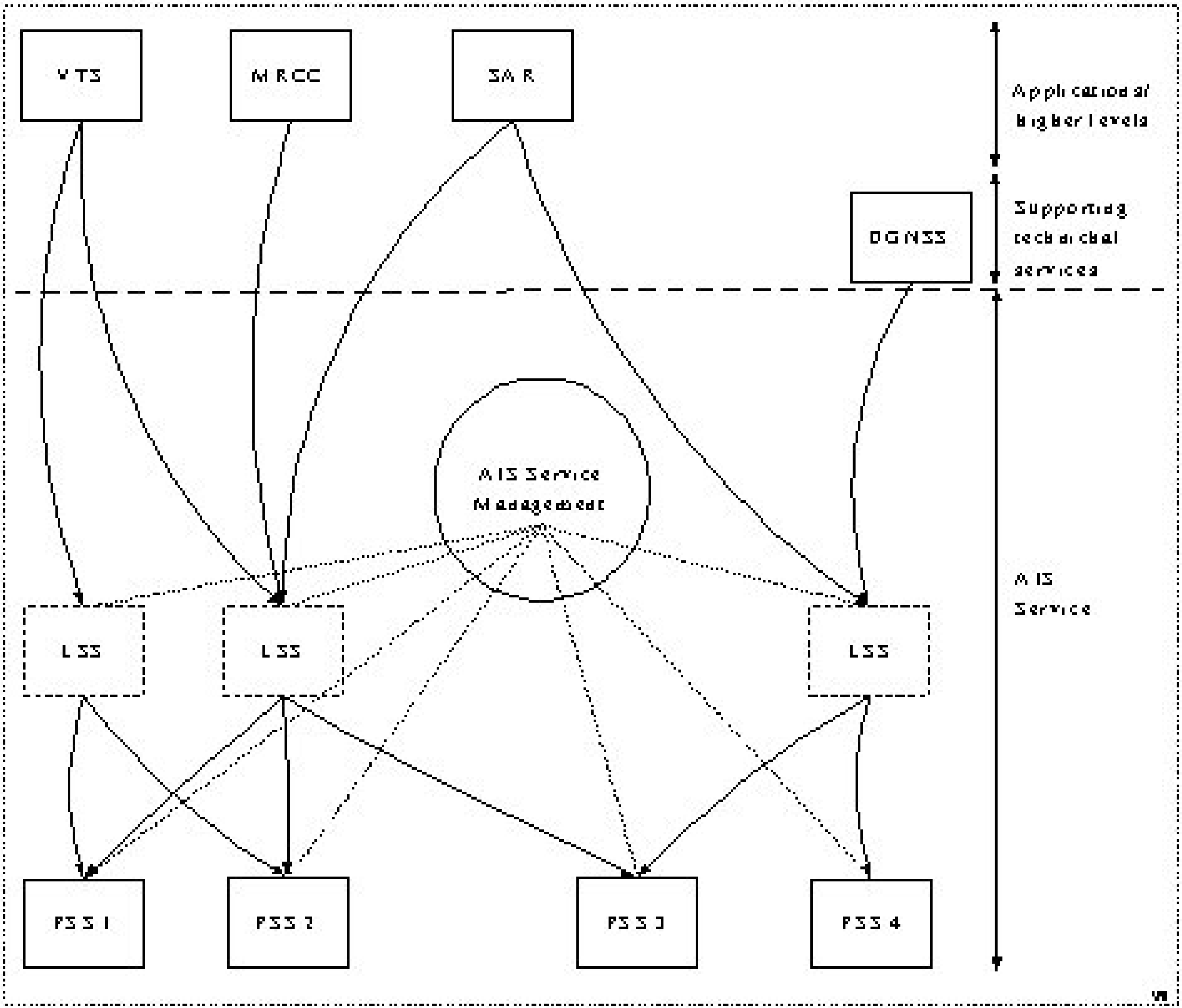


Figure 1.4: Example on an AIS Service with clients and providers of AIS Data.

This example in figure 1.4 describes an AIS Service, which includes Physical Shore Stations (PSS), Logical Shore Stations (LSS) and an AIS Service Management (ASM) entity. Several PSS are assigned to at least one LSS, which combines the data from these PSS in order to cover a certain area. In this example the AIS Service includes several LSS. Clients will receive data from the LSS distributing the data of interest to that certain client. The management of the AIS Service is done by the ASM. This entity controls the data flow in the system and configures the different entities in order to fulfil the given requirements.

1.8 AIS Data Transfer Network

The AIS data transfer network is a fully transparent data transportation means used to deliver AIS-derived data. Since all AIS-related functionality has been encapsulated in either the PSS, or the LSS or at the AIS Service level, the AIS data transport network does *not comprise any AIS-specific technology*. Hence, the AIS data transfer network is a virtual network transporting AIS-related data within a possibly much larger network of the competent authority.

1.9 Fundamental technical prerequisites

From the above considerations the following fundamental technical prerequisites can be deduced, which need to be fulfilled by proper planning (see the appropriate chapters):

The physical coverage of all physical AIS shore stations of one competent authority should always exceed the required coverage area of all logical AIS shore stations defined by that competent authority, where the same service level in terms of availability, reliability etc. applies.

Each of the layers of the AIS Service requires a certain amount of processing capacity. The competent authority should provide the needed processing capacity to ensure proper operation of the AIS Service.

The layered stack does not expressively state transportation of data over distances. Between each layer a transportation process is required; however, the distances and capacity requirements of which are totally dependent on local conditions. It is assumed, that the transportation processes do not constitute a bottleneck which determine the overall functionality. This can be achieved by standard modern technology even with high capacity needs.

Between each layer there are functional interfaces, which can be defined precisely.

1.10 The implications of the AIS Service as a co-operative system for its integration into shore-based environment

In section 1.5 above the place of the AIS Service within the shore-based technical environment was indicated (compare also Figure 1.1). Afterwards the various components of the AIS Service were introduced briefly. At the end of the introduction chapter into the technical aspects it appears now appropriate to address some more fundamental and philosophical implications of the integration of the AIS Service into (existing) shore-based technical environments.

1.10.1 Dependency of recipient on quality and integrity of transmitted data

Considering the co-operative and automated nature of the AIS from the recipients point of view, in particular from a VTS point of view, the following, issues need to considered:

- Who is the *recipient* of reported information? The premier recipient of the AIS transmitted data are the entities making use of the data in run-time, i. e. human users, such as the *VTS operator(s),* and / or machine "users", which *automatically evaluate AIS transmitted information* (The evaluation results will be presented to the human users eventually.). One major implication of this fact is, that real-time machine-to-machine exchange of safety-related information is now possible.
- Since the receiving entity can do virtually nothing to ensure, that only correct information is transmitted from ships the question arises, what steps have been taken to ensure this. In addition, the receiving entity may consider, what it could do to validate received information. These questions indicate the recipient's dependency on the transmitting side. Therefore, some fundamental questions must be raised:
  - How can a *high quality* of the transmitted data be guaranteed? This demand for 'high quality' translates into the following more precise questions:
  - Where will the transmitting AIS get a *correct position* – generally speaking: *correct ship data* - from *under all circumstances*?

- What *integrity monitoring information* will be included in position (ship data) reporting?

Yet there is more to it than just to consider the quality of information sources of single, AIS-fitted ships. *The path of the information flow from its ultimate source to the ultimate sink needs to be investigated.* A first step towards that investigation is provided by the following identification of different levels of integration of AIS.

1.10.2 The different levels of integration of AIS

Figure 1.5 shows an outline of all major systems and their components involved, again from the shore perspective: For simplicity's sake only two AIS-fitted ships have been introduced. For simplicity's sake these two ships are shown identical in their system layout, too. Their shipborne AIS stations receive data from "information sources", e. g. sensors. The most prominent of these sensors is the shipborne EPFD, which normally will contain at least one (D)GNSS position sensor. The (D)GNSS position sensor in turn will receive its positional information from a satellite system, which may be augmented by a terrestrial system. Since the radio navigation system proper is beyond the scope and control of both the AIS and the shipborne electronic environment, it is called "external". The consequence of this statement is simple, but fare-reaching: *As far as the reported position, speed and course are concerned, the automated position reporting of the AIS relies completely on a position source external to it.*

The EPFD and other shipborne sensors may be part of an Integrated Navigation System (INS). The INS may be part of an IBS, in turn. Therefore, the INS or the IBS electronically generates the data which is to be transmitted by the shipborne AIS station. In addition, the INS or the IBS electronically store manual input by the ship's OOW, and forward it to the AIS for reporting, when needed. The IBS constitutes the utmost boundary of the ship's electronic environment.

Every AIS station transmits its data to the AIS VDL. The transmissions are received by AIS shore stations or by other ships. The AIS system proper comprises the AIS VDL and all AIS stations, fixed and mobiles, in the vicinity. The AIS system proper interfaces the appropriate AIS stations both to the shipborne electronic environment or to the AIS-network ashore.

For timing purposes the AIS shore stations depend on the "external" system (D)GNSS, too. This is indicated in Figure 1.5 by the arrow from the "external" system to the AIS shore station. However, a second, independent timing source may be provided, such as a state-of-the-art Loran-C receiver.

Ashore, the received data is forwarded via the AIS data transfer network. The AIS-network may be a sophisticated internet-like network or simply a cable to the next VTS centre. There the AIS data is processed, and AIS derived information are eventually displayed.

All components including the "AIS system proper" and excluding the "external" radio navigation system are part of the system, which is called "AIS integration ship-shore/shore-ship".

To sum up: There have been identified the following four system levels:
- the AIS system proper, i. e. the AIS technology and its impact.
- the shipborne electronic environment of the various classes of ships (not just as simplified in the drawing of the Annex)
- the "external" radio navigation system
- the integration of various other VTS related functionality with the AIS functionality to one new integrated system.

1.10.3 Aspects and answers to the impact of the introduction of the AIS

After the different levels of integration of AIS have been considered, some aspects of the impact of the introduction of the AIS can be considered and possibly some answers be provided. These aspects, in their totality, constitute the design philosophy of the AIS.

1.10.3.1 Responsibility for the integrity of the data transmitted

The shipborne AIS station is the actual source of information only in rare cases. AIS basically constitutes, technically speaking, a highly sophisticated transport medium for navigational and safety-related information: Any shipborne AIS station transmits what it receives from other shipborne systems. Therefore, a fundamental design philosophy is needed, which guarantees - as far as at all possible - the integrity of any data item: *The shipborne source of any information is considered responsible for the integrity of the data produced and output by that source.*

Basically, this is not a new statement of philosophy: Within the shipborne electronic environment it has been in use for some time, and also Aids-to-Navigation are generally designed in accordance with this philosophy. By the introduction of the AIS, the rigid observation of this design philosophy now becomes more important.

1.10.3.2 Automated operation of the AIS and the AIS integration ship-shore/shore-ship to the maximum extent possible

The AIS has been designed as a "hands-off" system. This translates to the following statements: Manual operation should not be required for the default operation of the AIS. Manual operation should be minimised to the extent reasonable and possible when using AIS-enabled applications on top of the default operation. Manual operation should only be allowed where and when at all necessary. This part of the fundamental design idea was again and again stressed by IMO. The rationale for this stipulation is to minimise the influence of human error on AIS and the AIS integration ship-shore/shore-ship.

1.10.3.3 The importance of properly designed Human-Machine-Interfaces (HMI)

Applying this philosophy to all remaining manually input data items, it becomes clear, that at least the input part of all HMI:s should be designed in accordance with the following rules: Correct manual input should be prompted and made easy by correct default setting. The default settings may be selected to be context-sensitive. Any manual input should be evaluated to the maximum extent possible before accepting it. The reliability of the manually input data should be assessed in the medium run, i. e. during the introduction period of the AIS. An internationally agreed assessment might be helpful.

1.10.3.4 Fallback arrangements for important input data sources

There are many reasons why a shipborne AIS station might not receive required information from the ship's electronic environment, e.g. failure of one sensor, or breakdown of the communication between the sensor and the shipborne AIS station. If at all possible there have been introduced automated fallback arrangements into the design of the shipborne AIS station. Upon entering such a fallback mode the shipborne AIS station provides appropriate indication or even alarms to the shipborne electronic environment, so that this may not go unnoticed as far as this particular shipborne AIS station or its electronic environment is concerned.

1.10.3.5 Fundamentally new orientation in the VTS technology design philosophy

The present VTS design philosophy is generally characterised by a technology-oriented approach: In the past and still today, the major sensor has been radar and radar tracking /radar data processing. The technology-oriented approach does not constitute an issue as long as there has been just one major sensor for the VTS, i. e. radar. By AIS a second major sensor will be introduced. The continuation of the technology-oriented approach would mean, that AIS derived information is routed directly to the VTS operator's display. In the worst case, two or even more sets of information would be visible to the VTS operator for every single AIS-fitted ship.

Given this situation, it may be anticipated, that a mere continuation of the technology-oriented approach during the introduction of the AIS would create VTS systems, which would be prone for inconsistency (both on an operational and on a technical level), quite expensive, not providing the expected benefits, and cumbersome to maintain on the medium and long run.

Due to the introduction of the AIS, instead of a technology-oriented approach an information-oriented approach should be taken: All available sources of information would be merged and only one set of information would be presented to the VTS operator. This set of information would be derived by a fusion process, the details of which would need to be determined. This would still allow the VTS operator to access the more detailed and single-source information on request, when needed.

1.10.3.6 Validation of AIS transmitted data by non-co-operative sensors

Where locally available, non-co-operative sensors, such as shore-based radar or shore-based VHF direction finding equipment, could be used to validate the AIS data. This leads to *sensor fusion*, which in turn prompts a lot of questions in detail, e. g. with regard to a correct fusion algorithm.

1.10.3.7 Closer co-operation of formerly independently operating technical disciplines

Due to the integrative nature of the AIS and due to the peer-to-peer character of AIS-enabled applications, technical disciplines which formerly independently operated are now moving closer to each other. This applies in particular to a closer co-operation of the shipboard engineering environment with the shore-based engineering environment. The best example may be closer co-operation between IALA and IEC due to the AIS.

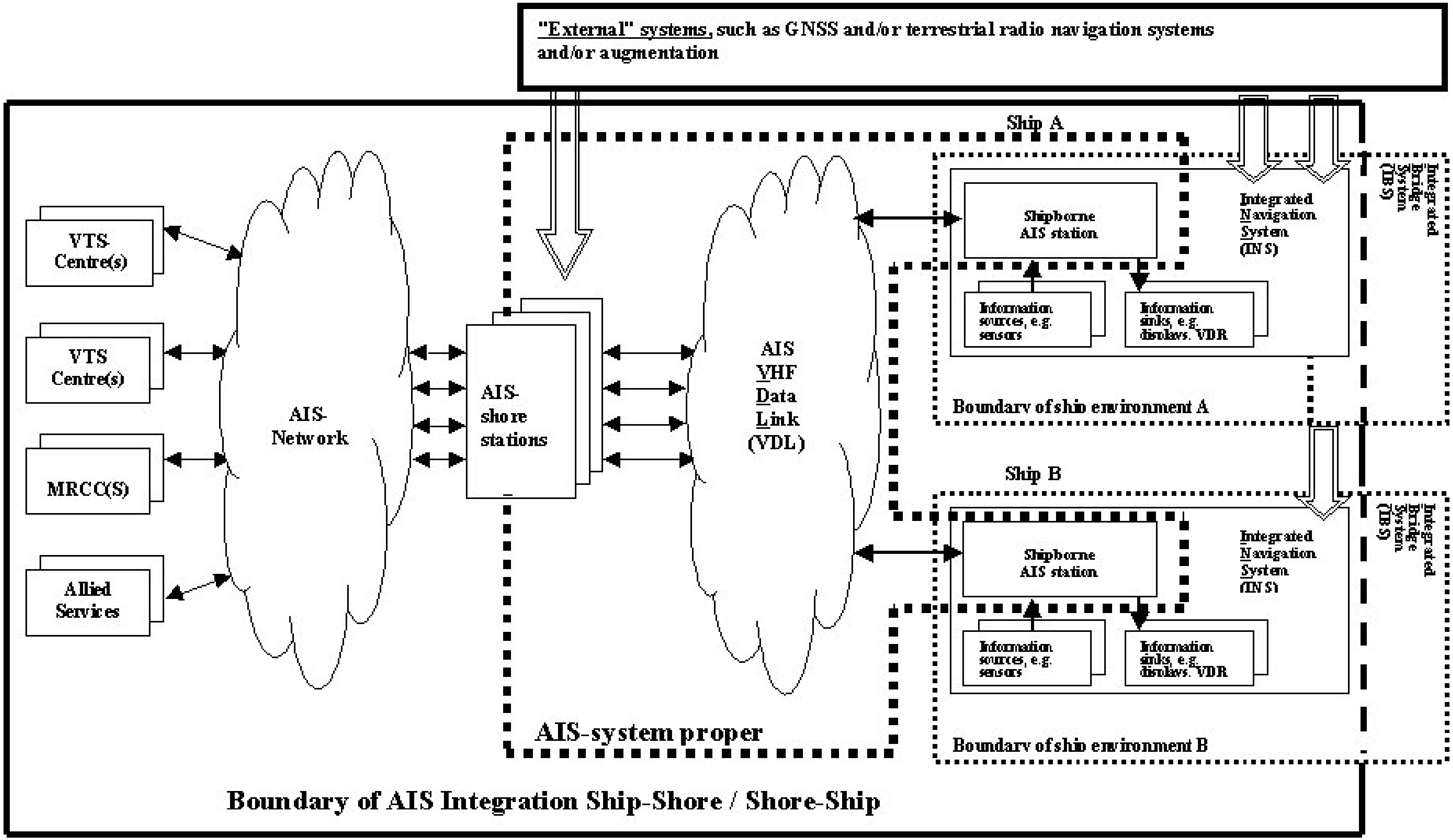
1.10.3.8 The peer-to-peer character of AIS-enabled applications in the AIS integration ship-shore/shore-ship

The information-oriented approach may also be the only way to allow the correct function of the required communication between AIS integration experts both on the VTS side and on the side of shipborne electronic environment. IMO has just started the discussion on AIS-enabled applications most of which require peer-to-peer information exchange between VTS and shipborne electronic equipment.

1.10.4 Conclusion and Cautionary note

These aspects can currently be no more than indications that much still has to be investigated with regard to the integration of the AIS. Also a cautionary note is required. The AIS concept, design and the technology proper is still evolving. These remain open issues, some of which are addressed at the end of Part II. Presently, AIS is sufficiently mature to be a significant enhancement to the safety of navigation. However, before taking final decisions on design or specifications it would be prudent to check the IALA web site for technical clarifications and updated technical descriptions of the AIS design.

Figure 1.5: Boundaries of different systems related to the AIS



2. Overview on international documents dealing with the AIS

2.1 The importance of international standardisation

Inter-operability is the most fundamental pre-requisite for any AIS-based application. Since the AIS is a global system, the inter-operability must be global, too. Extensive international standardisation of at least the AIS system proper, but also for those parts of the AIS integration ship-shore/shore-ship, which have direct bearing on the AIS's co-operative functionality is required to constitute the basis for global inter-operability. Such parts are the sensors connected to the shipborne AIS stations and the shipborne display systems.

Another fundamental pre-requisite for most AIS applications is globally uniform and deterministic behaviour even in non-default situations. There will be a plurality of different manufacturers world-wide producing components of the AIS system proper or components of the AIS integration ship-shore/shore-ship. International standardisation is the only practical way to achieve globally uniform and deterministic behaviour.

Further, only international standardisation makes it possible to implement test procedures globally, which guarantee the same world-wide quality of type approval. Still further, the international standardisation of instruments such as the Initial Survey and subsequent surveys (in accordance with SOLAS) allow to globally maintain the ships' equipment quality on the required level globally.

Finally, standardisation creates a global market, which is beneficial, first for economical procurement of both competent authorities and ship-owners, and secondly for the continued development of the AIS during the next decades.

2.2 Overview on international documents

Many documents on AIS are available from different organisations. They are all based on the IMO Performance Standards, followed by the ITU-R Recommendation on AIS. From here the standards were developed for both Class A and Class B mobile stations by IEC. IALA has described the Shore stations and is in the process of describing AtoN stations. Also IALA has created the IALA AIS Guidelines (this document) as an operational and technical source of AIS information.

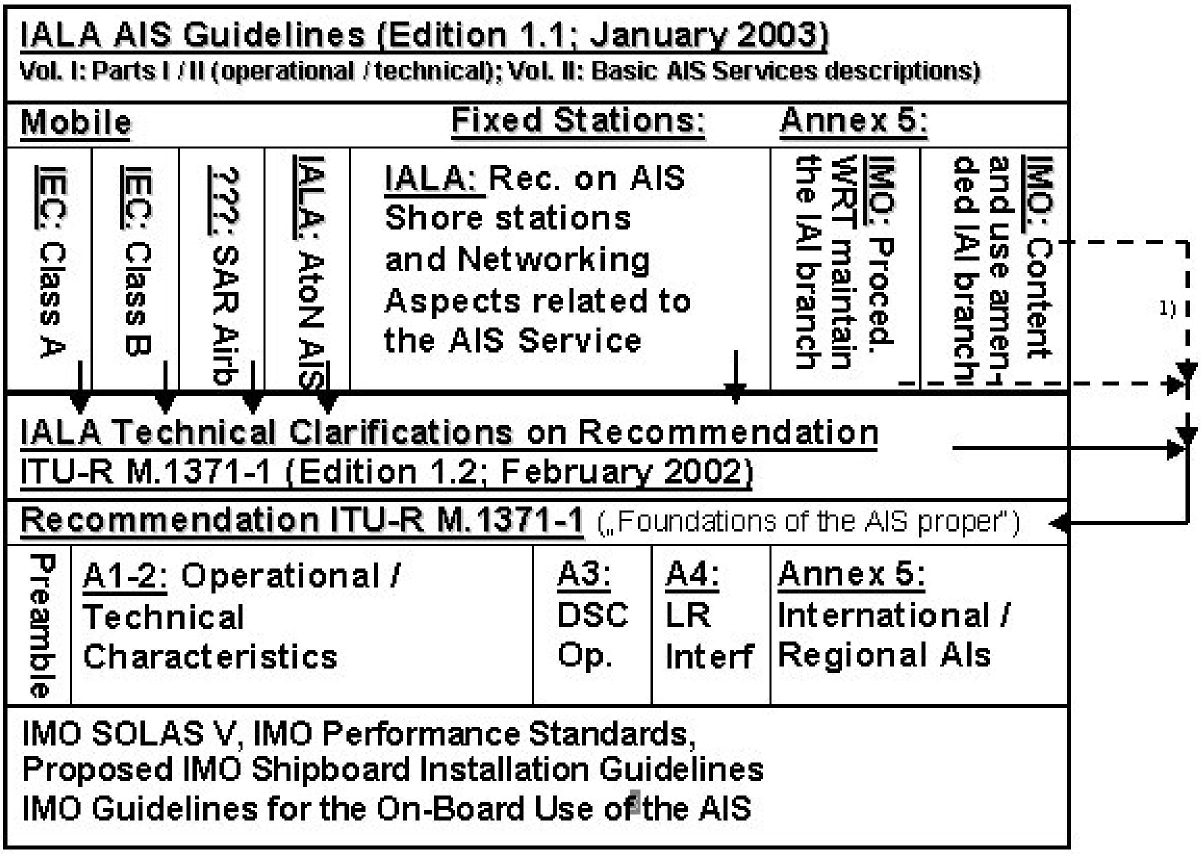
As a result of the work done by IALA and IEC, technical clarifications to the ITU-R Recommendations were made. In accordance with Recommendation 4 of the ITU-R M.1371-1, IALA is maintaining and publishing corresponding ‘technical guidelines’. Technical guidelines encompass the following documents: the Technical Clarifications and appropriate IALA recommendations.

The Technical Clarifications (see Table 2.1) are considered to fulfil amongst other documents Recommendation 4. Consequently IALA plans to submit to ITU the Technical Clarifications for incorporation into future revision of Recommendation ITU-R M.1371-1.

For reasons of practical use of AIS, IMO published some background documents for the use of AIS and installation of AIS on board ships. Table 2.1 shows all available documents and the relations between them. The table is followed by the official titles of the documentation.

Table 2.1 shows the logical relationship among the documents that comprise the body of knowledge on AIS.

Table 2.1 The logical relationship between the international documents



1) is being reviewed by IMO

2.3 List of the most important international reference documents

IMO:

[1] IMO Resolution MSC.90(73) Annex 7, Adoption of amendments to the international convention for the safety of life at sea, 1974, as amended

[2] IMO Resolution MSC.74(69) Annex 3, Recommendation on performance standards for AIS

[3] IMO Guidelines for on-board use of AIS

[4] IMO Shipboard installation guidelines

ITU:

[5] Recommendation ITU-R M.1371-1, Technical characteristics for a Universal Automatic Identification System using Time Division Multiple Access in the VHF maritime mobile band

IALA:

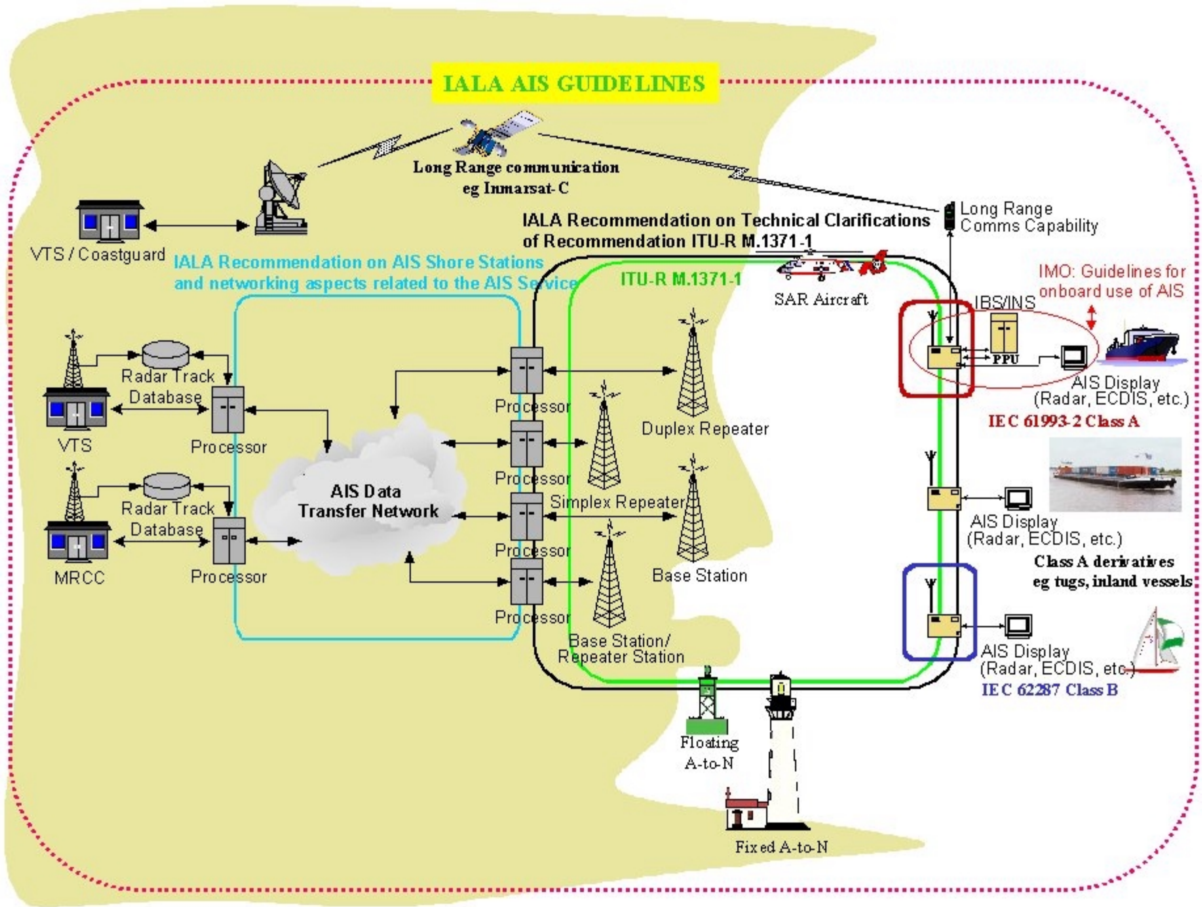
[6] IALA Recommendation on Technical Clarifications on Recommendation ITU-R m.1371-1

[7] IALA Guidelines on AIS (2 volumes, 3 parts)

[8] Recommendation on AIS shore stations and networking aspects related to the AIS service
[9] IALA Recommendation on AIS for Aids-to-Navigation (under preparation)

IEC:
[10] IEC 61993-2, Automatic Identification Systems (AIS); Part 2: Class A shipborne equipment of the Universal Automatic Identification System (AIS)
[11] IEC 62287, Class B ship-borne installation of the universal automatic identification system (AIS) using TDMA techniques (under preparation)

Figure 2.1 AIS system overview



The relationship between the AIS documents and the AIS stations is shown in Figure 2.1. All known types of AIS stations are present, the coloured lines are representing documents and the AIS system components described in that document.

PART B: MOBILE AIS STATIONS

3. Introduction to AIS Stations in General

The Recommendation ITU-R M.1371-1, as clarified by IALA's Technical Clarifications, subdivides all AIS stations into "mobile" and "fixed" stations. This subdivision determines the intended purposes of the AIS stations and thereby the capabilities associated with these stations. Mobile stations are intended to be used by mobile participants of the AIS, such as vessels, SAR aircrafts and in particular floating Aids-to-Navigation. Fixed AIS stations are intended to be used by the shore-based competent authority when setting up its AIS Service. Fixed AIS stations exhibit a much superior functionality in terms of controlling the AIS VDL than mobile AIS stations. Mobile AIS stations have no capability to control the AIS VDL. Therefore, it can be summarized, that "mobile" and "fixed" are determined by the capabilities of the AIS VDL rather than by their physical degree of mobility. This could mean, however, that a fixed station, such as a base station, is mounted on a more or less mobile device, such as a light vessel, while still performing a fixed station's functions. Also, an Aids-to-Navigation AIS Station may be mounted on a lighthouse, but it will still exhibit the mobile station's functionality.

The following table gives an overview and the correct titles of the different varieties of AIS stations, as defined in Recommendation ITU-R M.1371-1.

Table 3.1 Overview of AIS stations

Mobiles				**Fixed**		
Shipborne		Airborne	AtoN	Base	Simplex repeater	Duplex repeater
Class A*	Class B	SAR				

* including Class A derivatives

Mobiles:

- Class A shipborne (mobile) station
- Class B shipborne (mobile) station
- SAR (airborne) AIS station
- AtoN station

Fixed:

- AIS base station
- AIS simplex repeater
- AIS duplex repeater

4. Shipborne mobile AIS stations

4.1 Introduction

Two types of shipborne AIS mobile stations for vessels have been defined in ITU-R M.1371-1:
Class A Shipborne Mobile Equipment will comply with relevant IMO AIS carriage requirements
Class B Shipborne Mobile Equipment will provide facilities not necessarily in full accordance with IMO AIS carriage requirements. This type is mainly intended for pleasure craft.

There may be other varieties of mobile stations that have not yet been defined. This group of mobile AIS stations concerns professional users, not required to use Class A mobile stations but needing the Class A functionality. This AIS mobile equipment is called 'Class A-Derivatives'.

4.2 Definitions of Shipborne Mobile AIS stations

The most important issue is that all categories of mobile AIS stations must be fully compliant on the VDL level. They must recognise all different types of messages, only the processing of the messages can be different. The interfaces to external display systems and sensor system may vary between different types of AIS stations.
The definition of the different categories of shipborne mobile AIS stations is as follows:

- Class A Shipborne Mobile Station (Class A) must be 100% compliant with the IMO performance standard and the IEC 61993-2 standard.

- Class B Shipborne mobile stations (Class B) have a different functionality on VDL-message level. The position and static information reports are transmitted with their own VDL messages and with different reporting rate.

4.3 Common Features for all shipborne mobile AIS stations

The operating principles of a shipborne mobile AIS device can be described as follows. A ship determines its geographical position with an Electronic Position Fixing Device (EPFD). The AIS station transmits this position, combined with ship identity and other ship data via the VDL (VHF radio link) to other AIS equipped ships and AIS base stations that are within radio range. In a similar fashion, the ship, when not transmitting, receives corresponding information from all ships and base stations that are within radio range.

4.4 Specific issues for Class A Shipborne Mobile AIS stations

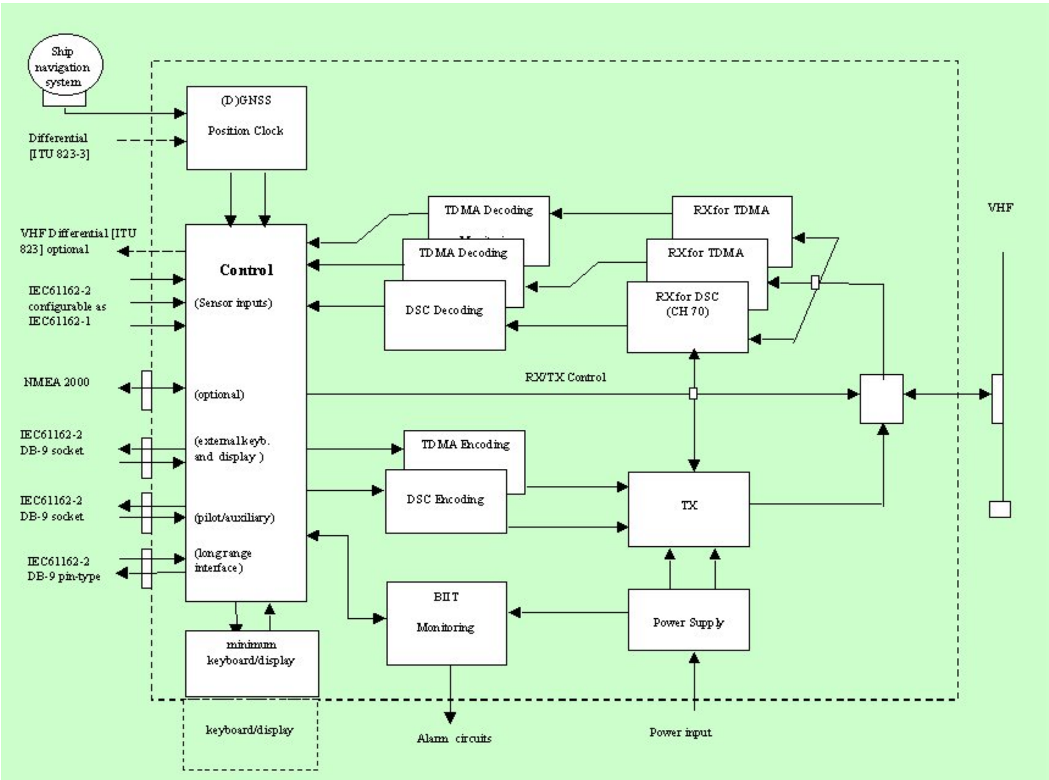
In addition towhat is described in the IMO Performance Standards, ITU-R M.1371-1, and the IEC 61193-2 standard there are no specific issues for Class A mobile AIS stations.

4.4.1 Functional Block Diagram

Figure 4.1 shows the principal component parts of a Class A shipborne mobile AIS station. Components for Class A are:

- GNSS receiver: The GNSS receiver supplies the time reference (UTC) to the AIS station to synchronise all transmissions such that there are no collisions or overlaps which would degrade the information being transmitted.

  - The internal (D)GNSS receiver may be used as a back-up source for ship's position , SOG and COG determination.
- VHF transmitter/receiver: There is one VHF transmitter and two VHF receivers for TDMA operation. The VHF transceiver transmits and receives the radio signals that form the data links that interconnect the AIS stations to each other (VHF Data Link or VDL). The individually assigned transmission time slots are short (26.6 ms). The VHF transmitter has to have a very fast switching capability (1 ms) from zero to full output power and vice versa. In the block diagram (Figure 4.1) the receivers are functionally shown as a radio receiver part (RX for TDMA) and a TDMA decoding part. In the same way, the transmitter consists of TDMA Encoding and radio part of the transmitter (TX).



***1) The external keyboard/display may be e.g. radar, ECDIS or dedicated devices.**
***2) The internal keyboard/display may optionally be remote.**
***3) A description of the installation of the "pilot plug" is given in the appropriate section.**

Figure 4.1 Block diagram of Class A mobile station

- DSC VHF receiver : The DSC receiver is fixed tuned to channel 70 to receive channel management commands for regional area designation. The DSC receiver can also be used for limited DSC polling. When replying to DSC polling the common VHF transmitter will be used.
- Controller: The Control unit manages the functions of all components of the AIS station. It manages the time slot selection process, the operation of the transmitters and receivers, the processing of the various input signals and the subsequent distribution of all of the output and input signals to the various interface plugs and sockets, and the processing of messages into suitable transmission packets.
- Built-in-Integrity-test (BIIT) controls continuously integrity and the operation of the unit.

- Power Supply
- Signal interface ports (Presentation Interface PI): In order to be able to transmit all the information that a position report includes, the AIS station has to collect information from various ship sensors. There are also interfaces for connection to external display systems and Long-Range equipment.

4.4.2 Presentation Interface Description

The Presentation Interface (PI) is the collection of all signal interface ports. It connects the AIS mobile station to external equipment such as:

- Electronic Position Fixing Device (EPFD)
- Gyro providing heading and optionally ROT
- Display systems (ECDIS, ARPA, INS, etc.)
- Personal Pilot Unit (PPU) or workstation
- Long-range communication means e.g. Inmarsat-C

The PI will consist at a minimum of the following signalling interface ports:

- sensor input ports (IEC 61162-1 or IEC 61162-2): EPFD and e.g. Gyro and ROT (Ch 1, 2 and 3 in the Figure 4.2)
- 1 bi-directional high speed interface (IEC 61162-2) to external display systems (Ch 4)
- 1 bi-directional high speed interface (IEC 61162-2) to external auxiliary equipment or pilot carry on board display systems (Ch 5)
- 1 bi-directional high-speed interface (IEC 61162-2) to operate Long-Range functions (Ch 8)

Optional ports can be added i.e. for DGNSS correction data (in and out) (Ch 9) and an IEC 61162-3 compliant port (Ch 6).

The following information is output via PI ports to display-systems or Personal Pilot Unit (PPU) / auxiliary:

- All received data from other AIS stations (base and other mobiles)
    - Position reports
    - Static and voyage related data
    - Binary and safety related messages
    - VDL related messages (e.g. channel management)
- Own ship information when it is transmitted
- Long-range interrogation information
- Ships sensor data and status, which is connected to the AIS station, every second
- Alarm and status messages generated by the BIIT

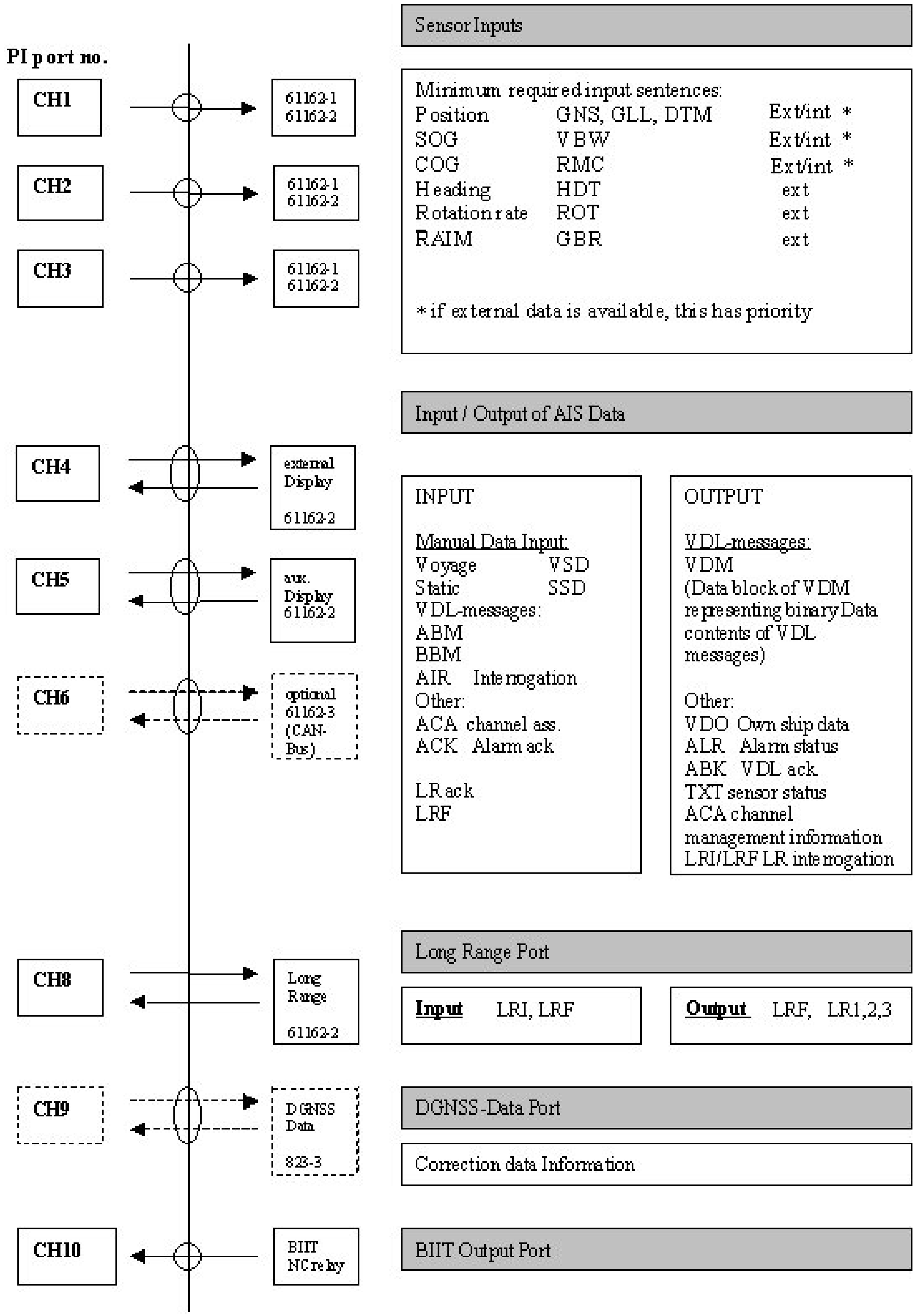


Figure 4.2: Presentation interfaces for Class A Shipborne Mobile Stations

The following information can be input via the PI from the connected systems:

- Voyage related data
- Station static data
- Long-range confirmation
- Binary and safety related messages
- Alarm confirmations

- Channel management actions

Long-range messages will be input to and output from external long-range communication system, e.g. Inmarsat-C via the Long-range port on the PI.

A dedicated connector for BIIT alarm status is available on Ch 10.

4.4.3 Built-in-Integrity-Test (BIIT)

Class A AIS mobile stations are equipped with a built-in integrity test unit (BIIT). This runs continuously or in appropriate intervals simultaneously with all other functions of the station. If any failure or malfunction is detected that will significantly reduce integrity or stop operation of the AIS, an **alarm** is initiated. In this case the alarm is displayed on the minimum keyboard and display unit and the alarm relay is set "active".
An appropriate alarm message is output via the Presentation Interface and repeated every 30 sec.

The alarm relay is deactivated upon acknowledgement of the alarm either internally by means of minimum display and keyboard or externally by a corresponding ACK sentence.

If a change of a relevant system status as described below is detected, an **indication** is given to the user. This indication is accessible on the minimum keyboard and display unit.
An appropriate text message is also output via the Presentation Interface.

4.4.3.1 Monitoring of functions and integrity

In case a failure is detected in one or more of the following functions or data, an alarm is triggered and the system reacts as given Table 4.1.

Alarm's description text	**Reaction of the system to the Alarm Condition threshold exceeded**
AIS: Tx malfunction	Stop transmission
AIS: Antenna VSWR exceeds limit	Continue operation
AIS: Rx channel 1 malfunction	Stop transmission on affected channel
AIS: Rx channel 2 malfunction	Stop transmission on affected channel
AIS: Rx channel 70 malfunction	Stop transmission on affected channel
AIS: general failure	Stop transmission
AIS: MKD connection lost	continue operation with "DTE" set to "1"
AIS: external EPFS lost	continue operation
AIS: no sensor position in use	continue operation
AIS: no valid SOG information	Continue operation using default data
AIS: no valid COG information	Continue operation using default data
AIS: Heading lost/invalid	Continue operation using default data
AIS: no valid ROT information	Continue operation using default data

Table 4.1 Integrity alarms

4.4.3.2 Sensor data status

In case a sensor data status changes, an indication is given and the system reacts as given in Table 4.2:

Text Message	Reaction of the system
AIS: UTC clock lost	Continue operation using indirect or semaphore synchronisation
AIS: external DGNSS in use	Continue operation
AIS: external GNSS in use	Continue operation
AIS: internal DGNSS in use (beacon)	Continue operation
AIS: internal DGNSS in use (message 17)	Continue operation
AIS: internal GNSS in use	Continue operation
AIS: external SOG / COG in use	Continue operation
AIS: internal SOG / COG in use	Continue operation
AIS: Heading valid	Continue operation
AIS: Rate of Turn Indicator in use	Continue operation
AIS: Other ROT source in use	Continue operation
AIS: Channel management parameters changed	Continue operation

Table 4.2 Sensor status

4.4.4 Minimum Keyboard and Display

A minimum keyboard and display unit (MKD) is mandatory on Class A mobile stations.

The MKD has the following functions:

- Configures and operates the equipment.
- Shows at least three lines of information.
- Inputs all required information via an alpha numerical keyboard with all valid 6-bits ASCII characters available
- Displays all the received vessels' bearing, range and names. The MKD displays at least Range, Bearing and vessel's name on a line-by-line display. Any horizontal scrolling does not remove the range and bearing from the screen. It is possible to scroll up and down to see all the vessels that are currently in the coverage area of the AIS unit.
- Indicates alarm conditions and means to view and acknowledge the alarm. When the AIS unit gives an alarm the display indicates to the user that an alarm is present and provides means to display the alarm. When an alarm is selected for display it is possible to acknowledge the alarm.
- Indicates the state/condition change inside the AIS and provides a means to view the state/condition change message. The MKD may be used to input voyage related information, such as cargo category, maximum present static draught, number of persons on board, destination, ETA, and navigational status.
- The MKD may be used to input static information such as MMSI number, IMO number, Ships Call sign, Ships Name, Length and Beam, Position reference points for GNSS antenna and Type of Ship
- Displays safety related messages. The MKD will indicate to the operator when a safety related message has been received and display it on request
- The MKD may be used to input safety related messages. It is possible to input and send addressed (message 12) and broadcast (message 14) safety related messages from the MKD.

- Change the AIS unit mode of response to Long-Range (LR) interrogations.
- It is possible to set the AIS station to respond automatically or manually to LR interrogations. The LR mode (automatic or manual) will be displayed as appropriate.
- Indicates LR interrogations when in manual mode and provides a means to acknowledge these indications. In case of automatic reply to LR interrogations, the display will indicate that the system was LR interrogated..
- The MKD may be used to change the AIS channel settings. It is possible to change the AIS operational frequencies and power settings from the MKD.
- Displays GPS position when the internal GNSS receiver is operating as the back-up position source for the AIS reporting. When the AIS is using the internal GNSS for position reporting, that position must be continuously displayed. The AIS unit has an option where it uses the internal GNSS receiver position information for position reporting. When in this mode, the position that is transmitted by the AIS will be available on the MKD.

Some of the above actions can be password protected.

4.5 Specific issues for Class B Shipborne Mobile AIS stations

Class B operation is identified in ITU Recommendation ITU-R M.1371-1 by defined message types and reporting rates. In the absence of mandatory regulations, carriage of Class B by leisure craft and other non-SOLAS vessels will be influenced largely by the perceived advantages as seen by each vessel's owner. However, carriage may be mandated in those waterways where competent authorities require AIS for this category of ships. Class B can be a stand-alone unit, interfaced with existing equipment (e.g. ECS or radar), or an integrated unit. During the July 2002 session of IMO's Sub-committee on Safety of Navigation a draft performance standard on Class B was created which stated in particular that Class B should not impair the use of the VDL.

There is an ongoing development by IEC for an international standard of Class B stations (future IEC 62287). This development takes into consideration the above IMO performance standard.

The minimum keyboard and display unit, as on Class A stations, is not required on pleasure craft. They may use the Class B station as a black box (to be seen) or connected to a display (e.g. ECS/ECDIS) to see and present other AIS stations and own position in relation to the environment. However, there must be at least one means to configure the station with static data during installation.

4.6 Class A-derivatives

Class A-Derivatives may be the result of any local or international development for particular groups of users for ships not falling under the SOLAS regulations. Examples are:

- Inland and coastal navigation
- Development of Personal Pilot Units.
- The use of AIS in harbours for service vessels like tugs, buoy tenders, hydrographic ships, pilot vessels, etc.

Class A-Derivatives are intended to use the same functionality as Class A stations on VDL level, but may deviate from supplementary functions like, DSC, LR, MKD or interface. The main difference between Class A and Class A-Derivatives is that not all mandatory components of Class A stations will be included but can be optional.

The use of DSC Channel Management depends on the geographical situation. In areas where AIS1 and AIS2 are not available DSC should be used to inform the mobile station which frequencies must be used for AIS.

Long-range functionality is optional for Class A derivative stations.

The minimum keyboard and display on Class A derivative stations may not be required. Non SOLAS vessels can use the Class A derivative station and can be configured as:

- a black box (to allow the vessel to be seen only),
- or connected to display system (i.e. ECS/ECDIS),
- or other external system for special applications to see and present own position in relation to the environment.

However, there must be at least one means to program the station with static data.

Non-SOLAS vessels with Class A-derivative stations should conform to the locally issued regulations with respect to the manner in which AIS information is displayed.

4.7 Overview mobile AIS stations

The following table shows the different options and possibilities of mobile AIS stations. The columns on Class B and Class A derivatives reflect the current state of the definition work.

	Class A	**Class B**	**Class A-derivatives**
Message 1,2,3 and 5	C	N	C
Message 18 and 19	N	C	N
Transmission message 6 and 8	C	TBD	TBD
Transmission message 12 and 14	C	TBD	TBD
Message 15	C	TBD	TBD
Message 10	C	TBD	TBD
External position (1st priority)	C	N 2)	O
DSC polling	C	O 1)	O 1)
Long-range	C	O	O
Pilot plug	C	O	O
PI compliant with IEC 61162-1	C	O	O
MKD	C	O	O
Semaphore function	C	TBD	TBD
Channel spacing 12.5 kHz	C	TBD	TBD

C = compulsory, O = Optional, N = not allowed

1) = depending on local regulations, 2) = internal GNSS mandatory

Table 4.3 Mobile station function overview

4.8 Pilot/Auxiliary port

Pre-AIS systems such as the one used in the Panama Canal have demonstrated their usefulness to pilots. All Class A mobile AIS stations therefore have a port intended for use in piloting operations (- Volume 1-Part 1-Chapter 10.5). In order to use this port, an extension cable must be installed permanently from the AIS mobile station to the ship's main conning position. (see Figure 4.3). This cable extension is terminated at a docking station installed at the conning position and is labelled "PILOT PLUG". Most of the vessels that are piloted will be fitted with an AIS mobile station

In practice, the pilot brings on board a workstation (such as a laptop computer) which he connects to the "PILOT PLUG". The workstation runs a display application which allows the pilot to see AIS data and targets on an electronic navigation chart that meets the pilot's own preferences. This workstation display will be installed near the conning position, and consequently the pilot's display is independent of where the ship's AIS display may be installed. In addition, the pilot workstation may run other AIS applications in support of piloting operations, such as exchanging short written messages with the VTS and with other ships, and receiving meteorological information.

The pilot workstation also receives navigation information directly from the ship's navigation sensors via de AIS mobile station to update the own-ship display at a fast rate. This update rate will generally be faster than the rate for other ships and for other information received via the radio link. The information arriving over the radio link will be displayed at AIS standard rates.

The "PILOT PLUG" at the conning position is not a part of the type-approved AIS equipment, and the fitting is voluntary for the ships' owners. Local administrations, however, may request or require that it be installed. The greatest benefit would be achieved if this plug is fitted on every ship that is likely to use pilot services.

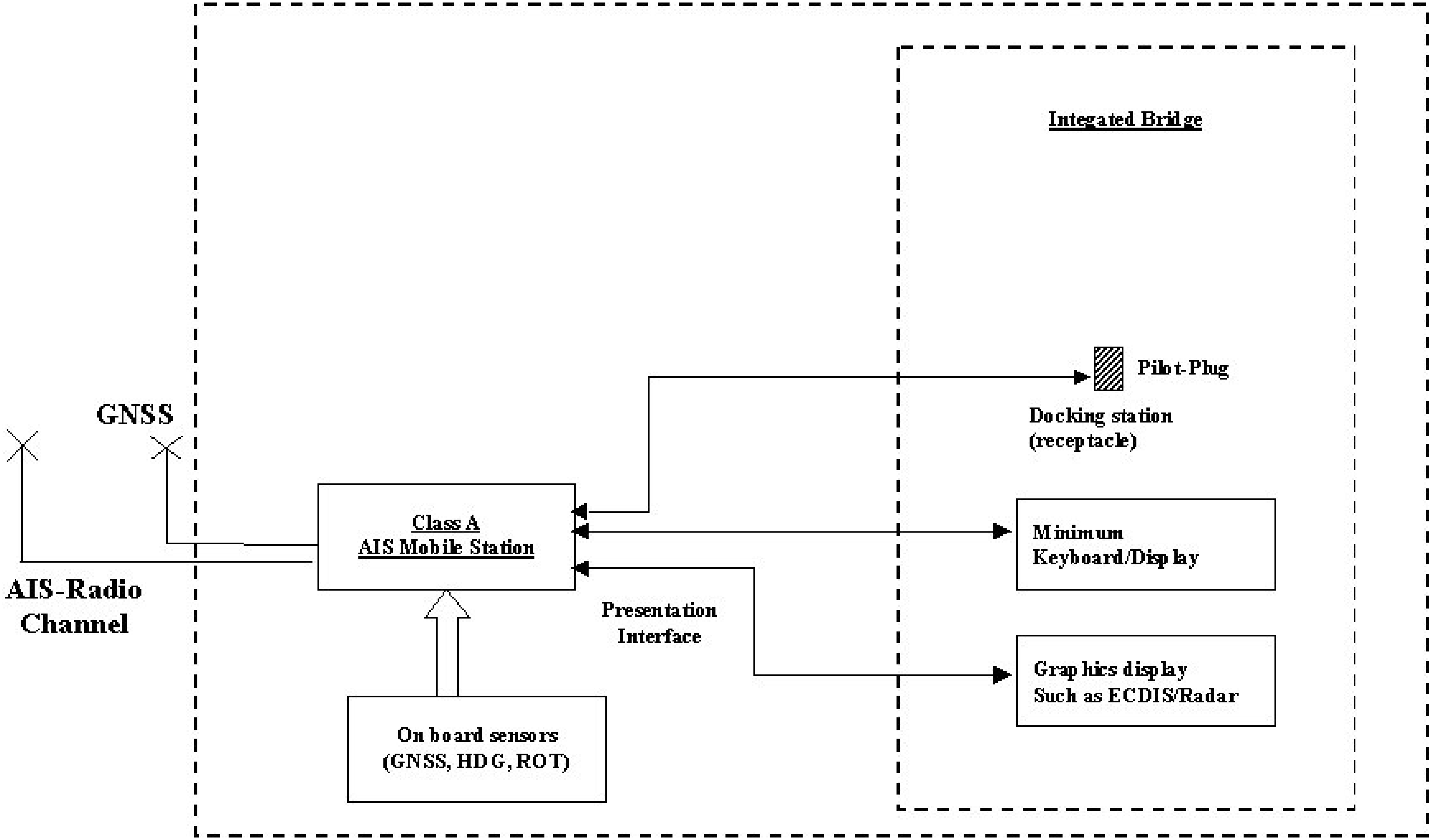
The Pilot/Auxiliary input/output port at the AIS mobile station itself is defined by IEC 61193-2. The "PILOT PLUG", which is located at the conning position, is specified as follows, although a physical, electrical and quality equivalent is acceptable.

AMP/Receptacle {Square Flanged (-1) or Free-Hanging (-2)}, Shell size 11, 9-pin, Std. Sex 206486-1/2 or equivalent with the following terminations

- *TX A is connected to Pin 1*
- *TX B is connected to Pin 4*
- *RX A is connected to Pin 5*
- *RX B is connected to Pin 6*
- *Shield is connected to Pin 9*

The pilot's workstation must be equipped with a matching connector.
The workstation interface must be IEC 61162-2 compliant, and power for the workstation should be available nearby.

Figure 4.3: The Use of the "Pilot-Port/Plug" of an Class A Mobile Station



5. SAR Aircraft AIS Station

5.1 Scope

The search and rescue (SAR) aircraft AIS station is an aircraft-certified AIS system, installed on aircraft used in SAR operations, allowing ships and aircraft involved in a SAR operation and the on-scene co-ordinator to know each other's position and identity, and to communicate with each other using text or binary messages. Position reports for SAR aircraft are continuously transmitted every ten seconds.

5.2 Certification

An AIS system used on aircraft must be designed, tested and certified to appropriate avionics regulatory requirements as determined by responsible aviation authorities. An off-the-shelf AIS system designed to meet shipborne requirements would normally not meet these requirements.

5.2.1 Input/Output

Since aircraft systems do not use the IEC 61162 data interface standard used by shipborne equipment, aircraft AIS equipment must use the data interfaces standards specified by responsible aviation authorities. Interface equipment designed to convert data sentences to and from IEC 61162 may alternatively be used. Since the AIS equipment includes and integral GNSS module for timing, it is possible that position, altitude, speed over ground, and course over ground data can be obtained from that module. The standard SAR aircraft position report (Message #9) also includes provisions for data defined by regional applications. The following data input and output information is required:

5.2.1.1 Input

aircraft GNSS data
altitude (derived from GNSS)
speed over ground
course over ground
GNSS antenna
VHF antenna (transmit/receive)
manual input from pilot
DTE
manual input from maintenance technician
power

5.2.1.2 Output

VHF antenna (transmit/receive)
pilot display
built-in integrity test (similar to that specified in IEC 61193-2)
received position reports to RCCs

5.2.2 Identity

The SAR aircraft AIS equipment uses the same nine-digit maritime mobile service identity (MMSI) used by shipborne, base station, and aids-to-navigation AIS equipment. Since International Telecommunications Union Radio Regulations make no provisions for MMSI use by aircraft, special arrangements would need to be made by national authorities for assigning MMSI use to SAR aircraft. The same MMSI format used by ships (i.e. "MIDNNNNNNN", where "MID" is the three-digit country identifier and "NNNNNN" is a six-digit numeric identity assigned by Administrations) should be considered for use by aircraft, pending any ITU amendments. Consequential amendments to the ITU Radio Regulations and ITU-R recommendations should be considered, particularly if SAR aircraft AIS equipment comes into widespread use. Note that a similar problem exists with the use of DSC-equipped radiotelephones on SAR aircraft.

5.2.3 Aircraft pilot interface

The AIS display and interface on a SAR aircraft is not used for navigation, but instead would be used for search and rescue purposes. Therefore if a display is used, it need not be installed at the pilot's position, if other crew positions exist. AIS display integration into most existing aircraft display and control systems, such as weather radar, is probably not feasible. In these cases, if an AIS display and control is required, a dedicated installation may be necessary. Since cockpit space is normally limited, installation at some other location may need to be considered. If the purpose of this AIS installation is solely to allow the on-scene co-ordinator and other ships to know the identity and location of the aircraft, no aircraft display or control may be needed.

5.3 Rescue co-ordination centre communication

An AIS-equipped SAR aircraft can relay ship information over a wide area to a rescue co-ordination centre (RCC) using a separate communications link between the aircraft and the RCC. Additionally, the RCC can track its SAR aircraft resources using the long-range option capability of the AIS.

5.3.1 Channel management

Because of the altitude SAR aircraft operate in, AIS propagation ranges would normally far exceed that of shipborne or base station AIS equipment. Aircraft also normally operate at speeds much higher than ships. For these reasons, channel management used for shipborne equipment may affect AIS-equipped SAR aircraft in different ways.

5.3.1.1 Transition zone

The channel management transition zone size is normally based upon the speed of ships transiting the zone, and the time necessary to for AIS equipment onboard those ships to switch channels without disruption. However, AIS-equipped SAR aircraft would travel through this zone at a much higher speed, which may cause ships and aircraft to lose information for short time. SAR aircraft circling in and out of a boundary of one or more regions may cause significant disruption because of the constant changing of frequencies and the continued transmission for one minute on the old frequency every time a boundary is crossed.

5.3.1.2 Interference

Channel management regions may be established because AIS 1 or AIS 2 is not available in a particular area, but is instead used for some other service. These channel management regions would be established based upon propagation ranges between ships and these other services. Because of the greater propagation ranges of AIS transmissions from SAR aircraft, interference between the SAR aircraft and these other services may become a problem.

5.3.1.3 Visibility

Because of the extended propagation distances between AIS-equipped ships and SAR aircraft, ships in a regional operating area may not see a SAR aircraft in a different regional operating area. Similarly, the SAR aircraft may not see the ships in that different regional operating area.

5.3.1.4 Increased probability of slot collisions

Because the AIS propagation range from SAR aircraft far exceeds that of ships, the probability of slot collisions between the aircraft and ships and among ships seen by the aircraft would be significantly increased. If the number of ships is large, free slots may not be available for the AIS-equipped SAR aircraft, and slot collisions will inevitably result. Intentional slot reuse procedures may cause interference problems with other distant AIS equipment due to high signal strength resulting from lower free space propagation loss. Additionally, propagation delays between the aircraft and ships further away than 100-200 nm will cause garbled transmissions.

6. Aids to Navigation AIS Station

6.1 Applying AIS to AtoNs

The primary purpose of applying AIS to aids to navigation is to promote and enhance navigation safety and efficiency by one or more of the following:

- Providing a positive and all-weather means of identifying an aid to navigation on AIS and ships' radar displays
- Complementing existing signals from aids to navigation
- Transmitting accurate positions of floating aids (possibly corrected by DGNSS)
- Indicating if a floating aid to navigation is off station
- Proving reference points for a ship's radar
- A complement to, or possible replacement of, racons
- Providing virtual aids to navigation.
- Providing weather, tidal, and sea state data.

A further set of benefits includes the following:

- Monitoring of aids to navigation status
- Tracking of a drifting floating aid
- Identifying ships involved in collisions with aids to navigation
- Gathering real-time information for condition monitoring
- Remotely controlling changes in AtoN parameters.

More information on the application of AIS to AtoN is given in the IALA document "Recommendations for AIS on Aids to Navigation" [under preparation].

AIS for aids to navigation may be applied to both floating and fixed aids to navigation, and more than one AIS message format may be transmitted.

There are three ways of implementing AIS on aids to navigation:

i) Install an actual AIS mobile unit on a real aid to navigation and use the AIS mobile message format to broadcast information related to the AtoN, or such other data as the competent authority may deem appropriate.

ii) Create synthetic AIS AtoN (i.e. where data from the aid is transferred to another location from where the AIS messages relating to the aid are sent):

a. "validated" data – the aid exists and its position can be validated from the aid, but the transmission is coming from another location (either from the shore or from another aid)

b. "unvalidated" data – the aid exists, but its position cannot be validated. In this case, it may be off-station and, hence, the AIS would be transmitting 'bad' AIS information. The AIS transmission is coming from shore or another aid. An 'unvalidated' Synthetic AIS may lead to potential navigation problems if used with a floating AtoN.

iii) Create a virtual AIS where the AIS message is an aid to navigation message, but no aid exists at the location. A virtual AIS may be useful for short-term temporary marks, but they should not be seen as a permanent AtoN solution at this stage.

The following AIS messages, as defined by ITU-R M1371-1 may be applied to AIS for aids to navigation.

- Message 21, Aid to Navigation Report Message – see Table 6.1 below
  - This is the standard AtoN message, and is always transmitted
- Message 14, Safety Related Text Message
  - This message may be sent from an AIS AtoN station when decided by a competent authority
- Message 8, application specific message
  - May be used for
    - AtoN data not carried by Message 21
    - Other data such as weather, wave, tide, sea data.

Message 21 should be transmitted autonomously at a reporting rate of once every three (3) minutes or it may be assigned by an Assigned Mode Command (Message 16) via the VHF data link. The message uses two slots.

The main content of this message is:

- Type of aid to navigation;
- Name of the aid to navigation;
- Position;
- Position accuracy indicator;
- RAIM indicator;
- Type of position fixing device;
- Off Position Indicator;
- Time stamp;
- Dimension of the aid to navigation and reference positions;
- 8 bits reserved for use by the regional/local authority (*can include the technical status of the aid to navigation*);
- Validated synthetic aid to navigation target flag.

The composition of Message 21 as defined by ITU is as follows.

Table 6.1 - Message 21, Aid to Navigation Report Message

Parameter	Number of bits	Description
Message ID	6	*Identifier for this message 21*
Repeat Indicator	2	*Used by the repeater to indicate how many times a message has been repeated. Refer to § 4.6.1; 0 - 3; default = 0; 3 = do not repeat any more.*
ID	30	*MMSI number*
Type of Aid-to-Navigation	5	*0 = not available = default; refer to appropriate definition set up by IALA; refer to Table 34bis.*
Name of Aid-to-Navigation	120	*Maximum 20 characters 6 bit ASCII, "@@@@@@@@@@@@@@@@@@@@" = not available = default.*

		The name of the Aid-to-Navigation may be extended by the parameter "Name of Aid-to-Navigation Extension" below.
Position accuracy	1	*1 = high (10 m; Differential Mode of e.g. DGNSS receiver) 0 □ low (□ 10 m; Autonomous Mode of e.g. GNSS receiver or of other Electronic Position Fixing Device) ; Default = 0*
Longitude	28	*Longitude in 1/10 000 min of position of Aids-to-Navigation (±180 degrees, East □ positive, West □ negative. 181 degrees (6791AC0 hex) = not available = default)*
Latitude	27	*Latitude in 1/10 000 min of Aids-to-Navigation (±90 degrees, North □ positive, South □ negative, 91 degrees (3412140 hex) = not available = default)*
Dimension/Reference for Position	30	*Reference point for reported position; also indicates the dimension of Aid-to-Navigation in metres (see Fig. 18 and § 3.3.8.2.3.3), if relevant. (1)*
Type of Electronic Position Fixing Device	4	*0 = Undefined (default); 1 = GPS, 2 = GLONASS, 3 = Combined GPS/GLONASS, 4 = Loran-C, 5 = Chayka, 6 = Integrated Navigation System, 7 = surveyed. For fixed AtoNs and synthetic/virtual AtoNs, the surveyed position should be used. The accurate position enhances its function as a radar reference target. 8 – 15 = not used.*
Time Stamp	6	*UTC second when the report was generated by the EPFS (0 –59, or 60 if time stamp is not available, which should also be the default value, or 61 if positioning system is in manual input mode, or 62 if Electronic Position Fixing System operates in estimated (dead reckoning) mode, or 63 if the positioning system is inoperative)*
Off-Position Indicator	1	*For floating Aids-to-Navigation, only: 0 = on position; 1 = off position; NOTE – This flag should only be considered valid by receiving station, if the Aid-to-Navigation is a floating aid, and if Time Stamp is equal to or below 59. For floating AtoN the guard zone parameters should be set on installation.*
Reserved for regional or local application	8	*Reserved for definition by a competent regional or local authority. Should be set to zero, if not used for any regional or local application. Regional applications should not use zero.*
RAIM-Flag	1	*RAIM (Receiver Autonomous Integrity Monitoring) flag of Electronic Position Fixing Device; 0 = RAIM not in use = default; 1 = RAIM in use)*
Virtual AtoN Flag	1	*0 = default = real A to N at indicated position; 1 = no AtoN =ATON does not physically exist, may only be transmitted from an AIS station nearby under the direction of a competent authority. (2)*
Assigned Mode Flag	1	*0 = Station operating in autonomous and continuous mode =default 1 = Station operating in assigned mode*
Spare	1	*Spare. Not used. Should be set to zero.*
Name of Aid-to-Navigation Extension	0, 6, 12, 18, 24, 30, 36, ... 84	*This parameter of up to 14 additional 6-bit-ASCII characters for a 2-slot message may be combined with the parameter "Name of Aid-to-Navigation" at the end of that parameter, when more than 20 characters are needed for the Name of the Aid-to-Navigation. This parameter should be omitted when no more than 20 characters for the name of the A-to-N are needed in total. Only the required number of characters should be transmitted, i. e. no @-character should be used.*
Spare	0, 2, 4, or 6	*Spare. Used only when parameter "Name of Aid-to-Navigation Extension" is used. Should be set to zero. The number of spare bits should be adjusted in order to observe byte boundaries.*
Number of bits	272 – 360	*Occupies two slots.*

The nature and type of AtoN is indicated by one of 32 different codes, as shown in Table 6.2 below.

Table 6.2 – Aids to Navigation Codes for Use with Message 21

	Code	Definition
	0	Default, Type of A to N not specified
	1	Reference point
	2	RACON
	3	Off Shore Structure
	4	Spare
Fixed A to N	5	Light, without sectors
	6	Light, with sectors
	7	Leading Light Front
	8	Leading Light Rear
	9	Beacon, Cardinal N
	10	Beacon, Cardinal E
	11	Beacon, Cardinal S
	12	Beacon, Cardinal W
	13	Beacon, Port hand
	14	Beacon, Starboard hand
	15	Beacon, Preferred Channel port hand
	16	Beacon, Preferred Channel starboard hand
	17	Beacon, Isolated danger
	18	Beacon, Safe water
	19	Beacon, Special mark
Floating A to N	20	Cardinal Mark N
	21	Cardinal Mark E
	22	Cardinal Mark S
	23	Cardinal Mark W
	24	Port hand Mark
	25	Starboard hand Mark
	26	Preferred Channel Port hand
	27	Preferred Channel Starboard hand
	28	Isolated danger
	29	Safe Water
	30	Special Mark
	31	Light Vessel / LANBY

Where more than one AtoN are located at one site, a separate Message 21 should be sent for each.

6.2 Complementing real AtoN

AIS messages may be broadcast for all types of AtoN, including floating and fixed AtoN.

The AIS message may be generated by an AIS unit located on the AtoN or may be sent by a nearby AIS unit, either an AIS base station or another AtoN AIS unit. The choice of whether to use an AIS unit on the AtoN, or to broadcast the AtoN data from an AIS unit at another location may be influenced by a number of factors including the power consumption of the AtoN AIS unit, the existence of other nearby AIS units, and local geography.

6.3 Providing 'virtual' AtoN

In certain cases, it may be appropriate to create a virtual AtoN on a visual display, where no AtoN exists. In this case the symbol would appear on the display for a certain location, even though there is no AtoN there. This message could be broadcast by a nearby AIS base station or AtoN AIS station. The transmitted message must clearly identify this as a validated synthetic AtoN by setting the “virtual AtoN Flag" in AtoN AIS Message 21. Any graphical representation should reflect this ‘virtual’ status.

There are some cases where virtual AtoNs could be useful, for example marking hazards to navigation on a temporary basis, until permanent aids can be established.

6.4 Disseminating marine information

An AIS AtoN unit can also be used to disseminate information from the AtoN site, such as weather, tidal, and sea state data. This data can be transmitted to enhance navigational safety by providing real time information.

6.5 Managing AtoN information

When an AtoN AIS station is fitted to an AtoN for the purpose of enhancing the safety of navigation, the information broadcast can also be used by the aids to navigation authority for AtoN management and maintenance. Examples include

- Reacting to an off-station buoy or light failure,
- Condition-based maintenance,
- Monitoring the AtoN system availability against standards
- Keeping a legal record of AtoN status history
- Etc.

The information available for this purpose may be augmented to include additional data on AtoN status within the standard AtoN AIS message, or may be sent within a separate text and / or application-specific message.

PART C: Fixed AIS Stations

7. The AIS Shore Station in General

7.1 Introduction

The AIS shore station is a fixed physical AIS entity, which exist on its own. Hereafter this entity is referred to as the Physical AIS Shore Station (PSS).

A PSS consists of at least the following components:

- Fixed AIS Station, (AIS base station or AIS repeater station)
- VHF-/RF-domain equipment, at minimum simply a cable and a VHF antenna
- Power supply
- if the Shore Station houses an AIS base station, a means to transport data to and from the AIS base station is required (an AIS repeater may operate without this data transport means).
- A means to protect the above components against environmental influence and damage.

7.2 Future work to be added at a later date

The functionality of the PSS will be described in detail at a later date. This will also be described in the "IALA recommendation on AIS Shore Stations and networking aspects to the AIS Service, part III".

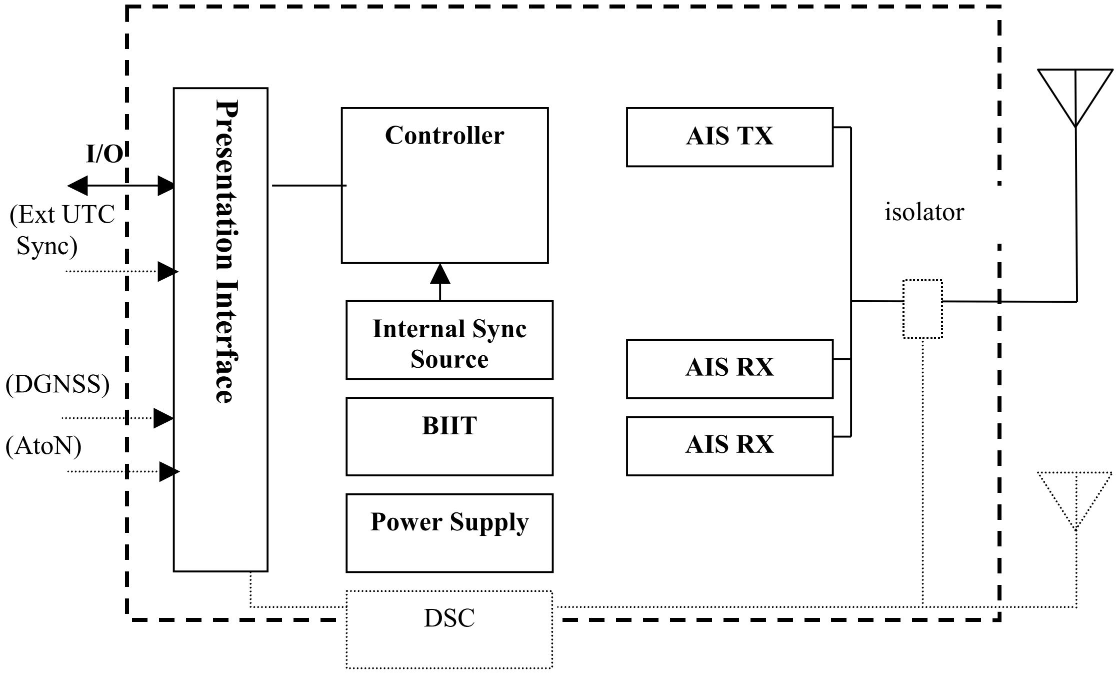
8. The AIS Base Station

The AIS base station is the most fundamental building block of the Fixed AIS Stations Layer of the AIS service. It has unique capabilities that differentiate it from other layers. ITU-R M.1371-1 and the "IALA Recommendation on AIS Shore Stations and Networking Aspects Related to the AIS Service" should be consulted for a more complete description.

8.1 Functional block diagram of an AIS base station

Figure 8.1 shows the functional block diagram of an AIS base station. The components within dotted lines or the input data in parentheses are optional.

Figure 8.1: Functional block diagram of an AIS base station



The following functional elements of the AIS base station are required (compulsory) in the minimum configuration of an AIS Base Station:

- Two multi-channel receivers
- One multi-channel TDMA transmitter: Since the minimum configuration of the AIS base station comprises only one transmitter, the AIS base station (in its minimum configuration) can not transmit on both AIS1 and AIS2 simultaneously.
- A controlling unit
- An internal sync source which may also be used as a position sensor for the AIS base station (see chapter on 'Requirements for Position Source of AIS Base Station')
- A Built-In-Integrity-Test unit (BIIT)
- A power supply
- A Presentation Interface (PI): The Presentation Interface allows the output of data from the AIS base station to the physical shore station and to input data to the AIS base station. The PI also allows for input of DGNSS corrections for transmission by the AIS base station if provided in the PI message format.

The following functional elements are optional to the AIS base station:

- Additional receiver(s).
- Additional transmitter.
- The AIS base station may contain DSC functionality, in which case the AIS base station would need some internal functionality to allow the internal DSC functionality to take effect in the operation of the AIS base station. The DSC functionality may be external to the AIS base station and should not interfere with TDMA functionality.
- Input of DGNSS corrections by a dedicated input port.
- The AIS base station may contain a functionality to transmit Aids-to-Navigation VDL messages (on behalf of physically existing AtoNs or as pseudo AtoN's).

8.2 General requirements for receivers and transmitters

The following general requirements apply to all receivers and transmitters:

- An AIS base station should use simplex channels or duplex channels in either full-duplex or half-duplex mode [M.1371, Annex 1].
- An AIS base station should be capable of 25 kHz and 12.5 kHz emission / reception in accordance with ITU-R M.1084-2, Annex 3 (as referenced by Recommendation ITU-R M.1371-1).
- An AIS base station should not be required to be bandwidth agile during normal operation, however.

The transmitter should meet the following additional requirement:

- The AIS base station should be capable of transmitting using two different power settings, asprovided for by ITU-R M.1371-1 and IALA Technical Clarifications On Recommendation ITU-R M.1371-1 *Edition 1.3*], and the AIS base station should have the capability to set its power level as stipulated by an input command. The possible different power level settings are given in the appropriate chapter below.

The detailed requirements for receivers and transmitters are given in a chapter below.

8.3 Configuration means

The AIS base station should provide the following configuration capabilities as part of the minimum or as an option, as indicated.

- Configuration of the autonomous transmission of Base Station Reports
- Configuration of autonomous transmissions of Data Link Management Commands (FATDMA set-up)
- Configuration of autonomous transmission of Channel Management Commands (Frequency channel set-up)
- Configuration of radio parameters
- Configuration of transmission of DGNSS corrections (optional functionality) BIIT minimum requirements

The functionality of the BIIT unit of the AIS Base Station should comprise the following alarms as a minimum. For details see the appropriate chapter below.

- TDMA Tx malfunction
- TDMA Antenna VSWR exceeds limit
- TDMA Rx 1 malfunction
- TDMA Rx 2 malfunction

- DSC Rx channel 70 malfunction – subject to DSC implementation (option)
- DSC Antenna VSWR exceeds limit - subject to DSC implementation
- DSC Tx channel 70 malfunction – subject to DSC implementation

8.4 Functional Definition of the Presentation Interface of the AIS Base Station

8.4.1 Overview

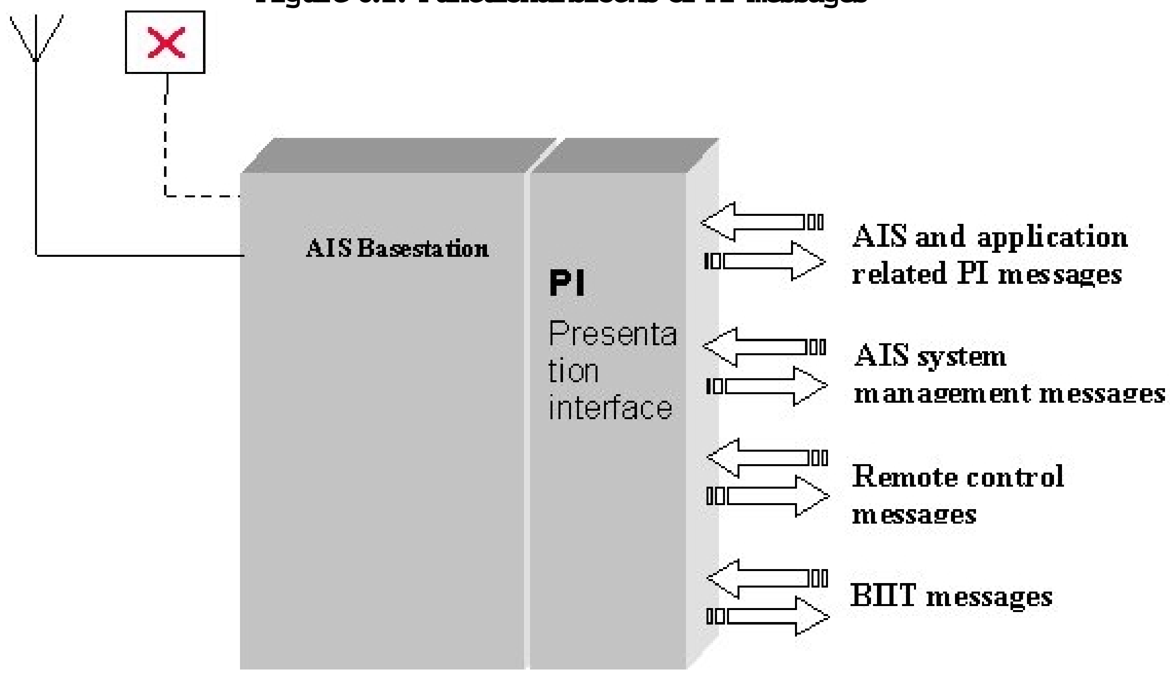
The Presentation Interface (PI) of an AIS base station consists of at least one input/output port. If the PI is supported by a combination of existing 61162-1 sentences and sentences as defined in IALA Technical Clarifications On Recommendation ITU-R **M.1371-1** *Edition 1.Annex C.*. The purpose of the PI data port is to:

- Exchange VDL data with the shore station
- configure the base station
- enable real time control of the base station
- provide an output for BIIT alarms and status

Optionally there can be additional ports as part of the PI such as DGNSS input, UTC timing input, etc. These will be discussed in the appropriate sections of this document.

The messages of the PI are subdivided in following functional blocks (refer to Figure 8.2).

Figure 8.2: Functional blocks of PI messages



8.5 Requirements for the internal processing of AIS VDL messages and PI sentences

The following sections describe the required functionality of an AIS Base Station with regard to internal processing of AIS VDL messages and PI sentences. For details of the PI sentence composition refer to IALA Technical Clarifications On Recommendation ITU-R M.1371-1 *Edition 1.3, Annex C.*.

8.5.1 General Rules

The AIS Base Station should comply with the following general rules:
The AIS base station should be able to receive all VDL messages
The AIS base station should be able to generate and transmit any of the messages as given in table 8.1.

Table 8.1: Base station messages

Msg ID	Message Name	Message Description
4	Base Station Report	Position, UTC, Date and current Slot number of base station
6	Binary Addressed Message	Binary data for addressed communication
7	Binary Acknowledgement	Acknowledgement of received addressed binary data
8	Binary broadcast message	Binary data for broadcast communication
10	UTC/Date inquiry	Request UTC and date
12	Addressed Safety Related Message	Safety related data for addressed communication
13	Safety Related Acknowledgement	Acknowledgement of received addressed safety related message
14	Safety Related broadcast Message	Safety related data for broadcast communication
15	Interrogation	Request for a specific message type (can result in multiple responses from one or several stations*)* (4))
16	Assignment Mode Command	Assignment of a specific report behaviour by competent authority using a base station
17	DGNSS Broadcast Binary Message	DGNSS corrections provided by a base station
20	Data Link Management Message	Reserve slots for base station(s)
21	Aids-to-Navigation Report	Position and Status Report for Aids-to-Navigation
22	Channel Management	Management of channels and transceiver modes by a base station

- The AIS Base Station should not filter data: Every received VDL message should be passed to the PI as a VDM sentence.
- Every received PI VDM sentence should be broadcast on the VDL.
- Every transmitted message on the VDL should be passed to the PI as a VDO sentence.
- The AIS Base Station should produce an “automatic response” when the AIS Base Station detects its MMSI in VDL messages 10, 6, 12 or 15 and respond with messages 4, 7, 13, 17, 20, 21 (if implemented), or 22 as appropriate.
- When configured accordingly, the AIS Base Station should periodically broadcast messages 4, 17, 20, and 22.

8.6 Default Base Station Reporting

If configured, the AIS Base Station should periodically generate the Base Station Report (message 4), which is transmitted for reporting UTC time, date and position. The base station should normally transmit this message with a minimum reporting rate of 10 seconds. The base station should operate in this state until it detects one or more stations that are synchronising to the base station. It should then increase its update rate of msg 4 to 3 1/3 second (nominal) intervals, interleaved between both AIS channels. It should remain in this state until no stations have indicated synchronising to the base station for the last 3 minutes. FATDMA reserved slots are used for these transmissions. SOTDMA communication state operation stays as defined in ITU-R 1371-1, A2, 3.3.7.2.2, except when slot time out is 0, then slot off-set equals 2250. The configuration sentence should be used to configure the msg 4 transmission schedule.

9. The AIS Simplex Repeating including the AIS Simplex Repeater

9.1 Introduction

The AIS Simplex Repeater station needs to perform in accordance with the Recommendation ITU-R M.1371-1 and IALA Technical Clarifications On Recommendation ITU-R M.1371-1 *Edition 1.3* in order to maintain harmony with the AIS system requirements.

Recommendation ITU-R M.1371-1 provides for AIS Simplex Repeating. Areas of application of AIS Simplex Repeating are described Chapter 17. In principle, AIS Simplex Repeating results in a simplex repeating process being performed on the AIS VDL. This simplex repeating process can be achieved

- by a dedicated station, which is called an AIS Simplex Repeater station, or
- by a simplex repeating functionality implemented as an option in an AIS Base Station, or
- by a simplex repeating functionality implemented in the Physical or even Logical AIS Shore Station level, employing the re-transmit capability of an AIS Base Station.

Cautions on using AIS Simplex Repeater

AIS Simplex Repeaters double the VDL link load for AIS mobile stations and should only be used in low traffic density areas to extend RF coverage. The AIS Simplex Repeater without filtering should only be used when the VDL link load is less than 25% as a good rule of thumb. The AIS Simplex Repeater can be used at higher VDL link loads with sufficient repeat message filtering.

9.2 General AIS Simplex Repeating Functional Requirements

The AIS Simplex Repeater is a store and forward process in which a different time slot is used for retransmission. The retransmission could be on the same channel as that in which it was received (per Recommendation ITU-R M.1084).

The AIS Simplex Repeater station needs to perform in accordance with the Recommendation ITU-R M.1371-1 and IALA Technical Clarifications On Recommendation ITU-R M.1371-1 *Edition 1.3*in order to maintain harmony with the AIS system requirements.

The AIS Simplex Repeater can synchronise on any AIS station that has direct UTC.

An AIS Simplex Repeater should have modular construction. To that end it should have standardised interfaces (both hard- and software) including a Presentation Interface for configuration.

9.3 Simplex Repeater Requirements

9.3.1 Functional Requirements for Simplex Repeater Retransmission Delay

The turn around time from receiving the message on the antenna port to retransmitting the message should be as short as possible and should not exceed four seconds.

9.3.2 Functional Requirements for Repeat Indicator for a Simplex Repeater

The simplex repeater should not change the content of the message, but should increment the repeat indicator by one (to a maximum of three) or set the repeat indicator to a pre-configured value. If the repeat indicator of the received message is set to three, the received message should not be repeated.

9.3.3 Functional Requirements for Communication State for the Simplex Repeater

The simplex repeater should not change the content of the message, but should change the SOTDMA communication state or ITDMA if relevant. The AIS Simplex Repeater should change the SOTDMA communication state as indicated in Table 9.1.

Table 9.1: - SOTDMA Communication State of Received Station

Received Parameter	Simplex Repeater Action
Synch State	Change to Synch State of Repeater
Slot Time Out	Set to zero
Slot Offset	Set to zero

The AIS Simplex Repeater should change the ITDMA Communication State as indicated in Table 9.2.

Table 9.2: - ITDMA Communication State of Received Station

Received Parameter	Simplex Repeater Action
Synch State	Change to Synch State of Repeater
Slot Increment	Set to zero
Number of Slots	Set to zero
Keep Flag	Set to FALSE (= 0)

9.3.4 Functional Requirements for Repeating Messages 16 and 20

When repeating messages 16 and 20 the slot offset value inside the messages should be recalculated by the simplex repeater to insure the correct VDL response.

9.3.5 Functional Requirements for Error Checking for the Simplex Receiver

The AIS Simplex Repeater should perform error checking to verify a valid message prior to retransmission.

9.3.6 Functional Requirements for the Access Scheme

The AIS Simplex Repeater should use FATDMA reserved slots for all repeated messages. If this is not possible, the RATDMA access scheme may be used.

FATDMA slots can be reserved by the following means:

The AIS Simplex Repeater transmits Message 20 to reserve FATDMA slots. In order to do this, the competent authority needs to configure the AIS Simplex Repeater with an MMSI number, an FATDMA allocation table and a report rate for VDL Message 20.

9.3.7 Functional Requirements for Regional Adaptations

The AIS Simplex Repeater radio parameters could be additionally subject to more stringent local/regional requirements.

9.4 Functional Block Diagram of an AIS Simplex Repeater

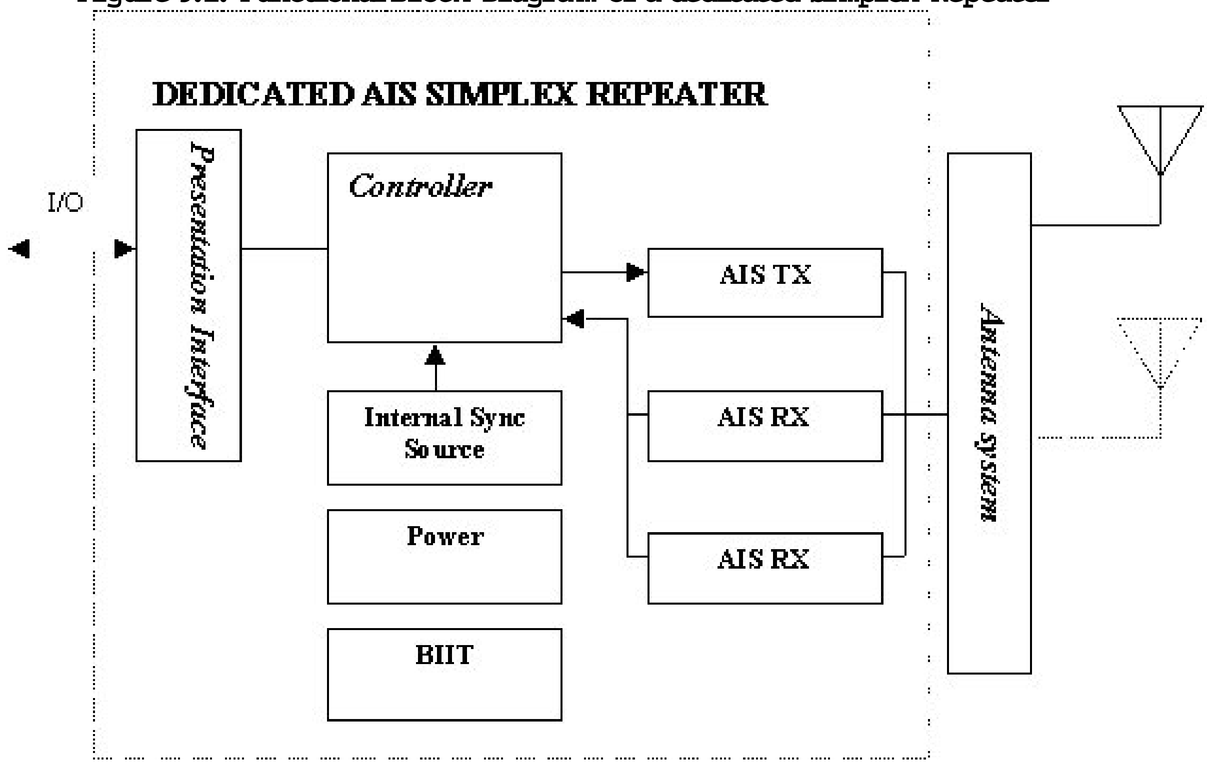
Figure 9.1 shows the functional block diagram of an *AIS Simplex Repeater*. The components in dotted lines or the input data in parenthesis are optional.

These functional elements of the *AIS Simplex Repeater* are required (compulsory) in the minimum configuration of an *AIS Simplex Repeater*:
One TDMA receiver
One TDMA transmitter
A controlling unit
A Built-In-Integrity-Test unit (BIIT)
A power supply

The following functional elements are optional to the *AIS Simplex Repeater*:

- A **Presentation Interface (PI)**: The Presentation Interface supports output data from the *AIS Simplex Repeater* and input data to the *AIS Simplex Repeater*.
- An **internal sync source**

Figure 9.1: Functional Block Diagram of a dedicated Simplex Repeater



9.5 General requirements for receiver and transmitter

The following general requirements apply to the receiver and transmitter respectively:
An *AIS Simplex Repeater* should operate on simplex channels (Recommendation ITU-R M.1371-1, Annex 1).
An *AIS Simplex Repeater* should be capable of 25 kHz and 12.5 kHz emission / reception in accordance with ITU-R M.1084-2, Annex 3 (as referenced by Recommendation ITU-R M.1371-1). However, bandwidth agility is not required during normal operation.
The *AIS Simplex Repeater* should be capable to transmit at low or high power , as stated in Recommendation ITU-R M.1371-1 and IALA Technical Clarifications On Recommendation ITU-R M.1371-1 *Edition 1.3.* However, power control is not required during normal operation.

10. The AIS Duplex Repeater

The AIS Duplex Repeater station needs to perform in accordance with the Recommendation ITU-R M.1371-1 and IALA's Technical Clarifications (latest edition) in order to maintain harmony with the AIS system requirements.

This part describes the minimum functional requirements for AIS duplex repeating and for the dedicated AIS Duplex Repeater Station.

AIS Duplex Repeater Cautions
Duplex repeaters may be built, but it may be difficult to fulfil the physical and link layer requirements of recommendation ITU-R M.1371-1 with respect to the AIS VDL.

Corrupt received messages would be transmitted, since the FCS check is not available on the received packet prior to the received packet commencing the repeat process.

10.1 Functional requirements for AIS Duplex Repeating

The AIS Duplex Repeater is a real time application in which the same time slot is used for retransmission on the paired frequency associated with the duplex channel (per ITU-R M.1084). The turn around time from receiving the message on the antenna port to retransmitting the message should not exceed two bit-times. The duplex repeater should not change the content of the message including the repeat indicator.

Each transmitted message contains a training sequence consisting of alternating zeros and ones. This 24 bit-time long training sequence should be maintained in the repeated message to ensure proper reception by the receiving AIS station.

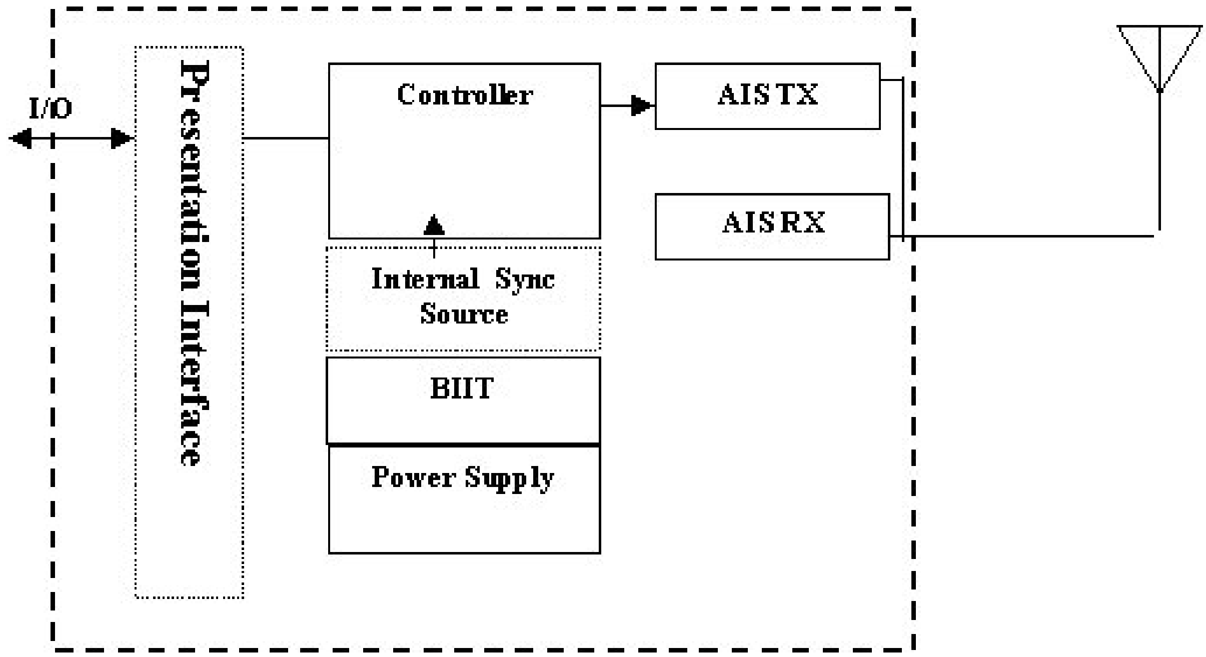
The duplex repeater should begin each repetition by turning on the RF power at the start of the received message, the RF power should be turned off after the last bit of the transmission packet has left the duplex repeater transmitter unit. This event must occur for all repeated messages.

The duplex repeater should use the RF power up flank to trigger the start of the repeat process in order to have the transmitter ready to repeat the incoming message. The duplex repeater could use the end flag to determine the end of the message to be repeated and to turn off the transmitter.

10.2 Functional block diagram of an AIS duplex repeater station

Figure 10.1shows the functional block diagram of an *AIS duplex repeater station*. The components in dotted lines or the input data in parenthesis are optional.

Figure 10.1: Functional block diagram of an AIS duplex repeater station



These functional elements of the *AIS duplex repeater station* are required (compulsory) in the minimum configuration of an *AIS duplex repeater station*:
One TDMA receiver
One TDMA transmitter
A controlling unit
A Built-In-Integrity-Test unit (BIIT)
A power supply

The following functional elements are optional to the *AIS duplex repeater station*:

- A **Presentation Interface (PI)**: The Presentation Interface allows to output data from the *AIS duplex repeater station* and to input data to the *AIS duplex repeater station*.
- An **internal sync source**

10.3 General requirements for receiver and transmitter

The following general requirements apply to the receiver and transmitter respectively:
An *AIS duplex repeater station* should operate on duplex channels in full-duplex mode (Recommendation ITU-R M.1371-1, Annex 1).

An *AIS duplex repeater station* should be capable of 25 kHz and 12.5 kHz emission / reception in accordance with ITU-R M.1084-2, Annex 3 (as referenced by Recommendation ITU-R M.1371-1). However, bandwidth agility is not required during normal operation.

The *AIS duplex repeater station* should be capable to transmit at low or high power , as stated in Recommendation ITU-R M.1371-1 and IALA Technical Clarifications. However, power control is not required during normal operation.

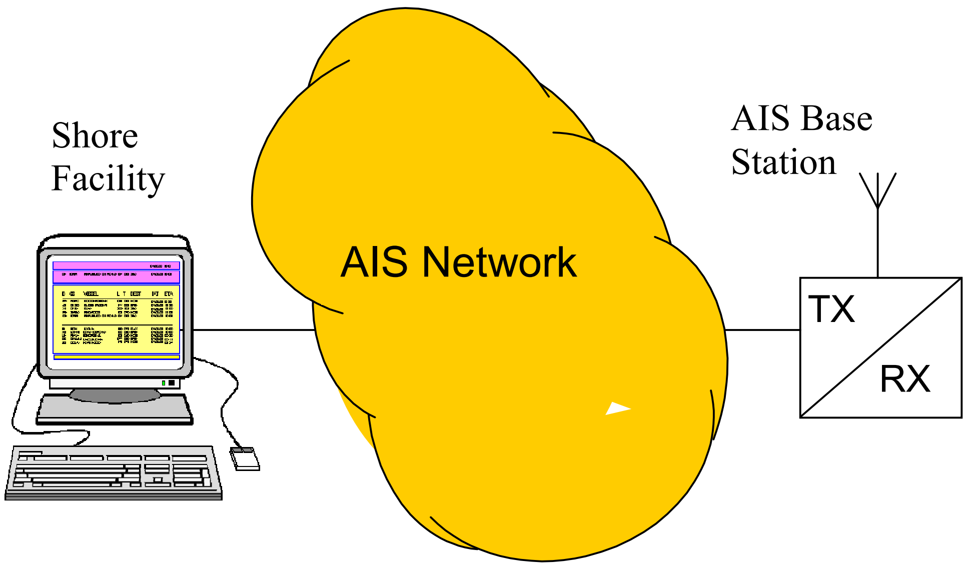
Part D: Setting UP the AIS Network of A Competent Authority

11. Introduction to Layers above the Fixed AIS Stations Proper

In this chapter a rudimentary example of an AIS network is presented in order to form a framework for the technologically more precise and detailed network descriptions in the following chapters. At some level in the decision making process within the Competent Authority, this may be helpful in formulating macro-level decisions on network configuration. It does not, and is not intended to be, a substitute for a technical approach to AIS network design.

11.1 Rudimentary AIS network concepts

The figure shown below illustrates the most rudimentary AIS network. The "cloud" may be a wire or a complex Wide Area Network, but the AIS network requirements are greatly simplified. Note that coverage area is limited by the physical location of the antenna and that no coordination between multiple base stations is required.



11.2 Progression from elementary to layered AIS network concepts

Section 11.1 has described some elementary AIS network concepts. The description emphasized common communication network elements but did not cover to any great extend the variety of demands the actually messages place on the configuration of the communication network itself. The following section introduces the concept of a layered structure that matches the physical communication network elements to the AIS Service elements in a logical and progressive process.

In its simplest configuration a layer may consist of a singled entity such as a physical piece of equipment or a software module running on a computer. As the degree of complexity of an AIS service category increases so does the configuration and capability of the associated network configuration. The following points illustrate the degree of complexity inherent in the AIS Service and how a layered structure can effectively address these requirements.

- Geographical coverage requirement:
  The requirement to provide coverage of AIS shore-infrastructure for a larger area has several important implications: Subdividing the coverage area of one AIS shore station into sectors using direction diversity of antennas may be required in areas with high traffic volume to receive non-garbled AIS messages from all mobile AIS stations in the vicinity. To employ direction diversity, an AIS shore station would house several AIS base stations, which would be connected to different antennas with antenna sectors which should not overlap each other to the maximum extent possible.

  In order to simply cover a larger geographical area and in particular to resolve the garbling issue in a larger geographical area several AIS shore stations may be needed, which may consist in turn of several AIS base stations each.
- Complexity handling:
  The AIS itself and the appropriate processing of AIS data exhibit a high complexity. To tackle this complexity, it is necessary to subdivide the total functionality of the AIS into appropriate sections. Since the geographical coverage requirements imply a hierarchical structure, functional layers may be considered a first step. The functional layers may be further subdivided in entities on the same functional layer.
- Encapsulation:
  To avoid inappropriate spread of design and configuration details, which apply to one specific layer or even some few entities within one layer only, over the whole of the AIS Service or even to application layers, the principle of encapsulation should be observed.
- Modularity / open system requirement:
  The layered approach would satisfy the general requirements for an open system. This requirement summarizes more detailed requirements of competent authorities, in particular
- a) the wish to employ "plug-and-play" components for ease of installation,
- b) the flexibility requirement (to design systems, which may be easily changed due to changing requirements or due to maintenance considerations in part during the whole of the life-cycle, without affecting the whole system),
- c) the "second source" requirement (to have at least one second vendor for spare parts),
- d) the timing requirements, i. e. it would allow some parallelization of processing on different layers and in different entities, and
- e) the cost requirements (achieve reasonable market prices by competition).

In the following sections 2 such layers will be described in detail i.e. how they are structured and how they function.

i) The layer of a logical AIS shore Station (LSS) (Chapter 12)
ii) The layer of an AIS Service Management (ASM) (Chapter 13)

12. The Layer of the Logical AIS Shore Stations (LSS)

In Chapter 11 the elementary AIS network concepts were introduced. They represent a very much simplified representation of the integration of a competent authority's AIS Service into its VTS environment (amongst other users). In reality, the AIS Service layout will be virtually nowhere that simply structured. Rather the entity entitled "AIS Network" in the elementary's AIS network concept descriptions will be subdivided into the AIS Data Transfer Network proper and several other AIS-related entities, which also exhibit a hierarchical structure and perform distinct tasks each.

The highest layer is constituted by the AIS Service Management (ASM). Although the ASM is the highest layer of the AIS Service and therefore has the overall control of all entities in the AIS, it is the next lower layer of the Logical AIS Shore Stations (LSS) which does the bulk processing work when providing the BAS to the higher levels. The LSS layer is supported by the layer of the Physical AIS Shore Station (PSS), which pre-process data from and to the fixed AIS stations proper, such as AIS base stations.

The present chapter introduces the functionality of the LSS layer in terms of "use cases". LSS, as opposed to PSS, are most likely pure software entities. To describe their functionality, it is therefore appropriate to use state-of-the-art system analysis and software engineering. A "use case" of the LSS describes a case, by which the LSS will be used. (By analogy: The main use case of a hammer constitutes to hammer a nail into a wall. However, a hammer may be used for other purposes, thereby constituting other use cases, such as breaking a glass window during a fire fighting situation.) The definition of "use cases" for all intended uses of the software entity helps to systematically and eventually determine its overall functionality.

Hence, the plurality of all "use cases" of an LSS constitute the total functionality of the LSS. From these use cases the common essential functionality can be derived, which then can be used directly when designing the software proper, while allowing freedom of how to implement these software entities to the maximum extent possible (by analogy: a hammer is composed of a cubic-shaped object, which must be at least as hard as the object the hammer is supposed to hit, and of a handle, which is fit for humans to grip the hammer. This description of the essential functionality of a hammer would allow – in the absence of other stipulations – a flint stone hammer as well as a steel hammer to fulfil the above "use cases" of a hammer: hammer a nail into a wall and break glass upon emergency. This illustrates that the definition of "use cases" and thereby determining the essential functionality of an entity is on the one hand to the point but on the other hand not prescriptive in terms of implementation.).

12.1 Justification for LSS

The top level of this stack provides at least one very important functionality for applications: It transforms the AIS Service linked to physical AIS shore stations to an AIS Service which is linked to logical AIS shore stations instead. The benefits of this transformation for applications using the AIS Service, such as VTS, are as follows:

- Each logical AIS shore station may be associated with a geographical area, which is completely determined by operational considerations only as opposed to any physical AIS shore station, the coverage area of which is determined solely by radio propagation, i. e. physical, considerations. In addition, the geographical area of

a logical AIS shore station can have any shape, as opposed to the shape of the geographical coverage area of one physical AIS shore station, which is determined by antenna planning and radio propagation.
Example: A VTS Center may determine as the geographical area of one logical AIS shore station exactly the area of its operational responsibility. Together with this geographical assignment there might be assigned by this VTS Center to this logical AIS shore station a further set of operational stipulations, such as a selection of Basic AIS Services provided to that VTS Center, or minimum/maximum reporting rates required to be provided by the AIS Service to that VTS Center and so forth.
Hence: The concept of a logical AIS shore station would provide an interface between the operational and the physical design of the AIS shore infrastructure.

- While the previous benefit is already valid when only considering just one kind of AIS application, e. g. VTS, the benefit increases when considering several different AIS applications, such as VTS, ship reporting, SAR. Each of these operational applications may define one or more logical AIS shore station, which would depend exclusively on their operational need. All of these logical AIS shore stations would be transformation processes, which would acquire the relevant AIS derived data from one or several physical AIS shore stations. The benefit for the different applications would be, that they could define different sets of operational stipulations for the associated geographical areas, which may partly or in total overlap.
Hence: The concept of a logical AIS shore station allows clean-cut access of different operational applications to the same resources, i. e. physical AIS shore stations, by a standardised interface, i. e. the logical AIS shore station definitions.

- The concept of a logical AIS shore station de-localizes the interface between the AIS Service and the applications. As a consequence, there remains no technical reason why the applications using the AIS Service should reside in the vicinity of physical AIS shore stations they use (there may be operational reasons, however).

While there may be other benefits, these benefits alone justify the introduction of the concept of a logical AIS shore station.[3]

12.2 Use Case of the Logical AIS Shore Station (LSS)

This chapter describes the use cases of the Layer of the Logical AIS Shore Stations recognised so far. The use case list constitutes the basis for appropriate description of the functionalities of the use cases.

The chapter is subdivided in accordance with the three different relationships a LSS can exhibit:

- use cases with regard to the Basic AIS Services
- use cases with regard to the mobile AIS stations which are taken care of by a LSS

[3] Besides, this concept may be derived from standard computer technology by analogy: Data is stored on harddrives. While application software or the user needs this stored data, they would never be interested in where the individual data portions are being stored on the harddrive: The user uses a logical path to identify the data on the harddrive, he wishes to access, instead of inputing all harddrive cylinder and sector numbers where the required data actually is stored physically. To determine these numbers he leaves to a transformation progamme, which is part of the firmware of each computer (and which is called BIOS).

- use cases with regard to the configuration of the Physical AIS Shore Stations assigned to a LSS

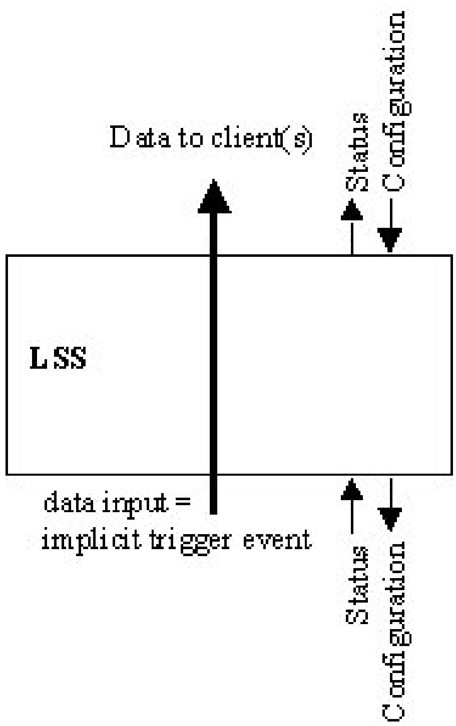
12.2.1 Use Cases of the Logical AIS Shore Station with regard to Basic AIS Services

These use cases can be further subdivided into five (5) different categories in accordance with their principle working mechanism.

12.2.1.1 BAS-related Use Cases Category I

These use cases share the following common characteristic: The data flow direction is from mobile to fixed. The use cases are <u>implicitly</u> triggered by AIS data input received from the Physical Shore Station layer, which then is processed and forwarded to higher levels. These use cases perform their function upon a trigger event and return to standby until the next trigger event, only.

Figure 12.1



<u>Use Cases of this category:</u>

The generation of the following BAS constitutes the use cases of this category:

A_STAT (without any application-specific message processing)
A_DYN
A_VOY (without any application-specific message processing)
B_DAT
SAR_DAT
ATON_DAT

SAFE_AD (information flow direction mobile-to-fixed)
SAFE_BR (information flow direction mobile-to-fixed)

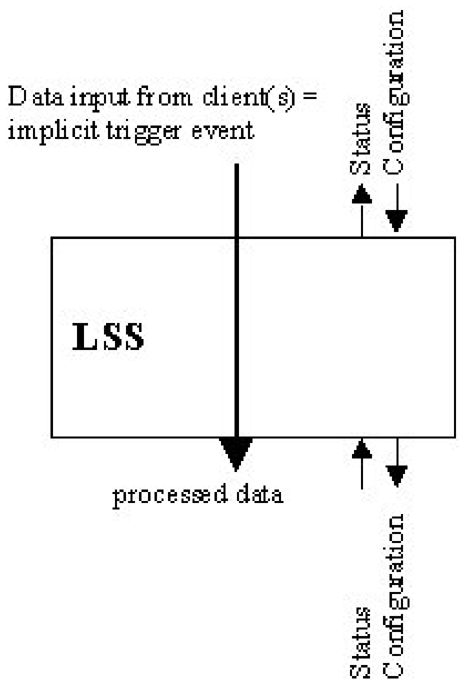
TRANS_IAI (information flow direction mobile-to-fixed)
TRANS_RAI (information flow direction mobile-to-fixed)

These use cases may also have a diagnostic functionality for individual mobile AIS stations.

12.2.1.2 BAS-related Use Cases Category II

These use cases share the following common characteristic: The data flow direction is from fixed to mobile. The use cases are implicitly triggered by AIS data input received from higher levels, which then is processed and forwarded to lower levels, i. e. the Physical Shore Station layer. These use cases perform their function upon a trigger event and return to standby until the next trigger event, only.

Figure 12.2

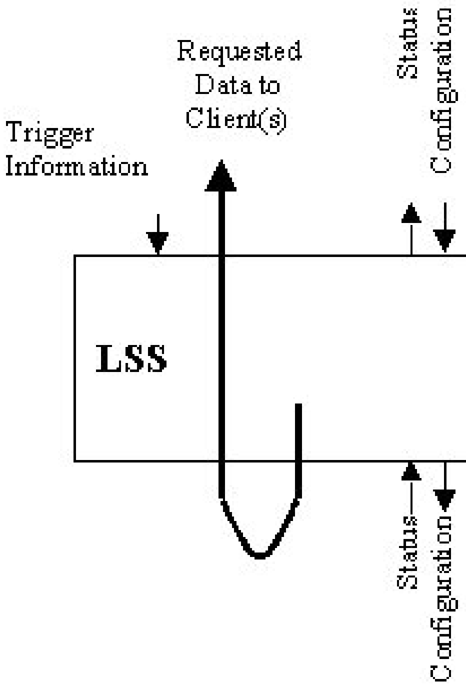


Use Cases of this category:
The generation of the following BAS constitutes the use cases of this category:
SAFE_AD (information flow direction fixed-to-mobile)
SAFE_BR (information flow direction fixed-to-mobile)
TRANS_IAI (information flow direction fixed-to-mobile)
TRANS_RAI (information flow direction fixed-to-mobile)
DGNS_COR

12.2.1.3 BAS-related Use Cases Category III

These use cases share the following common characteristic: These use cases are triggered expressly by a trigger information input received from higher levels (trigger event). This triggers a use case, which assembles a request for certain data, which then is processed and forwarded to lower levels, i. e. the Physical Shore Station layer. Upon receipt of the answer to the data request, the data is processed to be forwarded to higher levels (to the originator of the trigger event). These use cases perform their function upon a trigger event and return to standby until the next trigger event, only. The total information flow direction is fixed-mobile-fixed.

Figure 12.3

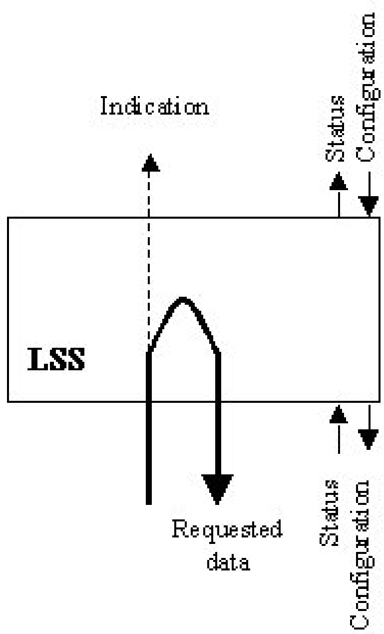


Use Cases of this category:
The generation of the following BAS constitutes the use cases of this category:
INT_TDMA (information flow direction fixed-mobile-fixed)
INT_DSC (information flow direction fixed-mobile-fixed)

12.2.1.4 BAS-related Use Cases Category IV

These use cases share the following common characteristic: The use cases are triggered expressly by a trigger information input received from the Physical AIS Shore Station layer. This constitutes the trigger event. It triggers a use case, which assembles the reply for certain data, which then is processed and forwarded to lower levels, i. e. the Physical Shore Station layer, to be forwarded to the originator of the trigger event. An indication on the request as such may be given to higher levels. These use cases perform their function upon a trigger event and return to standby until the next trigger event, only. The total information flow direction is mobile-fixed-mobile.

Figure 12.4



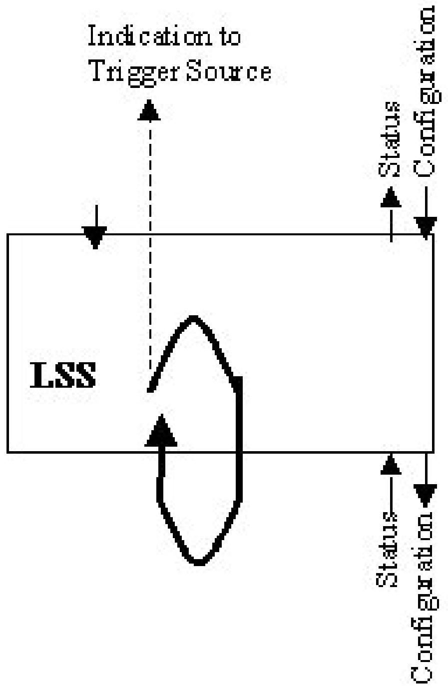
<u>Use Cases of this category:</u>
The generation of the following BAS constitutes the use case of this category:
INT_TDMA (information flow direction mobile-fixed-mobile)

Note: The BAS INT_DSC is allowed only for the information flow direction fixed-mobile-fixed.

12.2.1.5 BAS-related Use Cases Category V

These use cases share the following common characteristic: These use cases are triggered expressly by a trigger information input received from higher levels (trigger event). This triggers a use case, which, based on the configuration input from higher levels, generates and forwards certain AIS VDL management commands to the PSS layer. Upon receipt of the (implicit) answers to these management commands, they will be evaluated by the use case, and indications may be forwarded to higher levels (to the originator of the trigger information).
These use cases by default exhibit a continuous and autonomous behaviour, but one-shot behaviour may also be achieved by appropriate trigger information input. The total information flow direction is fixed-mobile-fixed.

Figure 12.5



Use Cases of this category:
The generation of the following BAS constitute the use cases of this category:
BASE_DAT
ASGN_RATE
ASGN_SLOT
CH_TDMA
CH_DSC
PWR_LEV
FATDMA

12.2.1.6 Other Use Cases with regard to BAS

In addition, there are the following use cases of LSS layer with regard to BAS:
Format transformation of VDL Message format to BAS format (and vice versa)
Fault detection and management of with regard to the BAS
Provide MMI for technical operation / maintenance of LSS layer

12.2.2 Use Cases with regard to the mobile AIS stations which are taken care of by a LSS

While the above use cases are defined with regard to an BAS, the following use cases are defined with regard to usually more than one BAS for one or more individual mobile AIS stations. The following Use Cases with regard to the mobile AIS have been identified:

- Management of the type-of-mobile-filter functionality of the LSS layer: This use case defines the mix of relevant type-of-mobiles for a given LSS. Types of mobiles could be Class A Shipborne Mobile AIS stations, Class B Shipborne AIS stations, SAR Airborne AIS Stations, and AtoN AIS Stations.

Higher levels may configure "their" LSS such, that this LSS forwards only data of relevant types-of-mobiles to them.
Example: An application (higher level) may be interested only in data from Class A and Class B shipborne mobile AIS stations. This application would then configure "its" LSS such, that only Class A and Class B data would be forwarded, but not data from AtoN or SAR Airborne AIS stations. The latter would have been received however, and could possibly be used by different LSS and their associated applications.

- Management of the type-of-ship-filter functionality of the LSS layer: This use case defines the mix of relevant type-of-ships for a given LSS. Types of ship could be determined by evaluating the appropriate data field in Class A and Class B Shipborne Mobile AIS stations reports.
Higher levels may configure "their" LSS such, that this LSS forwards only data of relevant types-of-ships to them.
Example: An application (higher level) may be interested only in data from ships identifying themselves as "passenger ships". This application would then configure "its" LSS such, that only data from "passenger ships" would be forwarded, but not data from any other type of ship. The latter would have been received however, and would possibly be used by different LSS and their associated applications.
- Management of the type-of-AtoN-filter functionality of the LSS layer: This use case defines the mix of relevant type-of-AtoN for a given LSS. Types of AtoN could be determined by evaluating the appropriate data field in AtoN AIS station reports.
Higher levels may configure "their" LSS such, that this LSS forwards only data of relevant types-of-AtoN to them.
- Management of the assignments of responsibilities of a PSS and/or fixed AIS station for a given mobile AIS station: In particular, but not exclusively so, for any information flow direction fixed-to-mobile, it is necessary to determine, which PSS and/or even fixed AIS station would be "responsible" for transmitting data from any BAS to that mobile AIS station. Since mobiles regularly move through the coverage areas of many fixed AIS stations and / or PSS, the assignment of responsibilities must be dynamic. The assignment would be based on the mobile's VDL-related identity.
- Geographical Filtering for information flow direction fixed-to-mobile: Which PSS would be responsible for outgoing data?
- Geographical Filtering for information flow direction mobile-to-fixed: Which LSS would be responsible for data received by a fixed AIS station / PSS?
- Remove duplicate data for information flow direction mobile-to-fixed
- Reduce data rate forwarded by this LSS to higher levels for information flow direction mobile-to-fixed: Upon configuration from higher levels, this use case would filter the data rate forwarded from a given LSS to its associated application. This use case would be employed when an application would have no need of data from mobiles at the rate the data is transmitted by that mobile on the AIS VDL. As a benefit, the reliability of the data flow regularly increases by employing this use case. Note: There is a similar use case defined at the PSS layer for a situation when a fixed AIS station / PSS would be sitting at a location with insufficient AIS data transfer network capacity to the associated LSS.
- Fault detection and management of the above use cases
- Provide MMI for technical operation / maintenance of the above use cases

12.2.3 Use Cases with regard to the configuration of the PSS assigned to a LSS

The following represent a class of use cases, completely internal to the shore-based AIS Service. They are relevant for the management of the assignment of LSS and PSS.

- Management of the assignments of usually more than one PSS to a given LSS
- Configuration management of individual PSS assigned to a given LSS within the margin of configuration rights given to that LSS by the ASM.
- Fault detection and management of the above use cases
- Provide MMI for technical operation / maintenance of above use cases

13. The Layer of the AIS Service Management (ASM)

13.1 Introduction

An AIS Service may include a number of Physical AIS Shore Stations (PSS) and Logical AIS Shore Stations. In order to remote operate and configure these PSSs and LSSs effectively, a top level is introduced. This top level is hereafter referred to as AIS Service Management (ASM). The ASM acts as a controlling entity for the whole AIS Service.

The ASM distributes data from the PSSs to one or more LSS(s). The LSS is a logical representation of one or a set of PSSs, which offers Basic AIS Services (BAS) to various clients. An LSS is the entry point for a client into the AIS Service. This chapter describes the currently identified use cases, or in other words the functionality, of the ASM layer.

13.2 Use Cases of the ASM with regard to the management of the BAS assignment to (individual) LSS

The common characteristics of these use cases are such, that they manage the responsibilities of any and all LSS in particular with regard to the internal BAS.

In some cases, the internal BAS control critical features of the VDL. In this case, the ASM must ensure, that responsibilities assigned to different LSS do not interfere with each other. This would mean in some cases, that only one LSS should be given the right to employ certain internal BAS.

The following use cases in this category have been identified:

- Management of the assignment of internal BAS to LSS.
- LSS selection based on geographical and, possibly other, configurable criteria for incoming data from higher levels for information flow direction fixed-to-mobile.
- Frequency management for the whole of the AIS Service: This use case controls the use of the internal BAS CH_TDMA, CH_DSC, PWR_LEV by LSS layer.
- Management of the AIS Service-wide slot reservation scheme using internal BAS: FATDMA
- Management of the AIS Service-wide assignment functionalities of mobiles using internal BAS: ASGN_RATE, ASGN_SLOT
- Management of the AIS Service-wide distribution of DGNSS corrections: DGNSS corrections are provided by some radio navigation service, e. g. IALA beacon reference stations, outside the AIS Service proper. This use case manages the distribution of the correction data input to the appropriate LSS. It is using the internal BAS DGNS_COR.
- Management of identity of the LSS, PSS and / or fixed AIS station: Instead of their own pre-configured MMSI, fixed AIS stations may use different MMSI, which may be provided by applications on higher layers and / or by a LSS and / or by a PSS. This use case manages the use of different MMSI's within the AIS Service.
- Diagnostics toolbox for individual AIS mobile stations.
- Diagnostics and failure management of entities within the AIS Service.

- Fault detection and management of with regard to the above use cases.
- Provide HMI for technical operation / maintenance of the above use cases.

13.3 Use Cases with regard to the configuration of any or all individual LSS except BAS

The common characteristics of these use cases are that they manage the existence and configuration of any or all individual LSS. The following use cases have been identified:

- Creation of an individual LSS
- Termination of an individual LSS
- Configuration management of an individual LSS with regard to its configurable parameters except BAS-related parameters
- Provide MMI for technical operation / maintenance of all LSS
- Fault detection and fault management for LSS functionality except for BAS-related functionality
- Tools for planned maintenance at the LSS level

13.4 Management of the assignments within the AIS Service

The common characteristics of these use cases are, that they all manage the assignments between individual functional entities within the AIS Service:

- Overall management of the assignments of LSS to the / more than one AIS Service
- Overall management of the assignments of PSS to LSS
- Overall management of the assignments of fixed AIS stations to PSS
- (Supplementary) management functionality of the virtual AIS data transport network within the overall network of the competent authority
- Perform basic configuration of individual PSS upon their initialisation
- Perform basic configuration of individual fixed AIS stations upon their initialisation
- Fault detection and fault management for assignments within the AIS Service
- Provide MMI for technical operation / maintenance of above use cases

13.5 Initialisation and Termination of the AIS Service

The following use cases have been identified:

- Initialisation of the AIS Service as a whole, including set-up of the minimum number of LSS for internal functions of the AIS Service
- Termination of the AIS Service as a whole.

14. The AIS Data Transfer Network

14.1 Employing TCP / IP protocol

Entities of the AIS Service should - to the maximum extent possible - employ the TCP/IP protocol for AIS data transfer.

TCP/IP packets containing safety-related data, i. e. TCP/IP packets handled by the BAS SAFE_AD or SAFE_BR, should have the highest priority set in the packet header and should be prioritised for transmission.

14.2 Security

The network should provide adequate protection against unauthorized use of the information and the network. A concept of user rights and authorization can be established to ensure that unauthorized users do not have the ability to change or obtain information to which they are not entitled. Likewise unauthorized transmission of data over the network should be prevented.

14.3 Other applications using the AIS network

A comprehensive view of the shore side network should include consideration of commercial as well as AIS requirements. While the use of the designated AIS channels for other than safety related communications must be strictly avoided, the network infrastructure can accommodate public correspondence messages if properly designed e.g. for both ship and shore users, the network can provide automated message service.

Part E: Issues related to the AIS Network of A Competent Authority

15. Introduction

The general flow of thought of the Technical Part of the IALA AIS Guidelines up to this Chapter has been as follows:

- *Part A* provided an overview of the technical aspects of the AIS Service as a whole. It concerned itself primarily with the question: How does the technical design fulfil the purpose of the AIS Service as a whole? What components and *fundamental relationships* are there anyway? And what are the *fundamental design principles* of the AIS as a whole?
- *Part B* moved onwards to describe the mobile stations available in the AIS, and *Part C* did the same with regard to the fixed stations proper. Part B and Part C introduced the *individual devices* of the AIS Service. Knowing these devices is essential for the understanding of the AIS Service as a whole, but is not sufficient.
- *Part D* then introduced the layered structure of the AIS Service above the layer of the individual devices. Thereby it introduced the *means to properly process the AIS data received from fixed AIS stations or to be transmitted by fixed AIS stations*, i. e. the definition and functionality of the Physical AIS Shore Station, the Logical AIS Shore Station, and the AIS Service Management.

All the chapters so far focused on the functionality needed – to a more or lesser degree, depending on the requirements of the competent authority - *to be able* to properly participate in the AIS *at all*. This functionality description mainly applies to considerations *relevant for the planning and installation time* of the AIS Service of the competent authority. Also it *applies to any AIS* Service, i. e. the description was highly generic, and *there still is a gap between the principle capabilities of the AIS Service and the concrete considerations a competent authority will encounter when planning the concrete local setup of its concrete AIS Service.* In doing so, issues of the *concrete configuration* of the AIS Service of a competent authority arise, both for the planning and installation time and the run-time. Hence *questions related to the run-time* of the AIS Service move to the forefront: Besides a bunch of more technically-related issues, these questions comprise the need *to evaluate, maintain and – possibly publicly – declare the expected quality level of the AIS Service* – key words are: "Service Level Provided", "Initial Operational Capability", and "Full Operational Capability" - and the *issues related to the necessary human interaction with the AIS Service on the level of technical operation and maintenance* (as opposed to the human interaction on the operational level).

Viewed from a life-cycle point of view, the phase of the technical operation of the AIS Service of a competent authority must not be treated lightly: It is this relatively long period of time where sound or flawed concepts, planning, installation, and configuration will take effect, whatever this may mean in terms of benefit or costs.

Therefore, the goal of a smooth technical operation of the AIS Service should be taken into consideration by a competent authority when planning, installing and configuring its AIS Service. (The goal of a smooth technical operation has been taken into consideration conceptionally to the maximum extent possible for the present state of the development of the concepts of the AIS shore infrastructure when creating the above and other relevant definitions.)

This part now moves onwards to aspects more related to the technical operation of a concrete AIS Service of a competent authority, and provides guidance to the maximum extent possible for the time being.

The issues raised are viewed from two different angles:

a) with regard to the concrete configuration of the AIS Service of a competent authority, but still during planning and installation time, i. e. configuration in a sense of making the generic AIS entities fit for their local use; issues arising out of this kind of configuration are being addressed.
b) with regard to the run-time configuration of the AIS Service

Both angles are required and are complementary to each other.

Due to the nature of an ongoing conceptual development of the AIS, not every aspect highlighted above can be covered by this edition of the IALA AIS Guidelines. However, they should be kept in mind while doing initial planning, and are therefore mentioned at this early stage.

16. Considerations for planning of AIS coverage

When planning AIS coverage, a competent authority should consider the criteria and methods discussed in this chapter. These criteria and methods can be applied to the design of various AIS shore facilities that are constructed to serve inland regions, typical territorial waters (12 nautical miles), or over an entire EEZ (Exclusive Economic Zone).

In this section the term “shore facility” applies to the establishment of either a base station, shore station, simplex repeater, or duplex repeater facility.

16.1 RF Coverage Area

AIS VHF operational coverage should encompass the following considerations.
In coastal areas, extending seaward at least 20 nautical miles (n.m.) from the territorial sea baseline as defined by the competent authority, and including navigable waters within an area extending in-shore to the extent of AIS coverage defined by the competent authority.

For regions along in-land rivers and lakes, including the navigable portion of the rivers and lakes and adjacent land areas, the extent of AIS coverage is defined by the competent authority.

The basic principles defined by IMO Resolution A.801(19) Provision of Radio Services For The Global Maritime Distress and Safety Service (GMDSS) for establishing Sea Area A1 for GMDSS VHF (156-174 MHz) can be used to make an approximate rough estimate of AIS radio coverage.

"Sea Area A1 is that area which is within a circle of radius A nautical miles over which the radio propagation path lies substantially over water. The radius A is equal to the transmission distance between a ship’s VHF antenna at a height (h) of 4 metres above sea level and the height (H) of the antenna of the VHF coast station which lies at the centre of the circle.

The following formula should be used to calculate the range A in nautical miles
A=2.5(Square root of H (in metres) + Square root of h (in metres))
H is the height of the coast station VHF receiving antenna and h is the height of the ship’s transmitting antenna, which is assumed to be 4 metres.

The following table gives the range in nautical miles (n.m.) for typical values of H:

h (m)	H (m)	Range (n.m.)
4	50	23
4	100	30

Table 16.1 RF coverage related to antenna height

<end quote>

The table gives just a rough estimation of the RF coverage. The given range can be different during the time as function of the weather and atmospheric conditions. Also the geographic situation (mountains, etc.) can influence the coverage of the RF coverage.

16.2 Coverage Performance

While operating in the coverage area, the coastal AIS VHF data link should satisfy the channel performance criteria for the AIS1 and AIS 2 frequencies as specified in ITU-R M.1371-1. The competent authority may, however, change these frequencies through the use of the AIS channel management methods.

16.3 Coverage Verification Recommendations

After construction, the coverage of shore facilities should be verified by field measurements and compared against the planning estimates. This process can identify isolated coverage problems unique to the local area and be used at a later date to detect changes in overall system performance. The field validation should include a combination of stationary and moving mobile stations. The use of fixed stations establishes referenceable coverage paths that can be used to detect system changes while the area coverage is assessed with the mobile stations. The assessment should be performed for both shore facility broadcasting and reception.

16.4 Planning criteria for an AIS land-based infrastructure

When designing an AIS land-based infrastructure, the competent authority should use the following checklist:

How high is the traffic volume?
Where are the points of traffic congestion?
What are the traffic statistics in the respective areas?
Can the desired area be covered using existing VHF shore stations?
Considering the anticipated traffic, will the desired area need to be subdivided / sectorised?
What are the geometric characteristics of the subdivided areas?
Can the siting of shore facilities be done to minimise the effects of garbling?
What level of operational redundancy is necessary?
How accessible should the shore facilities be?

16.5 Operational Coverage Area of a Base Station

When estimating the size of the operational coverage (operational cell) for shore facilities, an important consideration is the traffic load – number of mobile AIS stations within the area. Coverage areas that are designed to typically include a large number of mobile AIS stations will experience some loss in the number of reports that are received from each mobile. This is due to inter-message reception garbling. If the expected traffic load is high, consideration should be given to designing the operational coverage area using smaller geographic sectors in order to minimise the number of lost reports due to message garbling.

The size of the operational coverage area of an AIS station is determined primarily by the height of the transmit/receive antenna. For mobile AIS stations, the height can vary significantly depending on the size of the ship. Generally, the operational coverage area of an AIS shore facility is greater than that of a mobile AIS station. The reliable reception of data messages will also depend on local radio propagation characteristics, and topographical conditions. There are also two characteristics of AIS operation that can affect the reception of AIS reports:

- Mobile AIS stations that are "hidden" and
- Radio channel overloading.

16.5.1 Operation of non-synchronised mobile stations within the coverage area of a base station (hidden user)

Within the reception area of a shore facility, there will be mobile AIS stations that cannot receive each other. Hence, the broadcast schedule will not be exchanged among these stations. For this reason, these stations will at times transmit their reports using the same time slot – a random occurrence. During this event, the shore facility may receive only one, or none of the reports sent during the conflicting time slot. There are shore facility design measures that can reduce the effect of these events. (Also, see the basic architecture options discussed below.)

In some cases, the distance between the mobile stations and a base station may result in only the stronger mobile AIS station signal being received (discrimination). When the received signals are approximately equal, a base station will receive neither of the two mobile stations (garbling). The probability of data transmission collisions increases with the number of mobile AIS stations inside the coverage range of a base station.

16.5.2 Operation of mobile stations when the operational channel is overloaded

Mobile stations within VHF operational range organise 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. The range of reception is effectively reduced by this process. To avoid losing the most distant stations entirely, a mobile AIS station limits its simultaneous use of the time slot of a particular distant stations time slot to once per minute. Consequently, complete suppression of targets is unlikely. With respect to the fundamental collision avoidance requirement for AIS, it is more important to receive the reports of nearby mobile AIS stations than the most distant mobile AIS stations.

16.6 Reception Options for AIS Shore Facilities

In order to minimise the probability of garbling within the coverage range of a base station, the following options should be considered. Of the alternatives listed below, only those listed in section 16.6.1 have no effect on the technical operation of the mobile stations.

16.6.1 Design the coverage range for the expected traffic volume

The operational range of base stations must be designed such that the traffic volume remains well below the theoretical system capacity within the coverage range.

This can be achieved as follows:

16.6.1.1 Adjust the range of the shore facility

Adjust the range of the shore facility by adjusting the height of the antenna or sensitivity of the receivers. Site the adjacent shore facilities for these reception ranges. Reducing the range will require a larger number of shore facilities to cover a given geographic area.

16.6.1.2 Creation of sectorized coverage areas

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

16.6.1.3 Use of remote, receive-only, facilities

The coverage of a shore facility can be augmented using several remote receive-only facilities. The shore facility provides the broadcasting capability while the remote receiving stations augment the reception capability of the shore facility. The collection of all the received reports will require a filtering process to discard redundant reports that are received.

This approach requires the services of an independent communications system to forward received reports from the remote sites to the augmented shore facility. This approach could require many interconnected sites.

16.6.1.4 Using multiple base stations for a single coverage area.

Two or more complete shore facilities may be located to independently service the desired coverage area. The coverage overlap among the facilities should be significant. The resulting configuration creates a reception diversity that should overcome issues such as garbling. To realize the benefit of this diversity, these facilities should be connected by an independent communications method.

The overlap of coverage by these facilities also results in a significant increase in system level and operational redundancy.

16.6.2 Shore control of the mobile AIS station transmissions

Within its service range, a shore facility, such as an AIS shore station, can designate the transmission mode on a mobile station. To do this, the facility broadcasts a command that switches each mobile AIS station to the assigned mode. The reporting rate and time slot assignments can be specified by this command.

This control method can become very complex and requires constant attention by an operator to the movement of each vessel subject to these commands. Effective management of this capability may require co-operation between adjacent shore facilities. In addition to issuing commands, co-operation is needed to assure a complete and correct understanding of the constantly changing traffic conditions, AIS channel loading conditions, and dynamic changes in vessel movements. Acquiring a new mobile AIS station entering an operational area for the first time requires the holding of slot capacity in reserve. Since this control mechanism by itself already results in a high channel loading, it can be used only in special circumstances.

16.6.3 Using duplex repeaters to support the self-organising of mobile stations.

The duplex repeater shore facility provides all participants, within a strictly defined service area, with all of the data transmissions that originate in a service area. Every AIS station receives the broadcast from every other station, and is aware of its broadcast schedule. Ideal self-organising of the VDL is realised. As long as sufficient channel capacity is available, the coverage area of a duplex repeater is completely organised. The service area must be specified to assure system capacity is always available for mobile stations entering the coverage area for the first time. The use of duplex repeaters excludes direct ship-to-ship communications on the service channel that is used. Land-based full duplex repeaters process the entire communication traffic.

The use of full duplex repeaters requires that all mobile stations undergo a switch-over to the service's operational channel. During the switch, there is a slight increase in the loading on the duplex channel.

Adjacent duplex repeater service areas require different duplex channels.

16.6.4 Coverage areas arbitrarily defined by a cellular operational network

The assignment of regional operational channels to distribute mobile AIS stations among a number of VHF channels. Adjacent areas would only have one operational AIS channel in common. The size of these areas can be defined arbitrarily and can be substantially smaller than the actual operational range of a shore facility. In this manner, specially matched coverage areas can be defined, and the shore facility can directly receive many more reports using three or more radio channels.

The use of regional operational cells requires that all mobile stations be switched to a regional operational channel.

Adjacent operational cells require different operational channels. In the transition region, channel load increases as a result of additional transmissions from mobile stations.

16.7 Joint operation of several shore facilities

When co-ordinated coverage is necessary, several shore facilities must be connected to each other. Individual base stations must be networked to combine information and to filter out redundant information. The network, connecting the facilities, will not be discussed here any further since it will be described in detail elsewhere in this report.

The following options for the areas of an AIS shore station coverage exist. These techniques may be combined as required:

16.7.1 Coverage of large geographic areas by shore stations with extended VHF range capabilities.

Individual facilities may be arranged such that the largest possible areas are covered. This implies that antenna sites, as high as possible, with clear omnidirectional or highly directional views (clear view of all the desired coverage areas) be established. This approach is feasible if a small traffic volume can be assumed such that the system can operate with a low operational channel load. The probability of garbling due to two mobile stations not being able to receive each other is low due to the low channel load.

16.7.2 Avoidance of overload conditions for large areas

In order to avoid overload conditions for large area shore facilities (e.g. coverage far out to sea) due to too many participants, it is possible to partition the area of interest into sectors. This can be achieved by using directional antennas that only receive signals from specific directions. Any associated broadcasts may be either directive or omnidirectional. By using appropriate layouts, it is possible to effectively achieve omnidirectional coverage with several co-located directional antennas. Independent reception (and transmission) equipment is assigned to each coverage sector (i.e. each directional antenna is connected to a dedicated base station). Because antenna radiation patterns overlap, it may be necessary to filter duplicate position reports before passing data to other facilities.

16.7.3 Coverage of large geographic areas by several short radio range shore facilities

If large traffic loads are expected, it is reasonable to deliberately limit the coverage range of shore facilities. A smaller coverage area can be achieved by limiting the operational propagation range by reducing the antenna height, using directive antennas (sectorization), and reducing the reception sensitivity. By reducing the coverage area, only a small traffic load is experienced and overload conditions can be avoided.

16.7.4 Coverage of large geographic areas by extended VHF range base stations and several short radio range, passive reception stations

In order to deal with the garbling effect, an active base station, which is also responsible for ship-shore communication traffic, can be constructed for a given geographic coverage area. The transmission of this base station will be transmitted over previously reserved and readily available time slots.

Multiple use of time slots by mobile stations, which might still exist, will be resolved through appropriately staggered, passive base stations and the discrimination in favour of the stronger transmitter. Each of the passive base stations receives the transmissions in its immediate vicinity.

It is also feasible to co-locate passive base stations with active base station provided they are equipped with receiving sectors.

16.7.5 Multiple coverage in geographic areas of base stations

If the distances between base stations are chosen such that the operational cells overlap significantly, then targets from several base stations will be received simultaneously. This results in a redundancy of reception routes, namely from two or more base stations from different directions. Each of the base 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 operational cells is reduced. Interference of reception at one base station could be compensated for by another base station.

The probability of reception in the case of overlapping operational cells is higher.

16.7.6 Increase of the geographic coverage area of base stations by means of simplex repeaters

The range of AIS base stations can be increased by means of AIS simplex repeater stations. However, this technique increases the load of the operational channel because all received data telegrams must be send out once again.

Simplex repeaters can be used when the traffic density is low or in areas where the operating range of base stations is limited by shadowing of operational reception due to topography.

The repeater places minimal requirements on the infrastructure because the data messages are simply repeated and are not forwarded over the communication links.

17. Re-transmission of AIS Information

17.1 Overview

17.1.1 Introduction

This chapter describes the re-transmission elements of an AIS service, advantages/disadvantages of these elements and specific technological solution options to implement re-transmission.

Under most conditions an AIS system does not re-transmit received messages that are received by a shore infrastructure. In special circumstances, re-transmission of AIS information over the VDL may provide an efficient solution to those special circumstances. These circumstances include:

- geographical limitations to radio
- extension of RF coverage when there are limited connectivity options

17.1.2 Application areas for re-transmission

A competent authority would consider employing the re-transmission elements of the AIS Service when it would be operationally required. Such conditions could include the following examples:

- to extent the coverage area around geographical obstacles to radio propagation
- to relay received AIS data.
- to link two or more geographically separated operational areas via a shore-based communication link

17.1.3 Advantages and disadvantages of re-transmissions

Advantages of re-transmissions:

- Overcoming difficult propagation conditions due to geographic terrain that would prevent vessels that are within relatively close proximity from receiving each other.
- Increasing coverage areas while avoiding the need for a separate AIS base station assuming that there is a cost benefit for this.
- Making use of existing base stations to route addressed messages between vessels that are not located within the same base station coverage area. This of course raises the question of payment for this service.

Disadvantages of re-transmissions:

- Reduced system capacity when using simplex repeaters or certain configurations of VDM (VHF Data Messages) re-transmissions.
- The use of duplex repeaters will require a duplex channel and channel management capabilities.
- Increased system complexity.

17.1.4 Guidelines For The Use of Re-Transmission

Administrations considering the use of the re-transmission elements should take into account the following guidelines:

- Since erroneous data may be re-transmitted if the received data has not been error-checked by Re-Transmission by a Fixed AIS station, a competent authority should consider data monitoring.
- Quality and accuracy of data should be taken into consideration when re-transmitting data from sources other than the VTS.
- An administration having considered the benefits of the re-transmission capabilities of AIS needs to carefully assess the risks associated with this operation:
- Legal liability for accidents that can be proven to have been caused by re-transmission or where re-transmission was a contributing factor.
- Using re-transmissions can significantly reduce the system capacity (number of available slots are reduced)

17.2 Technical description of Re-Transmission Systems

Re-transmissions are achieved by applying one of three main techniques:

- Making use of Simplex Repeater
- Making use of Duplex Repeaters
- Making use of Base Stations to re-transmit VDM Presentation Interface sentences as VDL messages. This process are referred to as VDM re-transmissions

The reader should note that this description conveys the technical aspects of re-transmission, but does not describe the details. For details, refer to IALA Shore Station and Networking Aspects Related to the AIS Service Edition 1.0.

17.2.1 Simplex Repeater

Simplex repeating is a process whereby data is received, processed, and then re-transmitted on the same channel but in a later time slot (Store-and-forward re-transmission). There are possible two types of simplex repeaters:

17.2.1.1 Store and forward simplex repeater

Single frequency asynchronous reception and re-transmission processes controlled by a logical process. Re-transmission should be done using FATDMA reserved slots, for two primary reasons:

- the simplex repeater cannot receive while transmitting (therefore "move" the mobile AIS stations to slot times when the simplex repeater will be receiving)and
- to do otherwise opens the potential for the repeater to be a major channel jammer as it competes directly with mobile AIS stations in high traffic areas for SOTDMA slots.

A final determination would be reserved based on the expected traffic within the operating area of the Simplex repeater.

Each received packet must pass the Cyclic Redundancy Check (CRC) test. Only error free packets should be re-transmitted. Delay between reception and re-transmission is measured in "slots". The delay makes it necessary to change some of the bits in the packet. The Shore's logical repackaging process is liable for mistakes. Properly formatted packets will be re-transmitted without evaluation of their content - potential Garbage In Garbage Out (GIGO) issues. Not every correct packet receive has to be re-transmitted. The re-transmission schedule is governed by the real-time channel loading.

17.2.1.2 Store and forward simplex repeater with integrity

A store and forward simplex repeater (See 17.2.1.1 above) that performs tests on received packets to improve the integrity of the information that is re-transmitted. It makes significant attempts to reduce GIGO. Some of these tests include:

- physical measurements (eg direction finding, signal strength...)
- logical processing/filtering (eg geographic filtering, age of message...)

17.2.2 Duplex Repeater

Duplex repeating is a process whereby signals is re-transmitted in real time on a duplex frequency pair. The shore side transmit frequency is the B-side of the duplex frequency pair. As long as the duplex repeater re-transmits everything that is received, ship-to-ship communication is maintained. In addition the duplex repeater operation should take place using the secondary regional channel. The primary regional channel is reserved for normal simplex ship-to-ship operations.

Figure 17.1 below shows an overview of duplex repeater operation. Mobile stations M1 and M2 are within RF Line-of-Sight of each other while mobile station M3 is not. All three mobile stations are within RF Light-of-Sight of the Fixed Station at the top of a mountain. This fixed station is operating as a duplex repeater and therefore, all three mobile stations are receiving duplex repeated data from each other. f_A indicates the Mobile station transmit frequency and f_B indicates the Fixed station transmit frequency.

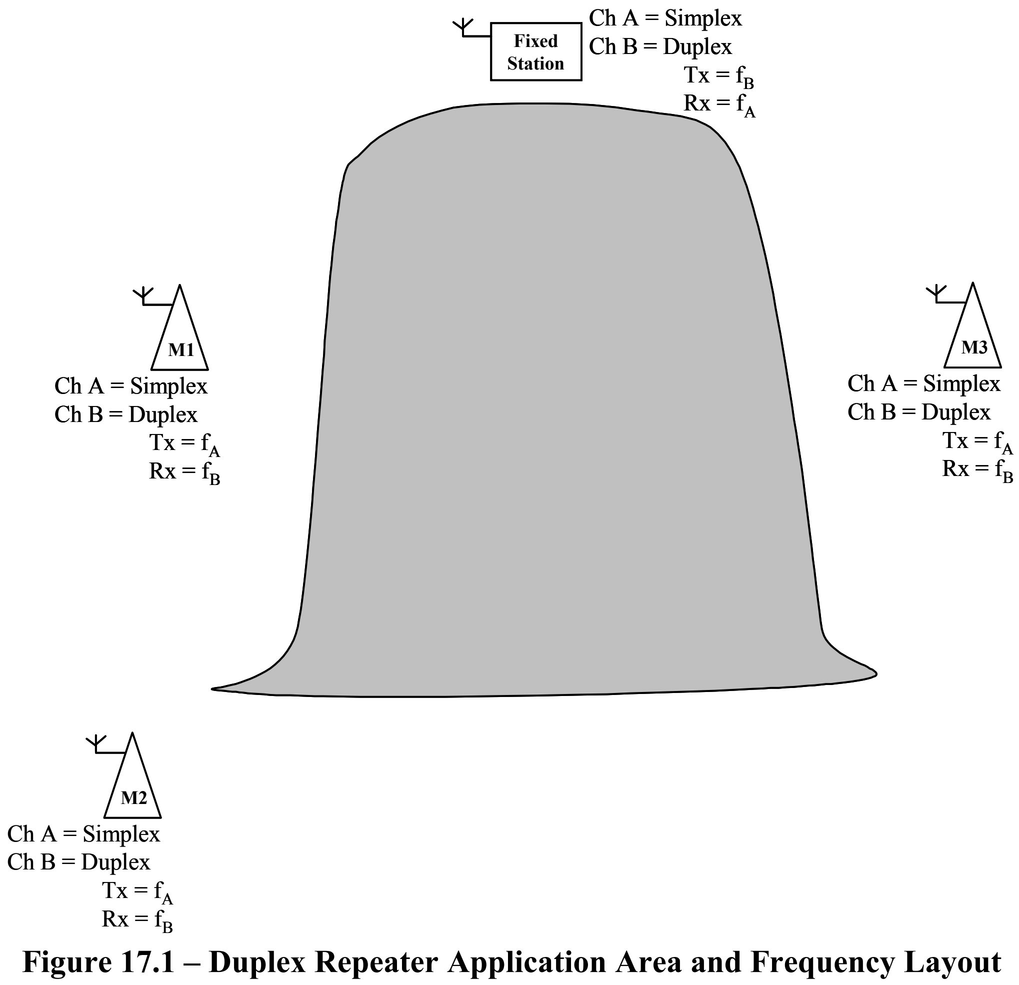


Figure 17.1 – Duplex Repeater Application Area and Frequency Layout

17.2.2.1 Analog duplex repeater

Retransmits, on the B-side frequency of the duplex channel pair, the analog signals received on the reception frequency (A-side of the duplex channel pair). It is immediately re-transmitted as the signal is received with very little signal delay. This process is essentially a "bent-pipe" re-transmission of everything received and occurs at the Physical Layer of the AIS station (refer to Recommendation ITU-R M.1371-1). These re-transmissions will repeat corrupt messages.

17.2.2.2 Regenerating duplex repeater

A regenerating duplex repeater processes the received signal at the Link Layer Sublayer 1 Medium Access Control (MAC) level (refer to Recommendation ITU-R M.1371-1). At this level certain characteristics of the received signal are regenerated without error checking or filtering. The signal is then re-transmitted in the same TDMA slot, but may be delayed by several bit periods. The regenerating duplex repeater design must control issues of packet delay and recovery of the Training Sequence bits.

17.2.2.3 Regenerating duplex repeater with integrity

This type of repeater uses an integrity process that evaluates all messages before re-transmission. The regenerating duplex repeater with integrity "regenerates" broadcast of messages that pass filtering checks. The signal is re-transmitted in the same time slot as it was received, but may be delayed by several bit periods. The regenerating duplex repeater with integrity design must control issues of packet delay and recovery of the Training Sequence bits.

17.2.3 Store and Forward Duplex Repeaters

It is theoretically possible to add store and forward capabilities to the duplex repeater. However this will adversely affect the VDL because all TDMA slot reservation information is lost. Therefore Store and Forward Duplex Repeaters should not be considered.

17.2.4 VDM Re-transmissions

An AIS Base station outputs all received VDL messages as Presentation Interface VDM output sentences. These received VDM output sentences are then processed by an external process and passed back to the same base station from where it was received for re-transmission **or** passed to another base station for re-transmission. It is also possible for an external process to use data from other sources, like a proprietary vessel tracking system or an AtoN monitoring system, and present this to an AIS Base station as a VDM input sentence for re-transmission.

17.2.4.1 Same Base Station Re-Transmissions

VDM re-transmission by the same base station is essentially the same process as simplex repeating, but because there is an external process involved the time delay between receiving and re-transmitting may be greater than in a simplex repeater. It is however not allowed to re-transmit AIS data older then 30 seconds. Because the decision on which data to re-transmit (i.e. the filtering process) is done by an external application, the filter criteria can be more intricate and defined than with a simplex repeater. This form of re-transmission does reduce the channel capacity because for every repeated message double the number of slots is used – original transmission and re-transmission.

- When information is received by an AIS base station as a Presentation Interface VDM Input Sentence, the AIS Physical Shore Station (or higher layers) can perform the same functionality as that of the AIS simplex repeater with integrity function described in Section 17.2.1.2.

17.2.4.2 VDM re-transmissions by another base station

The output VDM message from one base station may be processed by an external application and then transported via a network to another base station for re-transmission. This is an effective way to provide information to vessels for advanced planning (e.g. lock planning). As with the re-transmission scheme above, data older than 30 seconds will not be retransmitted.
If the two base stations are not within radio coverage of each other this system will not reduce the overall system capacity, but if the two units are within each others radio coverage area the same effect on system capacity as above applies.

17.3 Concluding Remarks

For more detailed technical information concerning AIS Simplex Repeaters, AIS Duplex Repeaters and Re-Transmission capabilities of an AIS Base Station, refer to the current edition of the IALA Recommendation "AIS Shore Stations and Networking Aspects Related to the AIS Service".

18. Channel Management

Not every single aspect of channel management is not well understood at this stage of the development of the AIS. This chapter provides an *introduction* to Channel Management for competent authorities. Some recommendations will be derived at the end of the chapter.
A section introducing most fundamental definitions and concepts is presented first, This introduction starts with the mobile AIS station and assumes that it is this station has to operate in accordance with regional operating settings that are different from the default operating settings. It then moves on to the consequential requirements for the shore infrastructure set up by the competent authority.

18.1 Introduction and fundamental concepts

In response to a request from IMO seeking global channels for AIS, the ITU designated two worldwide channels from the VHF maritime mobile band for this purpose (refer to ITU-R Radio Regulations (RR) Appendix S18). The channels are AIS1 – No. 2087 (161.975 MHz) and AIS2 – No. 2088 (162.025 MHz) - with 25kHz bandwidth, and in accordance with Recommendation ITU-R M.1084. Two channels were selected to increase capacity and mitigate Radio Frequency (RF) interference. AIS1 is the "primary channel" and AIS2 the "secondary channel" in "high seas" areas. This distinction will become relevant when considering some details of the transition between regions.

By default every mobile AIS station operates on these two channels, AIS 1 and AIS 2, as defined in Recommendation ITU-R M1371-1. A mobile AIS station is thus capable of receiving two messages, from two different stations concurrently, provided that it does not transmit at the same time. Every mobile AIS station transmits at its "*nominal reporting rate*". This nominal reporting rate is given in tables for the respective class of mobile AIS station (refer to the appropriate chapters of these AIS Guidelines).
Each of the two channels by default is used to transmit scheduled transmissions, such as autonomous and continuous position reports, *at half of the "nominal reporting rate."* E. g. a Class A shipborne mobile AIS station moving at a speed of more than 23 knots is supposed to report its position in intervals of 2 seconds. Therefore the nominal reporting rate would be once per two seconds. This means, that each of the two channels AIS1 and AIS2 will receive a scheduled position report from this mobile AIS station once every four seconds, i. e. at half the rate of the nominal reporting rate. To understand this fact is crucial for the understanding of the impact of channel management on reporting rates. This behaviour is called dual channel operation.

18.1.1 Reasons for Channel Management

The ITU also provided for administrations to designate "regional frequency channels for AIS" *where channels 2087 and 2088 are unavailable* and, if necessary, to derive new S18 channels using Recommendation ITU-R M.1084 (simplex use of duplex channels and/or 12.5 kHz narrow-band channels).

In addition channel management may be used to mitigate throughput breakdown caused by (local) RF interference on or blocking of one or both of the default operating channels by locally switching over to alternate operating channels.

A channel management scheme is also required when duplex AIS repeaters are used. The justification for duplex repeating may be derived from local unavailability of the default operating channels.

18.1.2 Parameters subject to channel management and their default settings

The following operating parameters (of any mobile AIS station) may be changed by channel management. Also their default setting and range of possible settings are given (see Recommendation ITU-R M.1371-1, Annex 2, §4.1):

- frequency / nominal bandwidth of the primary operating channel = channel A (as expressed by channel number in accordance with Recommendation ITU-R M.1084).
  Default: channel number 2087 = AIS1, 25 kHz bandwidth
  Possible range: all channels of 25kHz or 12.5kHz nominal bandwidth which can be identified by a channel number given in Recommendation ITU-R M.1084. Local possibilities may be depending on regulatory considerations.
-
- frequency / nominal bandwidth of the secondary operating channel = channel B.
  Default: channel number 2088 = AIS2, 25 kHz bandwidth
  Possible range: refer to primary operating channel
- Transmitter power level setting
- Default: high power level setting
  Possible range: low power level setting = 2W; high power level settings = 12.5W
-
- Transmit/Receive mode:
  Default: Dual channel operation (receive on both channels A and B simultaneously; transmit on channels A and B alternately, using half the nominal reporting rate on both channels A and B. Assigned mode may change the reporting rate of a mobile station without affecting the use of dual channels alternately.) = TxA/TxB; RxA/RxB
  Possible range:
  (TxA/TxB, RxA/RxB);
  (TxA, RxA/RxB) = transmit only on primary operating channel (channel A) and receive on both channels simultaneously (while not transmitting);
  (TxB, RxA/RxB) = transmit only on secondary operating channel (channel B) and receive on both channels simultaneously (while not transmitting);
-
- Narrow-band mode for primary channel A:
  Default: nominal bandwidth as specified by channel number (see above)
  Possible range: nominal bandwidth as specified by channel number; reduced to 12.5 kHz (when channel number designates a channel with 25kHz nominal bandwidth)
  Note: It should be observed that the optional use of 12.5 kHz bandwidth reduces somewhat the receiver sensitivity and FM discrimination (slot sharing capability), but still gives the required transmission rate of 9600 bits per second.
-
- Narrow-band mode for secondary channel B: refer to Narrow-band mode for primary channel A
-

- Transition zone size:
  Default: 5 nautical miles
  Possible range: 1 to 8 nautical miles in steps of 1 nautical mile
-
- Addressed mode: A base station can command specific channel management behaviour, using the above parameters, to an individual mobile AIS station.
-
- Geographical region: Region defining latitudes and longitudes - not only do these values establish the location and size of the region, they are also used to identify the region and the station characteristics data for that region. See below.

Channel management is performed, when mobile AIS stations are switched from their default operating settings to any different operating setting, which may only differ in one parameter.

Channel management can be performed over the VDL using AIS Message 22 or via VHF-FM Ch 70 by using DSC. The parameters that can be set by the DSC-based AIS Channel Management has the limitation that it cannot modify the Transition Zone Size. A parameter-by-parameter comparison is shown in Table 18.1. Competent authorities need to be aware of these differences if implementing the DSC-Based AIS Channel Management capability. Appropriate coordination of the contents of AIS Message 22 transmitted over the VDL with the DSC-based AIS Channel Management is necessary.

Table 18.1 Channel Management Parameter Comparison of DSC-Based vs TDMA-Based

Parameter	AIS Message 22 (TDMA)	DSC-Based AIS Channel Mgmt
Channel A Frequency & Nominal Bandwidth	X	X
Channel B Frequency & Nominal Bandwidth	X	X
Transmit/Receive Mode	X	X
Transmitter Power Mode	X	X
Longitude of NE Corner	X	X
Latitude of NE Corner	X	X
Longitude of SW Corner	X	X
Latitude of SW Corner	X	X
Addressed or Broadcast Message Indicator	X	X
Channel A Bandwidth	X	X
Channel B Bandwidth	X	X
Transition Zone Size	X	N/A

The whole set of channel management settings and region specification is called *"regional operating settings"*.

The above list highlights that channel management is not just about changing operating frequencies. *Channel management should rather be understood as a walk in a* *multi-dimensional channel parameter space*. The complexity of channel management results from the many inter-dependencies between these parameters.

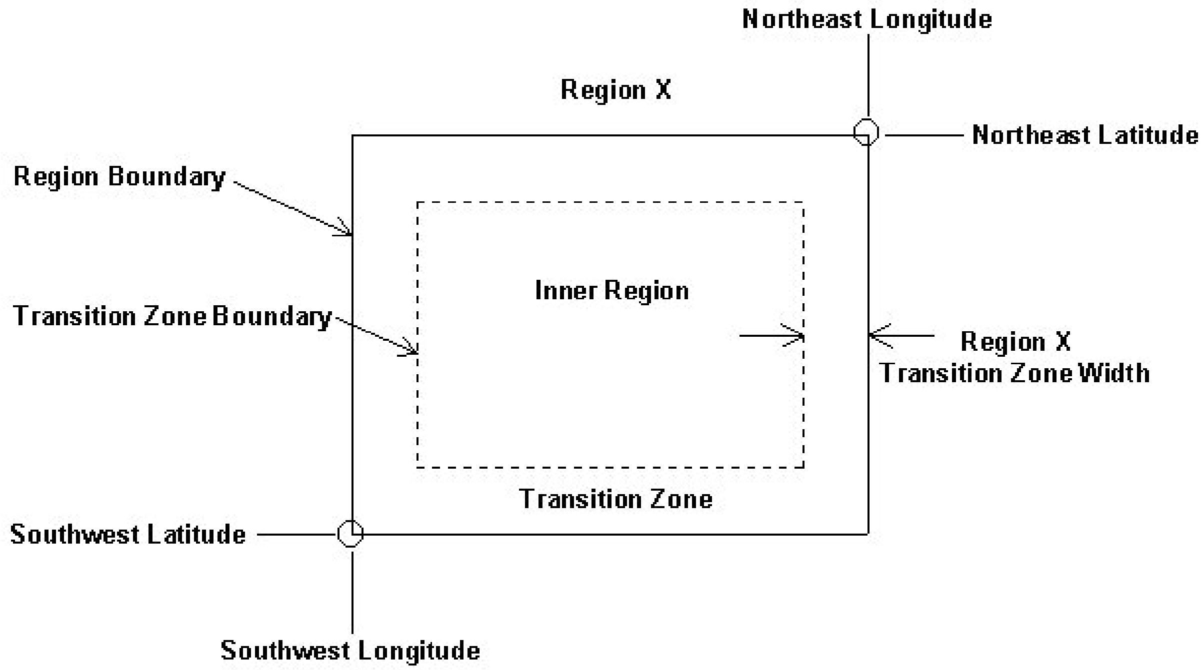
18.1.3 The definition of a region and its transitional zone

Depending upon the geographic location of the station and the regional operating settings stored in memory, a mobile AIS station is supposed to automatically change several fundamental operating characteristics from their default values. This feature is designed into the operation of every mobile AIS station. This feature allows local authorities to automatically manage mobile AIS stations' use of the VHF marine band.

Channel management data is organised by geographic regions. This section describes how these geographic regions are defined. In fact, channel management in effect is *only* possible within *precisely defined geographical regions*. This means, that any channel management operation applies to the specified region, only. Mobile stations outside all regions, to which channel management settings apply, will stay in or return to the default settings.

The regional operating areas are designated by a Mercator projection rectangle with two reference points using WGS84 datum. The first reference point is the geographical co-ordinate address of the north-eastern corner (to the nearest tenth of a minute) and the second point is the geographical co-ordinate address of the south-western corner (to the nearest tenth of a minute) of the rectangle. Since it is an area on the curved surface of the earth, a region is not a true rectangle in shape. The sides of the region follow either constant latitude or longitude lines. A rectangular representation of this area is shown in Figure 18.1.

Figure 18.1 Rectangular representation of a region and its components



Inside every region's boundary there exists a "transition zone." The width of the transition zone is also part of the data that defines the region. The transition zone for a region is the area between the "Transition Zone Boundary" and "Region Boundary" as shown in Figure 18.1. The transition zone width is specified in increments of one nautical mile and range of one to eight nautical miles. If no value is given in the region's definition, the default width is five nautical miles. The zone size is the same on the 4 inside boarders of a region.

While the transition zone is expressively defined in ITU-R M.1371-1, the portion of the region that is not inside the transition zone is not given a special name. In order to simplify the discussion below, the term "Inner Region" will be used to refer to the portion of a region that is not the transition zone. This means that the area of a region can be described as being equal to the area of the transition zone plus the area of the inner region.

When the mobile AIS station receives different channel management commands for the same geographical region, the information received latest will be used in accordance with an algorithm described below.

Any Class A shipborne mobile AIS station can internally store information for eight different regions. This gives the possibility to “download” to Class A shipborne mobile AIS stations information for several regions (for example covering inland waterways) from one shore station.

The AIS automatically changes to a transitional mode of operation when it is within the specified transitional zone which surrounds the region boundaries. In this zone ships transmit and receive on one of the channels for the area it is leaving and one of the channels for the area it is entering. Within the transitional zone, the reporting rate will be the nominal reporting rate for *both* channels (as opposed to just half the nominal reporting rate in each individual channel during default dual channel operation).

Within the transitional zone, Class A shipborne mobile AIS stations will ignore any assignment of higher nominal reporting rates by shore stations. This guarantees that the broadcasts of mobile AIS stations operating in the transition zone will be received at nominal reporting rate for the benefit of other mobile stations in the immediate vicinity of that station.

The precise details of the behaviour of a mobile AIS station within a transition zone are described below.

18.1.4 A Region's relationship to the high seas (or default) region

The "high seas" or default region has the primary channel of AIS1, and the secondary channel of AIS2 with a bandwidth of 25kHz on both channels. The size of the transition zone is 5 nautical miles. The power level is "high power" and all of the mobile AIS station‘s receivers and the frequency-agile transmitter are used. Figure 18.2 shows the relationship of the Figure 18.1, Region X, and the high seas region.

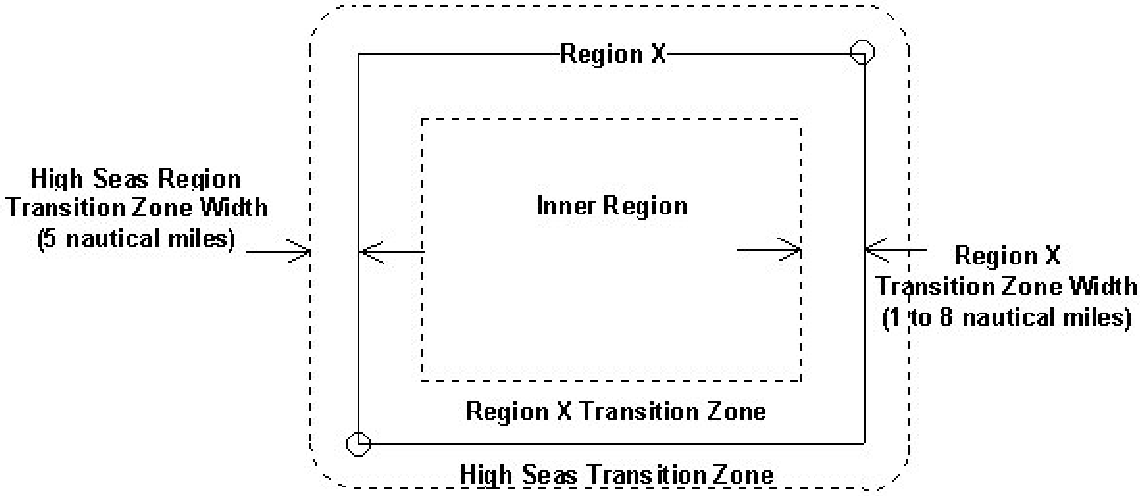


Figure 19.2 - Relationship of region X to the High Seas Region.

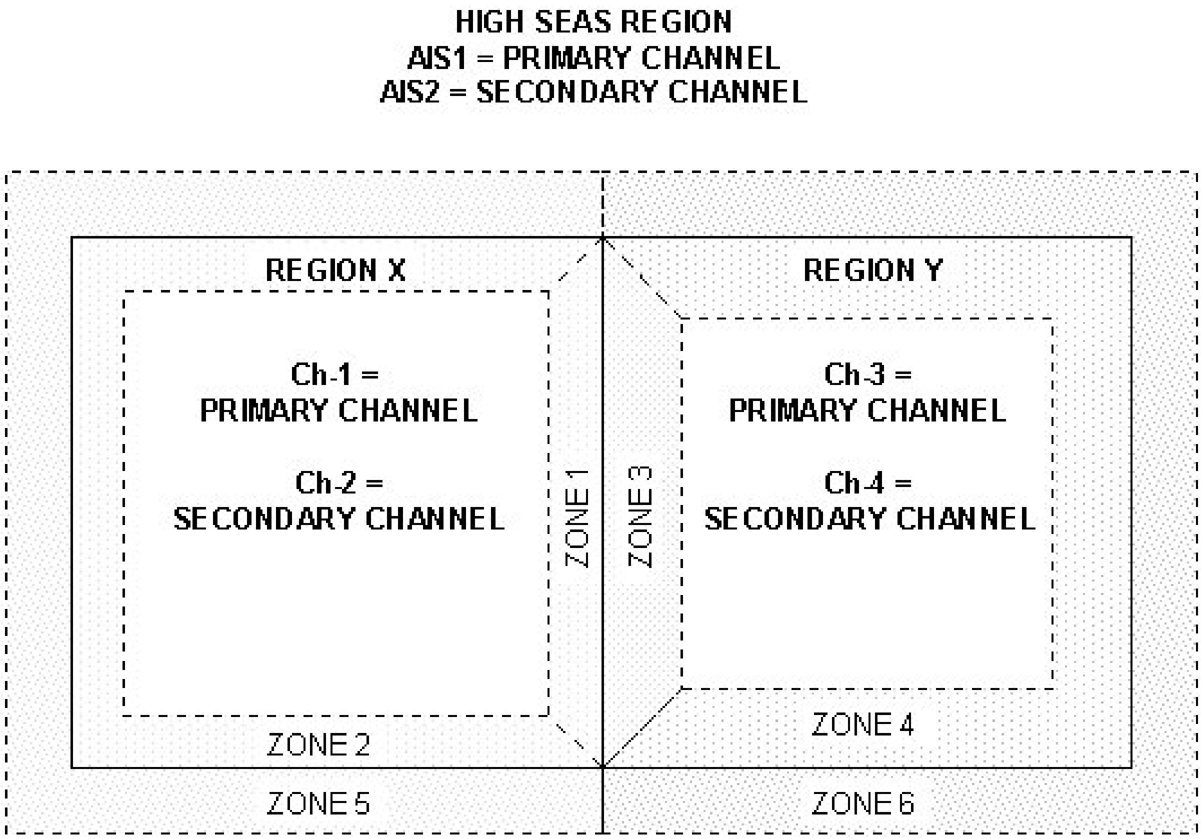


Figure 18.3 Breakdown of operating zones for two adjacent regions

The high seas region's regional operating settings are all equal to the default values. They cannot be changed by channel management. Channel management data can only create additional regions that exist within the high seas region. Wherever a defined region is created, if not adjacent to another defined region, this relationship with the high seas region is automatically created.[4]

18.1.5 Two Regions' relationship including the High Seas Region

If two regions are defined with either a latitude or longitude boundary exactly the same, to 1/10 minute, the two regions exist adjacent to each other, see the common side of Region X and Region Y in Figure 18.3. If the boundary of a region falls inside the boundary of another region, the regions conflict and a decision about which to region to use must be made by the mobile AIS station. Recommendation ITU-R M.1371-1, § 4.1.8, states, "*The most current and applicable commands received should override previous channel management commands."* Applying this rule would mean the more current regional definition would apply and the older definition ignored. This also implies that the data and time that a region's data is received should be retained along with the region's data.

4 Note: There is a slight ambiguity at the corners of the High Seas Transition Zone Boundary. Figure 19-2 is drawn using the 5 nautical mile distance from the region X boundary. Some equipment designers may use lines of constant latitude and longitude that are 5 nautical miles from the region X boundary. This would result in 90 degree corners rather than constant radius corners. These optional interpretations do not represent a significant operational safety issue. Because accurate curved lines are difficult to draw, the remaining diagrams will use "square" corners on the high seas transition zone boundary - with this ambiguity implied.

Figure 18.3 shows two adjacent regions, Region X and Region Y, surrounded by the high seas region. The Region X transition zone is further broken down into zone 1 and zone 2. Zone 1 is the portion of the Region X transition zone nearest to the boundary in common with Region Y. Zone 2 is the portion of the Region X transition zone nearest to the boundary in common with the high seas region. Recognition, that the transition zone may be sub-divided depending on the relationship it has with adjacent regions, is key to understanding how a mobile AIS station will safely operate as it travels between and among regions that use different radio frequencies, signal bandwidths, power, etc. In a similar fashion, the Region Y transition zone is broken down into zone 3 and zone 4; and the high seas region's transition zone is broken down into zone 5 and zone 6.

How a mobile AIS station will safely operate as it travels between and among regions will be described in detail below, using the above definitions.

18.1.6 IMO requires maximum extent of automated channel management

The AIS is designed as an automatic system. Accordingly, even operating conditions that differ from the default, *such as channel management should be automated as much as possible*. This is in full accordance with the appropriate IMO guidance (refer to IMO/NAV47 "Draft Liaison Statement to ITU-R Working Party 8B", which is Annex 15 of document NAV47/13, 26 July 2001, paragraph 1.2):

> "IMO notes that there may be areas where alternative frequencies are in use but where no base stations exist. This should be an unusual situation, however where it exists, information should be available to all ships sailing in these areas. Therefore, IMO requests that all Administrations notify IMO of these areas for the circulation by the appropriate IMO circulars as well as promulgate this information to shipping in these areas by a suitable means. Also IMO recognises that from the viewpoint of avoiding accidents due to human error, automatic switching should be the normal procedure and manual switching should be limited to specific purposes such as maintenance for the equipment."

This statement clearly applies to both shipboard and shore side.

18.1.7 Overview on means for automatic and manual channel management

Automatic switching of regional operating settings for mobile AIS stations can be done by one of the three means described below. Automatic switching is considered a safer way than manual switching. Among the automatic means, there are two ways to switch regional operating settings from the shore by the competent authority and one automated way to switch regional operating settings on board the ship.

A competent authority may set up AIS shore stations utilising Basic AIS Service "Switch AIS VDL channels via AIS VDL", that uses Message 22 ("Channel Management message") and that gives information of region boundaries, channels and other parameters to be used within the region. The Basic AIS Service "Switch AIS VDL channels via DSC Channel 70" can also be used for this purpose.

In addition, a shipborne information system, which may be connected to the AIS, may input regional operating settings to the AIS. This information may be derived automatically from i.e. a database or from a manual input to this shipborne information system.

Manual channel switching by the AIS operator on the ship can be performed via any suitable interface. The Class A shipborne mobile AIS station provides for manual inputs via the Minimum Keyboard and Display.

Manual channel switching should be avoided if possible in normal operation and should only be based on information issued by the competent authority of that region (compare IMO statement).

The database of the shipborne information system may not fully reflect the current regional operating settings required for the particular region, or the manual input may be flawed.

Therefore, regional operating settings received from a shipborne information system or by manual input, will not be accepted by a Class A shipborne mobile AIS station, if a regional operating setting was received for the same region from a shore station recently.

18.1.8 Channel management as a privilege and as a responsibility for competent authorities

Since the exchange of navigational data between ships and between ship and shore can only be done when both the transmitting and the receiving station use the same channel with compatible operating settings, *a wrong operating setting in just one mobile AIS station may result in it being "invisible" as far as the AIS is concerned*. This may be a safety issue. Therefore, *ITU only allowed competent authorities to do channel management.*

Since channel management is one of the most complex functionality of the whole of the AIS and since channel management, when done wrongly, thus can be potential hazardous to safety, it is strongly recommend that every competent authority should consider the use of channel management carefully before implementing it: *Careful planning is required before a Competent Authority implements a Channel Management scheme.*

18.2 Channel management commands to a Class A shipborne mobile AIS station

All Class A shipborne mobile AIS stations are using the following algorithm to keep the internal eight store memory up to date and to accept new regional operating settings. This algorithm, in general, has three different stages:

- continuous checking of store regional operating settings, and possibly automatic erasure of remote or old settings.
- checking of input before accepting it as new regional operating settings. It should be noted, that this is an exception from one fundamental concept of shipborne equipment design, i. e. that the receiving device normally does not check the data it is receiving. For example, the mobile AIS station does not check the sensor data it receives for reporting.
- operations performed after a new regional operating setting has been accepted.

In detail the Class A shipborne mobile AIS station will perform the following steps (in the following order, if applicable):

- All stored regional operating settings will be time/date-tagged and they will be tagged with information by what input means this regional operating setting was received on-board (via AIS VDL, DSC telecommand, Manual input via Minimum Keyboard and Display (MKD), input via Presentation Interface).
- The Class A shipborne mobile AIS station constantly checks, if the nearest boundary of the region of any stored regional operating setting is more than 500 miles away from the current position of its own position, or if any stored regional operating setting was older than five weeks. Any stored regional operating setting which fulfils any one of these conditions will be erased from the memory. This means, that the AIS station automatically "forgets".

- Any regional operating settings will be handled as a whole, i. e. a change requested for any parameter of the regional operating settings will be interpreted as a new regional operating setting input to the device.
- When the mariner requests to manually input a regional operating setting via the MKD, the regional operating settings in use, which may be the default operating settings, will be presented to the user on the MKD. The mariner will then be allowed to edit these settings partly or in full. The Class A shipborne mobile AIS station will ensure, that a region is always input and that it conforms to the most fundamental rules for regions. After completion of input of an acceptable regional operating settings set, the Class A shipborne AIS station will require the mariner to confirm a second time that the input data shall be stored and possibly used instantaneously.
- Regardless of means of input, automatic or manual, the Class A shipborne AIS station will not accept, i. e. ignore, any new regional operating setting which includes a region, which does not conform to the most fundamental rules for regions. In addition, it will not accept a new regional operating setting, which was input to it via its Presentation Interface (interface to other shipboard equipment; see following chapters), if the region of this new regional operating setting partly or totally overlaps or matches the regions of any of the stored regional operating settings, which were received from a base station via AIS VDL or by DSC telecommand within the last two hours.
- A channel management command or a DSC telecommand addressed to one individual Class A shipborne mobile AIS station will be accepted only if the Class A shipborne mobile AIS station is in a region defined by one of the stored regional operating settings. In this case the set of regional operating settings will be composed by combining the received parameters with the region in use. An channel management command addressed to an individual Class A shipborne mobile AIS station will not be accepted for the high seas area.
- If the region of the new, accepted regional operating setting overlaps in part or in total or matches the region of one or more older regional operating settings, this or these older regions will be erased instantaneously from the memory (“overlap” rule). The region of the new, accepted regional operating setting may be neighbouring tightly and may thus have the same boundaries as older regional operating settings. This will not lead to the erasure of the older regional operating settings.
- Subsequently the Class A shipborne mobile AIS station will store a new, accepted regional operating setting in one free memory location of the eight memories for regional operating settings. If there is no free memory location, the oldest regional operating setting will be replaced by the new, accepted one.
- No means other then defined herein are allowed to clear any or all of the stored regional operating settings of the Class A shipborne AIS station. In particular, it is not possible to solely clear any or all of the stored regional operating settings by a manual input via the MKD or by an input via the Presentation Interface without input of a new regional operating setting.

There is not yet a similar algorithm developed for other classes of mobile equipment, except the most fundamental rules in Recommendation ITU-R M.1371-1. The IEC has begun work on Class B standardisation, however. IALA will begin work on A-to-N AIS stations in 2002.

18.3 Behaviour of a shipborne mobile AIS station entering or moving in a channel management scheme

When a mobile AIS station enters a transition zone, it changes operation to the "two-channel transitional operating mode." How the mobile AIS station operates among zones and regions will now be discussed. In particular, how the mobile AIS station schedules periodic repeated messages.

"Two-channel transitional operating mode" is entered when there is a change of either operating frequency or bandwidth, or both, from one region to the next. This mode of operation begins when a transition zone is entered. There are three exceptions to this rule:

1. If the regional operating settings in both regions use the same channels and bandwidths, operation in the "two-channel transitional operating mode" is not necessary. However, when the region boundaries are crossed, there may be an internal "virtual switch" of the primary and secondary channel designations within the mobile AIS station
2. If the primary channel is the same in both regions, the mobile AIS station should use only that single primary channel at nominal reporting rate while operating in the "two-channel transitional operating mode.
3. If the primary channel in one region is the same as the secondary channel in the other region and that secondary channel is a simplex channel, the mobile AIS station should use only that channel at the nominal reporting rate while operating in the "two-channel transitional operating mode."

18.3.1 Description of mobile AIS station operation in the "two-channel transitional operating mode"

The following describes the operation of a mobile AIS station as it moves between Regions X and Y through zones 1 and 3 of Figure 18.3. The possible movements of the station are shown in Figure 18.4 with notes describing changes to the stations operation.

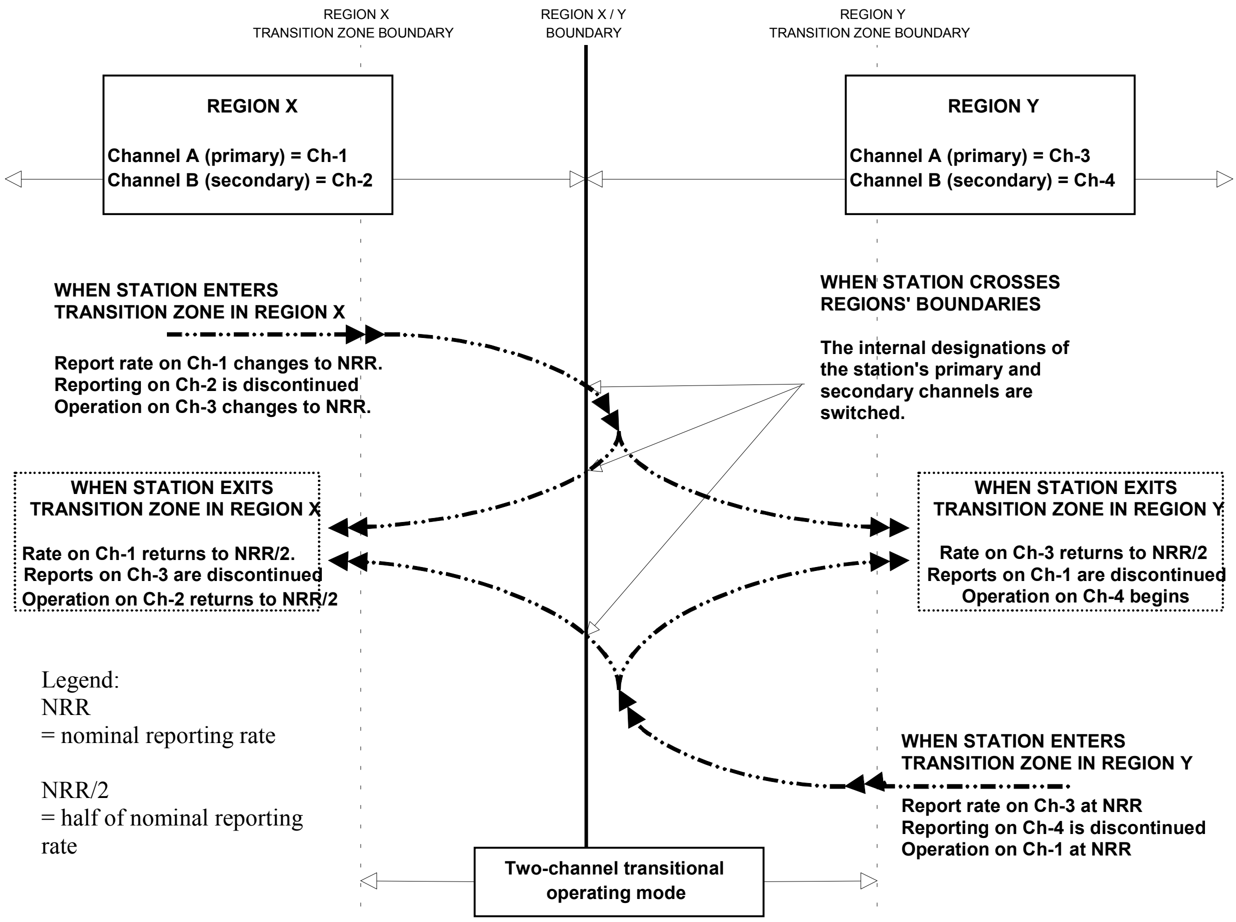


Figure 18.4 - Expected operation of a mobile AIS station in "two-channel transitional operating mode".

Upon entering the transition zones between two regions, the mobile AIS station should switch to the "two-channel transitional operating mode" by:

1. Switching the secondary receiver channel to the primary channel of the adjacent region and begin initialisation phase, while
2. Continuing to broadcast and receive on the primary channel (channel A) for the occupied region for one minute, and broadcast on the secondary channel (channel B) for one minute closing out the previously reserved slots,
3. Increasing the reporting rate on channel A to the nominal reporting rate after the first minute,
4. beginning broadcasts on the adjacent region's primary channel - at the nominal reporting rate.

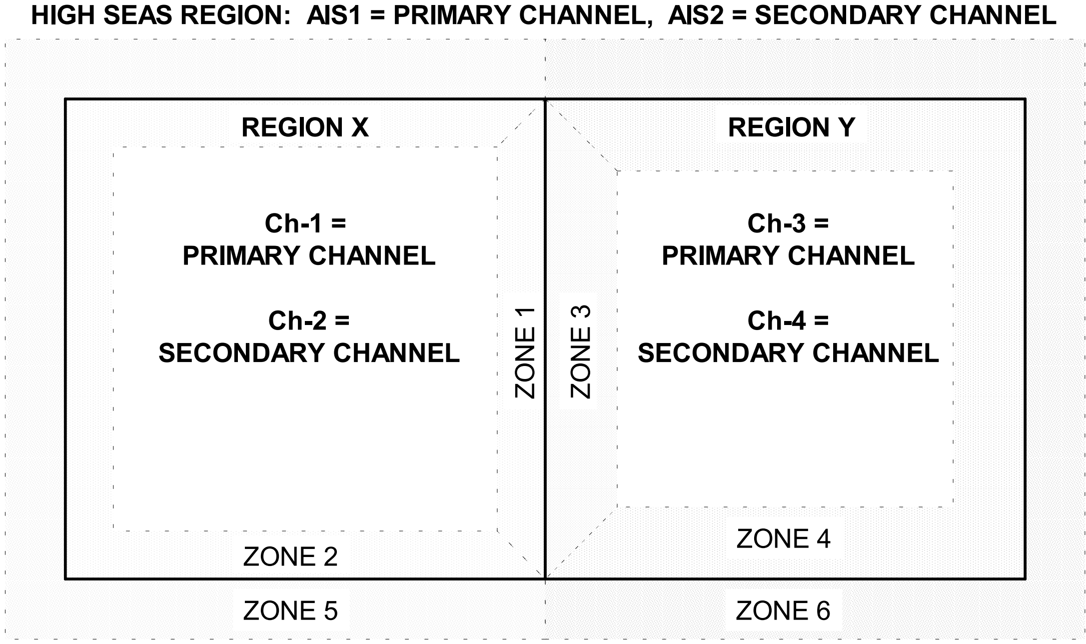
   Note: While inside the transition zones, the mobile AIS station's primary channel (channel A) is defined as the primary channel for the region that the mobile AIS station is inside at any given moment. The mobile AIS station should use this rule to change the primary channel, as needed, while it is in the "two-channel transitional operating mode." While inside the transition zones, the mobile AIS station's secondary channel (channel B) is defined to be the primary channel (channel A) of the nearest adjacent region. This rule should be used, as needed, to change the secondary channel while the mobile AIS station is in the "two-channel transitional operating mode."

Upon exit of the transition zones, the mobile AIS station should discontinue "two-channel transitional operating mode" by:

1. Switching the secondary receiver channel to the secondary channel of the occupied region and begin initialisation phase,
2. Decreasing the reporting rate on the primary channel (channel A) for the occupied region to half of the normal channel reporting rate (This will take about one minute.), and broadcast on the secondary channel (channel B) for one minute closing out the previously reserved slots,
3. Beginning broadcast on the secondary channel - at half of the nominal reporting rate.

18.3.2 Operation of a mobile AIS station moving between and among three regions

The description of mobile AIS station operation during movement between two regions can be used to describe more complex relationships. As described above, once a mobile AIS station enters the transition zone, it operates at nominal reporting rate on both the primary channel for the region it is in, and the primary channel for the next closest region. This is the rule used to draw the zones of Figure 18.5. Figure 18.5 contains both Figure 18.3 and a table indicating the proper operating channels for each of the zones in the figure.



Location of mobile AIS station	Double rate primary channel	Double rate secondary channel
ZONE 1	Ch-1	Ch-3
ZONE 2	Ch-1	AIS1
ZONE 3	Ch-3	Ch-1
ZONE 4	Ch-3	AIS1
ZONE 5	AIS1	Ch-1
ZONE 6	AIS1	Ch-3

Figure 18.5 - Channel selection for transition zone operation.

Using the table in Figure 18.5 and the concepts described in Figure 18.4, the operation of a mobile AIS station can be described for any of the possible tracks between and among the three regions of Figure 18.5. For example, if the station enters zone 1, crosses into zone 3, travels down zone 3 and crosses into zone 4, continues into zone 6, and exits into the high seas region, the following channel combinations well be used (first channel is "primary" / second is "secondary"):

1. Start in Region X, Ch-1 / Ch-2,
2. Enter zone 1, nominal reporting rate on Ch-1 / Ch-2 replaced by Ch-3 at nominal reporting rate,
3. Cross into zone 3, nominal reporting rate on Ch-3 / nominal reporting rate on Ch-1; a virtual switch of channel designations,
4. Cross into zone 4, nominal reporting rate on Ch-3 / Ch-1 replaced by nominal reporting rate AIS1,
5. Cross into zone 6, nominal reporting rate AIS1 / nominal reporting rate Ch-3; a virtual switch of channel designations,
6. Exit into high seas, half of the nominal reporting rate AIS1 / Ch-3 replaced by half the nominal reporting rate AIS2.

Other examples can be similarly constructed and analysed. Under all combinations and circumstances, the station must have one channel in common with nearby stations.

18.3.3 Single-channel operation

The possibility of single-channel AIS operation is briefly addressed under the parameter Tx/Rx Mode. Little, if any, information is given elsewhere in the ITU recommendations. Conditions that may warrant single-channel operation include limited, continued operation after a duplex repeater failure, areas with severe spectrum limitations, and remote waterways with little marine traffic.

If the Region Y secondary channel (Ch-4) is not defined, Figure 18.5 can be used to describe how the mobile AIS station should operate as it moves from any location in Figure 18.5 into the inner region of Region Y. For example, if the mobile AIS station moved from Region X to Region Y, the sequence of channels used might be the following (first channel is "primary" / second is "secondary"):

1. Start in Region X, Ch-1 / Ch-2,
2. Enter zone 1, nominal reporting rate on Ch-1 / Ch-2 replaced by Ch-3 on nominal reporting rate,
3. Cross into zone 3, nominal reporting rate on Ch-3 / nominal reporting rate on Ch-1; virtual switch of channel designations,
4. Exit into Region Y's inner region, continue nominal reporting rate Ch-3 / discontinue Ch-1.

18.4 Requirements and recommendations for competent authorities with regard to channel management

After this description on how the mobile stations operate within a given frequency management scheme, it becomes obvious, that the regional operating settings should be set up by the competent authority in such a way that the transition between the different regions is safe. The onus for a safe and proper channel management is on the competent authority.

18.4.1 Fundamental layout rules for when planning regions

In order to fulfil this requirement the competent authority should make sure that the following conditions are met (requirements taken directly from Recommendation ITU-R M.1371-1 or inferred from description above):

1. Regions should be *as large as possible*. For practical reasons, in order to provide safe transitions between regions, these should not be smaller than 20 nautical miles but not larger than 200 nautical miles on any boundary side. (from ITU-R M.1371-1)

2. The boundaries of each region, *which are meant to be adjacent to each other in the strict sense of the word, should be identical*. A “small” gap between “adjacent” regions, however small, will be interpreted by mobile AIS stations as a combination of three regions in total: two regions with regional operating settings different from default separated by “high sea”, i. e. by a region with default settings. Therefore, the mobile station will enter the transition zone behaviour of three different regions when moving from one region to the other through the alleged region with default settings.

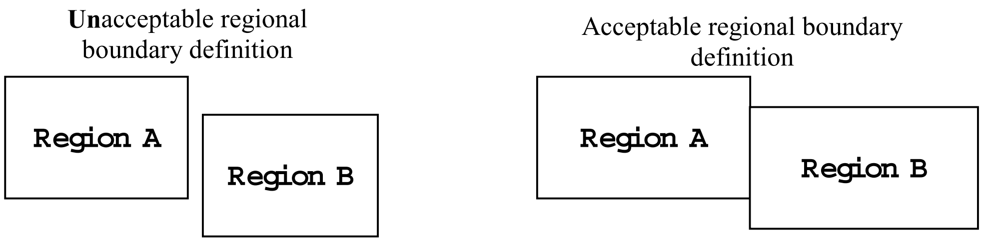


Figure 18.6

3. The distance between regions, *which are meant to be neighbouring, but not to be strictly adjacent*, should be at least the sum of the size of the transition zones of the two regions plus one nautical mile.

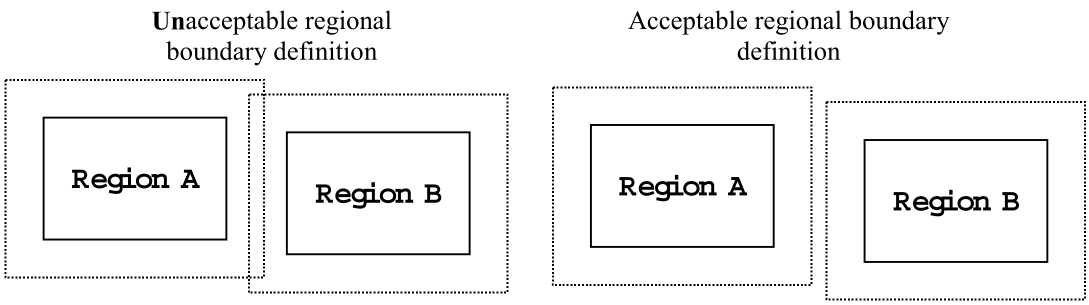


Figure 18.7

Having more than three adjacent regions at any regional boundary intersection must be avoided. In this context, the high seas area should be considered to be a region where default operating settings apply. When there are three or more adjacent regions, the minimum distance between the first and the second adjacent corners on one side and any other corner should be at least 8 nautical miles (which is the maximum size of a transition zone). This 8-miles-distance rule will be checked by the Class A ship-borne mobile station before accepting a new regional operating setting.

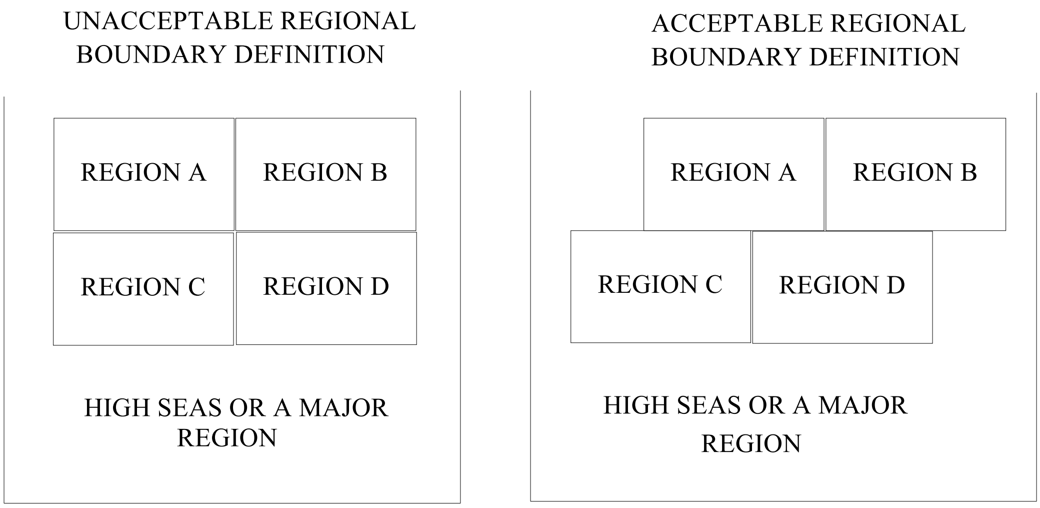


Figure 18.8

The region rules and general operation of the mobile AIS station are designed to successfully operate under the "worse case" conditions where every channel in every region is different. Although the AIS technology and methods adequately deal with these possible conditions, the actual application of channel management should recognise that AIS channel management is the safest when the primary channel of the regions is either AIS1 or AIS2.

18.4.2 Channel management by automatic means, i. e. by base stations

It is strongly recommended – in full accordance with the IMO guidance cited above - *that all areas where the default operating settings does not apply should be covered by AIS shore stations* utilising Basic AIS Service "Switch AIS VDL channels via AIS VDL", that uses Message 22 ("Channel Management message"), and that gives information of region boundaries, channels and other parameters to be used within the region. The Basic AIS Service "Switch AIS VDL channels via DSC Channel 70" can also be used for this purpose.
Base Stations that provide service in regional operating areas should use one of the above Basic AIS Services *also for all regions surrounding the actual regional areas.* It is recommended that Basic AIS Service "Switch AIS VDL channels via AIS VDL" should be used by a competent authority for all regions *at least every 10 minutes*. The actual rate should *depend upon the speed of vessels within regional transition zones*. With regard to the Basic AIS Service "Switch AIS VDL channels via DSC Channel 70" similar considerations should take place. It should be noted, however, that the ITU restricts the use of DSC Channel 70 for AIS related purposes, such as channel management, to 0.0375 Erlang in total (refer to Annex 3 of Recommendation ITU-R M.1371-1, §1.3). Therefore, this Basic AIS Service may not be adequate for all situations where channel management is required.

18.4.3 Change of regional operating settings over time

The change of regional operating settings over time may be required in some situations. Although this potential of the AIS needs much more investigation, some fundamental principles can be stated already.

18.4.3.1 Fundamental rules

Since the Class A mobile AIS station stores regional operating settings for up to five weeks, *carefully planned overwriting of the older, stored regional operating settings is needed when there are changes required for the same area over time.*

Channel management regions should only be changed – for safety reasons - *over a longer period of time, i. e. in the order of half-hours instead of minutes*.

The steps should be carefully planned beforehand, and the effects of any change should be well understood before implementing it. After one change step the system should be allowed to return to a stationary mode, i. e. all transitional states should have had time to subside. When there is a need to change operating frequencies within a region, there should be a minimum time period of 9 minutes after the first operating frequency has been changed before the second operating frequency is changed (refer to Recommendation ITU-R M.1371-1, Annex 2, §4.1.9).

Base stations should never change two channels (A and B) simultaneously within any region.

18.4.3.2 Preliminary procedures to change regions over time: Changes in region boundaries

Two possible changes of regional boundaries apply:

A region will be deleted, i. e. operation is intended to return to default

If the competent authority determines, that a region should no longer exist as a defined region, and the settings of that region should be changed to the default settings, the procedure as described as follows should be applied for that particular region: A channel management command must be transmitted by a base station to change the first operational frequency and all other parameters except the second operating frequency set to the default values, followed by a second channel management message after at least 9 minutes to change the second operational frequency. The region (geographical area) should be identical in size and location as the region to be deleted. If all AIS stations in that region are using the new operational frequencies, periodical channel management messages are no longer needed if the new operational settings are all equal to the default settings. The regional operating settings, which are stored in the memory of the Class A shipborne mobile AIS stations, will then be deleted in accordance with the algorithm given above, i. e. after five weeks latest.

A region will be moved or a new region will overlap the current region.

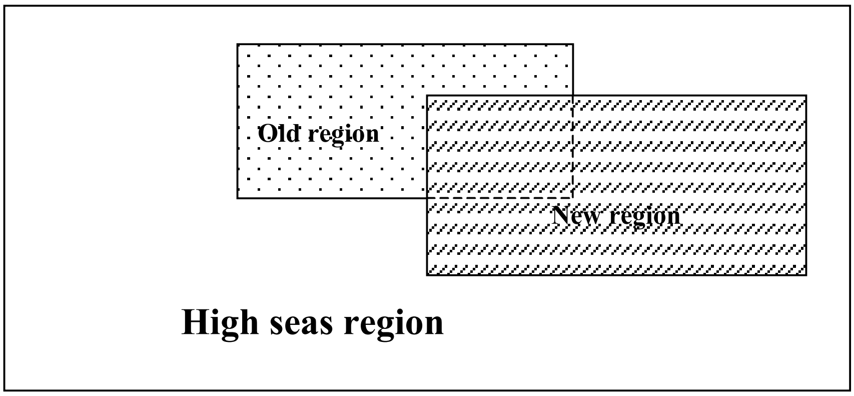


Figure 18.9

The picture illustrates the possible movement of a region from the old position to the new position. The same applies if a new region overlaps the old region. Any new region overwrites the stored old region as a whole immediately (refer to description of memory algorithm above). Therefore, the change from old to new could be accomplished in one step, i. e. all mobiles, which have been in an old region and are no longer in any specifically region – because the old region has been overwritten – would automatically be in "high seas" and would thus use default settings for *all* parameters immediately.

While this may be desired with some parameters other than operating frequency or just one operating frequency to be returned to default, this would not be a safe procedure, if more than one operating frequency different from AIS1 and AIS2 would need to return to default. Instead a step-by-step approach should be planned as explained before.

19. Co-Location of DSC Functionality

19.1 Introduction

Digital Selective Calling (DSC) functionality is a significant part of the ITU 1371-1 AIS standard. The intention of this inclusion was two-fold. To provide a bridge between the ITU 825-3 standard and AIS as well as a method to provide all mobile AIS stations access to regional AIS operating frequencies. DSC also can provide DSC-based AIS channel management that adds some useful additional functionality that may be of particular interest both to countries that cannot easily implement the system using the designated international frequencies, and those who anticipate a very high traffic density.

Indiscriminate use of DSC functionality, however, can negatively impact an AIS system and reduce its safety value. It can also negatively impact the primary function of DSC as an aid to search and rescue. Because of these inherent problems, shore-based DSC implementation for an AIS system must be carefully planned and operated. A competent authority must consider traffic flow and traffic density before implementation. The overall safety of the waterway, including both the control of obvious threats, such as hazardous cargo, and less obvious threats, such as waterborne terrorism, must be paramount.

19.2 Overview of AIS DSC Functionality

NOTE: ITU-R M.1371-1, Annex 3, and the standards cited in that document, must be consulted for a complete description. The following summary is provided to allow this discussion to be read without referral to other documents.

The DSC functionality described in ITU-R M.1371-1 is a subset of DSC functionality described in ITU-R M.825-3 and ITU-R M.493-10. For mobile AIS stations, the AIS standard specifically excludes all distress-related functionality and limits the dedicated AIS DSC receiver to Channel 70. Shore based DSC commands for an AIS shore station are of two types: DSC-based AIS channel management and DSC polling. DSC-based channel management commands allow a competent authority a method to change all mobile AIS stations AIS working frequencies on a regional basis, and they may be output in the form of geographical area command or a command to an individual ship. Polling commands implement a limited polling function that may be utilized by a competent authority. These commands include the following:

101: switch to VHF channel x for subsequent AIS communications

102: report position at intervals of x minutes

103: report position

104: VTS expansion messages

108: report length of ship

109: report course of ship

111: report ship's name or identification

112: acknowledge message

116: report speed of ship

VTS expansion messages (104) supported include:

00: frequency channel

01: transmit power level

09: primary regional channel

10: secondary regional channel

11: regional guard channel

12: Northeast corner of region

13: Southwest corner of region

The ITU 1371-1 specification places two restrictions on the use of these messages:

> Any DSC traffic on Channel 70 must be limited to 0.075 Erlangs to prevent any interference with DSC distress-related calls.
>
> The implementation of DSC by a competent authority must not impair AIS channel monitoring and information reporting.

19.3 Benefits of DSC Implementation

DSC functionality is supported by the Class A broadcast unit, but there is no requirement that a competent authority implement it. When is this implementation necessary or desirable? It may be necessary when the international channels (87B and 88B) are not available in a region. If a competent authority may not use the default channels, DSC-based AIS channel management messages will provide access to those ships via DSC rather than some other less automatic form of communication.

DSC-based AIS channel management messages also are the only universal method for transmission of AIS data both to ships on default channels and those on regional channels. This should not be necessary when operating under normal conditions, but it may be useful if part of a shore system fails or shipboard equipment does not respond normally. With proper planning the former situation should not occur, but the use of DSC could be used as a failsafe mechanism.

19.4 Possible Conflicts Between DSC and AIS Functionality

Two major conflicts can occur when AIS DSC messages are implemented. These are loss of AIS messages on the broadcast unit and at the shore station, and loss of availability on channel 70 for DSC distress-related messages. Both of these conflicts result in a lessening of the overall maritime safety that both DSC and AIS were designed to enhance. The competent authority can ensure that this does not occur.

Although possible within the supported AIS messages, switching AIS frequencies on either a single ship or a group of ships must not be implemented. This would cause that ship or ships to no longer receive position reports on the VHF data link from other vessels not included in the message. The use of these messages would make the output of an AIS display on the affected ships misleading.

Loss of AIS messages can occur when the competent authority implements any message requiring a response from a broadcast unit. ITU 1371-1 does not require that a broadcast unit simultaneously receive information on the working frequencies while transmitting its own position information. A single antenna system can meet all of the requirements. It is possible both to transmit and receive simultaneously on a single antenna, but receiver sensitivity is reduced when this is implemented (limiting the range of the unit and therefore increasing the possibility that messages will be lost). The use of automatic position reporting on channel 70 (message 102) is especially problematic, since it may cause continual disruptions in the reception of messages on the AIS working frequencies.

When does this become disruptive? Many factors can play a part. Traffic density relates directly to the likelihood that messages may be lost when the broadcast unit is transmitting on channel 70. An installed shore system that produces few conflicts when the number of vessels carrying broadcast units is low, may cause future problems as the number of ships carrying AIS equipment increases. Vessels with high reporting rates (high-speed vessels, vessels carrying passengers) exacerbate the problem. Segmentation of the coverage area into regional channels, with resulting higher reporting rates during transitions, can also contribute.

Loss of channel 70 availability obviously is related to traffic on that channel generated by AIS messages. Again, any AIS messages have an impact. Increases in the number of AIS broadcast units will increase the probability that distress-related messages may be lost.

19.5 Harmonization of DSC and AIS Functionality

Since the conflicts are all related to transmission of messages on channel 70, minimizing those messages will ensure that neither the Shore Station or Mobile Station's AIS VHF data link nor DSC-related distress functions are impaired. In areas where the default international channels are available (87b and 88b), regional channels may be implemented using channel messages built into the AIS standard (Message 22). This is obviously the preferred method. In areas where this is not an option, channel switching via DSC may be formatted so that no reply is required (command 112 should not be used). The acceptable transmission frequency of these messages must be based on the propagation and the speed of participating vessels: an interval of 10-15 minutes between broadcasts should be sufficient in most cases. Receipt of these messages by broadcast units must occur at least 5 NM before a vessel reaches the regional area. This will allow the switch to occur as specified in 1371-1.

Polling using AIS' DSC commands is, as has already been discussed, a possible source of disruption to DSC and AIS functionality. Its use makes sense only when the number of participants is low, the required reporting rate is at lower intervals, and using the AIS VHF Data Link is not possible. Before implementation, a competent authority must calculate the probability that disruptions will occur and then determine the possible impact on safety. In an area where the number of participants is steadily or dramatically increasing (as carriage requirements are implemented), this may be a difficult task. Active monitoring of the VHF data link is the safest and most predictable way to receive position reports.

20. Co-Location of VHF Voice Communications

In some situations it is necessary to have an AIS station co-located at the same general physical location with other communication assets. This occurs both for a mobile AIS station located on a vessel as well as for a fixed AIS station located on a communications tower used by other communication assets. In the case of the shore-based physical infrastructure, a lack of available tower space can be a significant issue in regions of the world for a variety of reasons. These reasons include: high cost of constructing a new tower, lack of utility services, environmentally sensitive areas, historically sensitive areas, amongst others.

Harmful effects of co-location with VHF voice communications (both on the AIS system and the VHF voice communication system) can be mitigated by common and sound RF engineering practices.

20.1 Installing a Separate Fixed AIS Station on a VHF Communication Site

A given communication site is being used by other VHF users for voice and/or data. The AIS Station can be installed as a separate entity with its own antenna(s) from the other VHF users. In order to mitigate co-site VHF interference some basic RF engineering principles should be considered.

- Obtaining proper vertical or horizontal physical separation between the AIS antenna and the VHF voice/data communication system(s).
- Identification of the other VHF users operational frequencies. What frequencies are always used? What frequencies are occasionally used?
- Performing an intermodulation analysis between the AIS system and the other systems sharing the same communication site. Particular attention to the other VHF users.
- In-line filtering can be used to attenuate non-VHF frequencies, certain VHF frequency bands as well as particular VHF frequencies.

The Competent Authority should understand the following items that can affect both the planning and operation of the AIS System:

- In-line filtering creates an RF insertion loss that will reduce the RF coverage for that particular fixed AIS station.
- In-line filtering will limit the available VHF channels that can be used by the AIS system.

20.2 Installing a Fixed AIS Station on a VHF Communication Site Using A Common Antenna System

A given communication site antenna system is to be used both by the VHF voice/data users and the fixed AIS system. In this scenario, if nothing is done to mitigate co-site VHF interference between the systems a significant reduction in performance of both systems would be expected. Similar basic RF engineering steps should be considered as to the previous section.

- Necessity for the fixed AIS station to have separate receive and transmit antenna ports.

- Identification of the other VHF users operational frequencies. What frequencies are always used? What frequencies are occasionally used?
- Performing an intermodulation analysis between the AIS system and the other systems sharing the same communication site. Particular attention to the other VHF users.
- In-line filtering can be used to attenuate non-VHF frequencies, certain VHF frequency bands as well as particular VHF frequencies.

The competent authority should understand the same items as the previous section with regards what impacts in-line filtering has on the RF coverage and the VHF channel availability for AIS.

21. Long-range AIS applications

Because the communication system for long-range applications of the AIS Class A mobile system (optional for Class B) has not been defined by any IMO requirement, a choice has to be made for long-range data communication means in order to use this service of AIS. In principle every long-range communication system can be used as long as it is suitable for data communication. In the architecture, as described in this chapter, all examples are given for Inmarsat-C as a practical solution, but also other satellite based systems as well as shore-based systems for long-range data communication can be used. From a standardisation's point of view a common solution should be preferable. This would avoid re-connecting AIS to different communication systems in different areas. In case of a fully integrated bridge design, where all communication systems, including AIS, are in a common network, it might be possible to use any suitable long-range communication system on request of the 'calling' authority. This is not further developed in this chapter.

The Long-range application can only be used on basis of interrogation by a competent authority. That excludes 'alarm' messages over long distances generated by the mobile station.

21.1 Architecture

The functional design of the long-range application can be as follows.

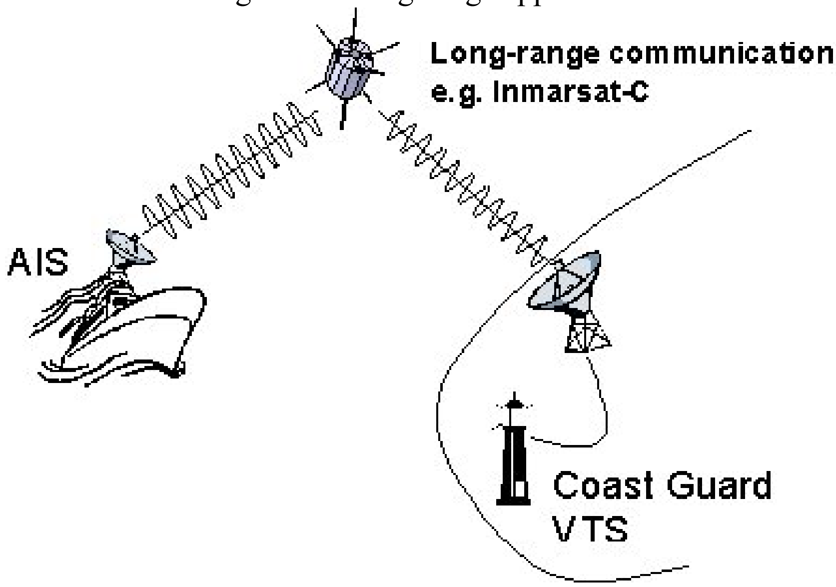


Figure 21.1

As stated above, the long-range mode requires a long-range communication medium. A maritime and/or public service provider will normally operate the long-range communication medium. Long-range AIS information exchange between that service provider and the VTS will be done by telephone lines or other communication means.

The applicable AIS standards do not specify the nature of this long-range communication medium. So an administration is free to choose a long-range communication system that can be easily interfaced to the AIS on board and that provide cost-effective services. For example, Inmarsat-C terminals, which are already carried by many vessels as part of their GMDSS obligations, can be candidates for this application. Also other satellite systems as well as the future UMTS service can take into account. However, most current Inmarsat-C terminals on board, as well as other shipborne long-range communication systems, do not support the IEC 61162-2 interface standard that has been adopted for AIS transponders and all future maritime onboard systems. Consequently, for long-range applications an active interface box is required that translates the long-range AIS 61162-2 messages to the required messages suitable for the chosen communication system and vice versa. This active interface can also gather information that may not be standard to AIS. This could be another information source on board a ship, if installed.

Figure 21.2 and Figure 21.3 are schematic representations of the interface requirement to a long-range communication medium. Figure 21.2 describes the ideal situation. However, as this ideal situation cannot be realised at this point in time, Figure 21.3 illustrates the recommended interim solution.

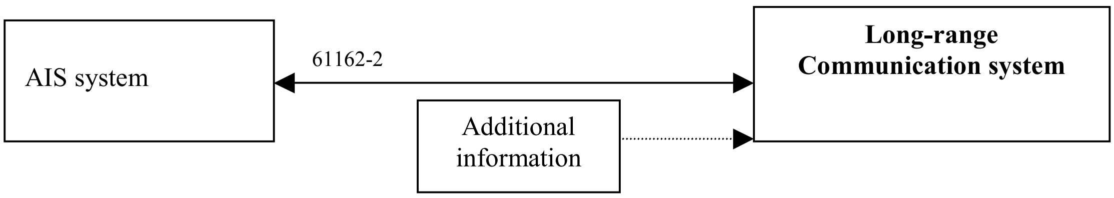


Figure 21.2

If no IEC 61162-2 interfaces exist for long-range communication systems, the following configuration can be used as an interim solution.

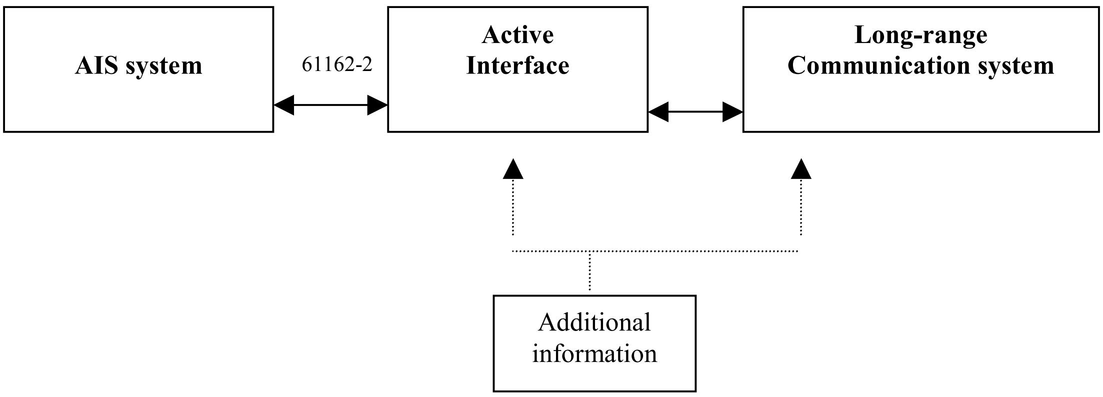


Figure 21.3

21.2 Messages between the AIS and the long-range communication system

Standardised IEC 61162-2 interfaces on the Class A AIS units are defined to communicate with the external long-range communication system.

21.2.1 Interrogation of the AIS

Long-range interrogation of AIS units is accomplished through the use of two IEC 61162-1 sentences - LRI and LRF. This pair of interrogation sentences provides the information needed by the AIS unit to determine if it must construct and provide the reply sentences - LR1, LR2, and LR3. The LRI-sentence contains the information needed to determine if the reply needs to be constructed. The LRF-sentence identifies the information that is being requested.
The information, that can be requested by the LRF-sentence, is shown in Table 21.1 (AIS Long-range Communications Input Data and Formats). These information items are the same as those defined in the table in chapter 7.5 of the operational part of this guideline. The letters shown in parenthesises are from IMO Resolution A.851 (20) and are used in the LRF-sentence. Details of these sentences are contained in IEC 61162-1.

Data	**IEC 61162-1 Sentences**
Long-range Interrogation Type of request Geographic area request AIS unit request	LRI - Long-range Interrogation
Long-range Function identification Requestor MMSI and Name Request for: Ship's name, call sign, and IMO number (A) Date and time of message composition (B) Position (C) Course over ground (E) Speed over ground (F) Destination and ETA (I) Draught (O) Ship / Cargo (P) Ship's length, breadth, and type (U) Number of persons on board (W)	LRF - Long-range Function Identification

Table 21.1 AIS Long-range Communications Input Data and Formats

21.2.2 Reply of the AIS

The long-range reply of the AIS unit is accomplished through the use of three IEC 61162-1 sentence formatters - LR1, LR2, and LR3. The AIS unit shall reply with the three sentences, in the order LR1, LR2, and LR3, when responding to an interrogation - even if all the information items in the sentence are ‘null’. The LR1-sentence identifies the destination for the reply and contains the information items requested by the "A" function identification character in the LRF-sentence. The LR2-sentence contains the information items requested by the "B, C, E, and F" function identification characters in the LRF-sentence. The LR3-sentence contains the information items requested by the "I, O, P, U and W" function identification characters in the LRF-sentence. The individual information items will be 'null' if any of the following conditions exist:

The information item was not requested in the LRF-sentence,
The information item was requested but is not available, or
The information item was requested but is not being provided.

The output data shown in Table 21.2 shall be provided when specifically requested by function identification characters contained in the preceding LRF-sentence portion of the interrogation. Details of these sentences are contained in IEC 61162-1.

Data	**IEC 61162-1 Sentences**
MMSI of Responder MMSI or Requestor Ship's Name Ship's call sign IMO Number	LR1 - Long-range Response, line 1
MMSI of Responder Date and time of message composition Position Course over ground Speed over ground	LR2 - Long-range Response, line 2
MMSI of Responder Destination and ETA Draught Ship / Cargo Ship's length, breadth, and type Number of persons on board	LR3 - Long-range Response, line 3

Table 21-2 LR Output Data Formats

21.3 Data exchange over the long-range communication system

Because the long-range communication system is not defined nor standardised, the communication over the long-range link is not defined. To make international use of the long-range application possible, at least the communication requirements and functional design will be described here.

21.3.1 Requirements

The long-range communication system must comply with the following minimal requirements:

- Suitable for data communication.
- Because the long-range mode will be initiated by a general-ships broadcast message directed to a specific geographically defined area, the system must be suitable to receive geographically defined calls or at least general calls. In the last case, the AIS will select the received interrogation message.

- MMSI number will address succeeding long-range interrogations, so the receiving onboard station must be able to select a MMSI number.
- The onboard receiver must be able to distinguish AIS messages in order to direct them to the AIS designed I/O port.
- If the onboard system is equipped with an IEC 61162-2 interface, the communication system must transfer the long-range data message from the communication link into long-range AIS messages as defined in IEC 61162-1 and vice versa.

21.3.2 Functional design

The functional design for long-range communication is strongly dependent of the communication medium in use. The communication system will normally use a shell to transfer the required data messages. Measures have to be taken for addressing the messages from the sender to the receiver. The following functional diagrams illustrate the long-range communication design.

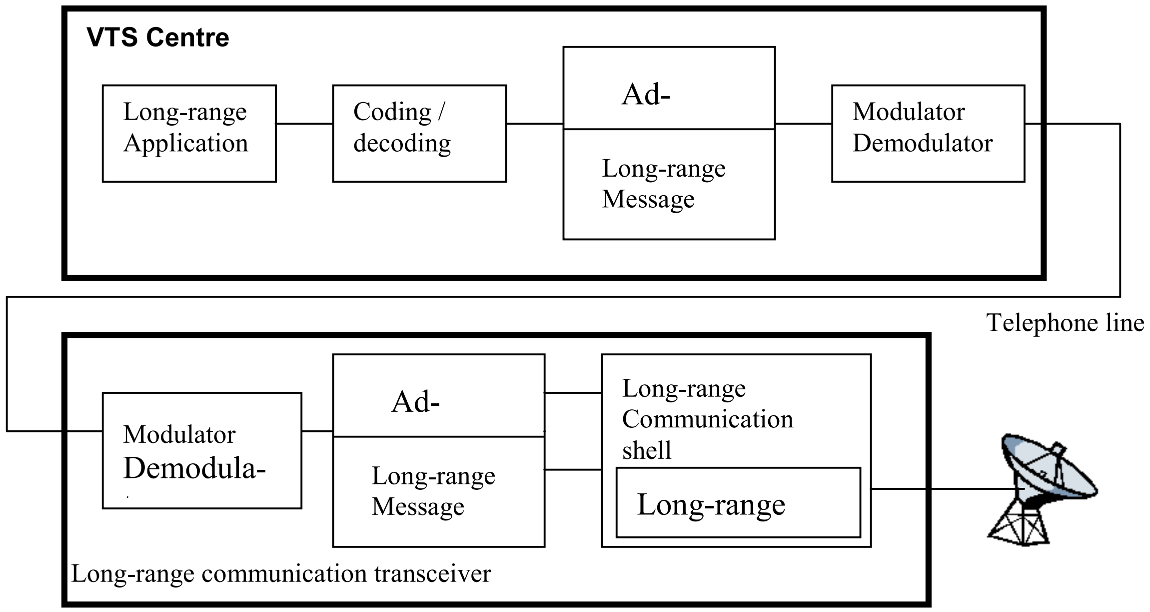


Figure 21.4: Shore-based functional set-up

In the VTS station a long-range application will manage the long-range AIS communication. Interrogations, geographical as well as addressed, will be coded to long-range messages together with the corresponding addresses. Via telephone lines this information will be transferred to a long-range transmitter/receiver station (e.g. an Inmarsat-C earth station). For the air transfer of the information, a communication shell will be required, depending of the communication system to be used. The long-range data and the address information are just elements of that shell.

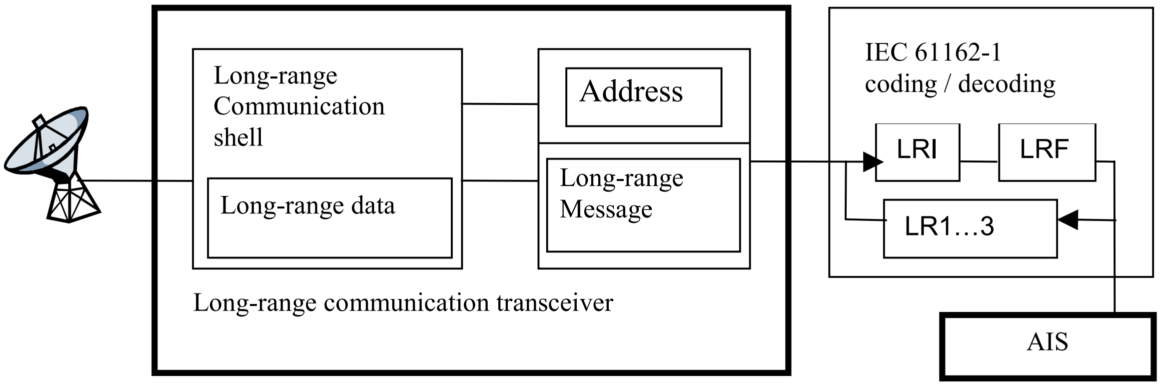


Figure 21.5: Functional set-up onboard

After receiving the message onboard, the long-range message and address information will be decoded from the shell. Now it is clear that the information is addressed to that particular vessel and its AIS system. The coding and decoding to IEC 61162-1 format of the long-range message can be an integral part of the long-range communication transceiver or a separate unit.

22. DGNSS Correction Transmission via AIS

22.1 Introduction

The introduction of Class A shipborne AIS stations as a mandatory shipborne equipment under SOLAS chapter V during from 2002 onwards will make this new on board equipment an important tool for the exchange of navigational data between ships and between ships and shore stations improving the safety of navigation. This also applies to voluntarily fitted Class B shipborne AIS stations as well.

Many administrations have implemented an IALA DGNSS MF Beacon System but the carriage of a DGNSS beacon receiver is not mandatory. This means that there can be both uncorrected GNSS and corrected DGNSS positions in an area. This serves to degrade the overall accuracy picture in the area.

In the AIS specifications, there is a provision for the Basic AIS Service **DGNS_COR**, which utilizes the AIS VDL message #17 designated for distribution of DGNSS corrections. The implementation of this BAS results in the broadcast of differential GNSS corrections from one or many AIS base station(s) on the AIS VDL to all mobile AIS stations in the vicinity.

The design of the shipborne AIS stations – both Class A and Class B – took into consideration the importance of using DGNSS correction data, either from IALA DGNSS MF beacon and / or by the AIS VDL, when available: By default and in accordance with IMO requirements, the Class A shipborne mobile AIS station will use the ship's own position sensor for position reporting by AIS, which is also used for navigation of the ship. <u>If</u> an internal GNSS receiver, which conforms to the applicable requirements of IMO and IEC for position sensors, is integrated in the design of the shipborne mobile AIS station, this internal GNSS receiver will be used for position reporting by AIS, <u>when</u> there is no external differentially corrected position source presented to the shipborne mobile AIS station <u>and</u> DGNSS corrections are available to the shipborne mobile AIS station from either IALA DGNSS MF beacons or via the AIS VDL. When both of these sources of DGNSS correction data are available to the shipborne mobile AIS station under these circumstances, the DGNSS corrections via the AIS VDL take precedence over MF beacon DGNSS corrections.

For Class A shipborne AIS stations, it is not mandatory to include an internal GNSS receiver, which conforms to the applicable requirements of IMO and IEC for position sensors. However, market surveys show that virtually all Class A shipborne AIS stations include such an internal GNSS receiver and are thus able to use a differential corrected position for position reporting, when correction data is available. As opposed to Class A, for Class B shipborne AIS stations, the provision of an internal GNSS receiver, which conforms to the applicable requirements of IMO and IEC for position sensors, is required in the appropriate IEC specification, because the provision of a quality position from an external position sensor to the Class B shipborne AIS station cannot be assumed.

Concluding, broadcasting differential GNSS corrections from an AIS shore station on the AIS VHF datalink to all mobile AIS stations enables virtually all Class A and

Class B recipients to navigate and to report with differential accuracy and meet the requirements of IMO Resolution A 915(22).

The purpose of this chapter is to look at some aspects of the service from the service provider's point of view, in particular coverage, integrity and channel occupancy. The effect on existing services (radiobeacon DGNSS) is also considered.

Provision of DGNSS via AIS, i. e. implementing the BAS DGNS_COR, is not mandatory. It is an additional service that may be provided by the local competent authority. On the other hand, this BAS may only be operated by the competent authority responsible for distribution of navigation signals such as DGNSS corrections.

22.2 Alternative system designs

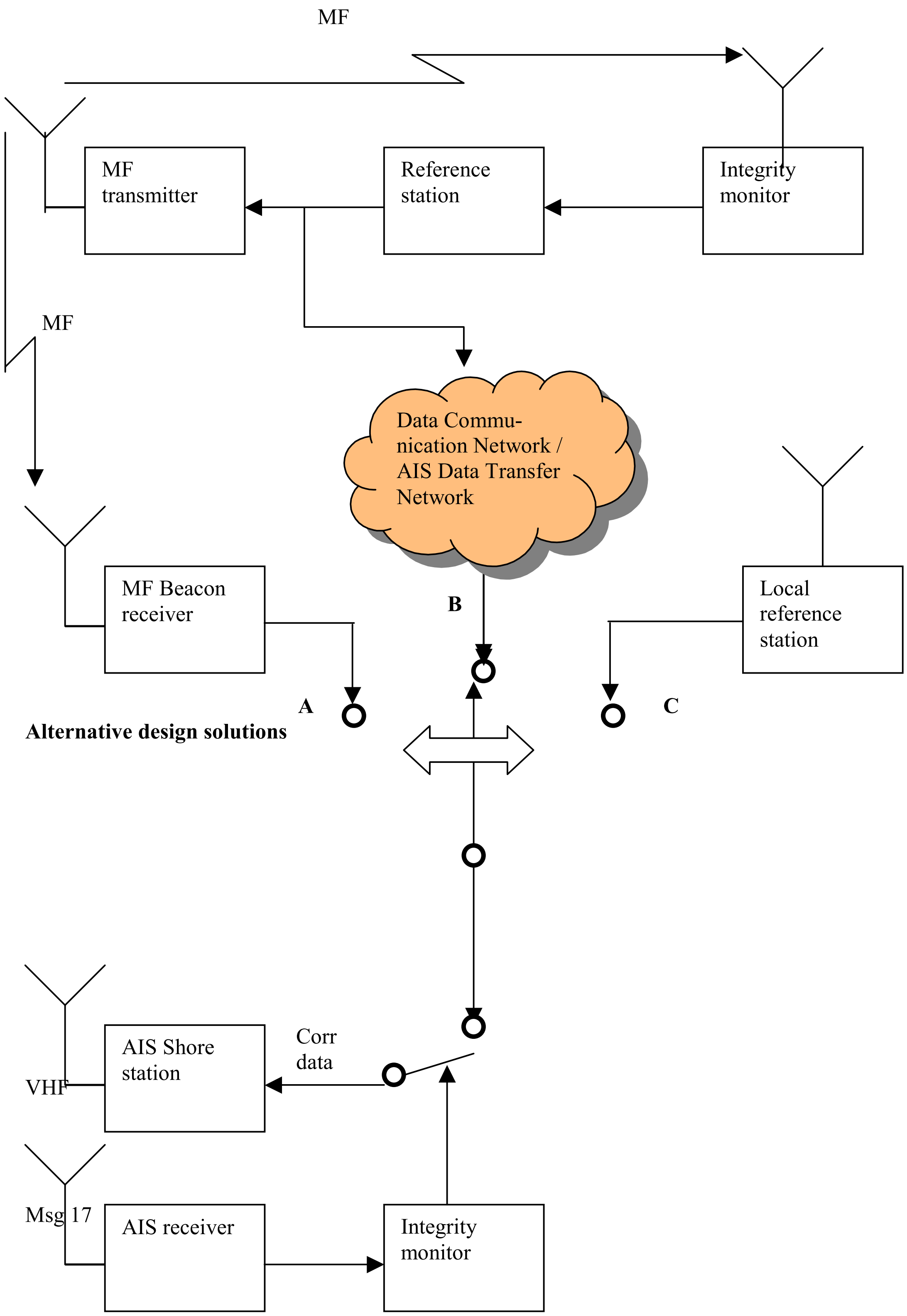
There are several different ways to obtain the DGNSS corrections to be transmitted. Three such alternatives are discussed here and indicated in Figure 22.1 as A, B and C. Alternative A and B has an existing MF beacon system as a precondition while alternative C can, from a technical point of view, be applied anywhere.

- Alternative A - the information (corrections) is transferred from the MF beacon reference station to the AIS shore station via the MF transmissions. The information is received at the AIS shore station by an MF beacon receiver and then retransmitted by the AIS shore station.
- Alternative B - the information is transferred to the AIS shore station via any telecommunication network.
- Alternative C - the corrections are generated locally by a local reference station at the AIS shore station.

In alternatives A and B the integrity of the corrections is checked at the MF beacon reference station, while alternative C requires local integrity monitoring. Corruption of the corrections during transmissions (Alt A and B) is considered to be highly unlikely, however a local integrity monitoring of the actually transmitted signal will add to the level of safety of the system.

Note: For simplicity's sake Figure 22.1 only shows the alternative sources in a simplified shore infrastructure setup. When setting up the concrete shore infrastructure of a competent authority the layered structure of the AIS Service needs to be taken into account.

Figure 22.1 Overview on alternative DGNSS correction sources when implementing BAS DGNS_COR



22.3 Coverage

It is obvious that VHF broadcasts have a much shorter range (< 40 M) than the MF broadcasts from radiobeacons (>150 M) or the wide area coverage of Eurofix or SBAS (WAAS, EGNOS). On the other hand the AIS shore stations are required to provide VHF coverage of important areas such as ports, port approaches and traffic separation schemes and these are the areas where DGNSS coverage will be most needed. It should be noted that the area for safe reception of AIS messages from an AIS shore station is considerable smaller than the nominal coverage area of the shore station. This is due to the fact that the transmissions from the shore stations may be interfered with by transmissions from ships outside the coverage area of the shore stations and thus will not take into account the slot reservations made by the shore station.

In general an MF beacon DGNSS station will serve the coverage areas of several AIS shore stations. Installation of dedicated reference stations at each shore station would substantially increase infrastructure costs, if the levels of redundancy and integrity monitoring provided in the MF system are to be matched.

22.4 Integrity

In the MF beacon system on-site integrity monitors are generally provided, so that the broadcast of erroneous data is effectively prevented. The status of the reference station is also provided in the message header, so that if it is unmonitored or unhealthy the user is notified almost immediately. These are essential functions of DGNSS and are also provided in slightly different ways by wide area systems such as SBAS and Eurofix. Any stand-alone DGNSS reference station used by an AIS shore-station (alternative C) would need integrity monitoring to the same standard.

The slow rate of degradation in applicability of corrections since SA was removed means that the integrity function now determines the rate at which messages should be broadcast. The Time To Alarm specified in IALA Recommendation R.121 is 10 seconds.

22.5 Channel Occupancy

The IALA Recommendation on AIS Shore Stations and Network Aspects related to the AIS Service, Annex B states:

> *"The reference receiver generates corrections with a high update rate. Normally a complete set of corrections is available each second.*
> *Dependent on the used communication link the data will be available at the AIS base station with a latency of 1 to 8 seconds (alternative A and B respectively). The AIS base station will transmit the AIS VDL Message 17 within 3 time slots with a repetition interval of ≤ 5 seconds. To fulfil the demands of integrity and accuracy it is important that the AIS base station will always use the most topical set of correction data that is available at that time."*

If the 10 second TTA from Rec. R.121 is considered, a suitable interval between each full set of corrections is 5 s. The number of slots occupied by a full set is 3 (256 bits per slot, 560 bits for 12 satellites) the channel occupancy by DGNSS from a shore station would be 0.6 slots per second or 0.8% of the total capacity on the two AIS channels. Neighbouring shore stations would be occupying different slots, so that the overall occupancy by DGNSS at any given spot could be 1-4%. The geographic validity of corrections is much wider than the coverage of a VHF Broadcast from a shore station, so it should only be necessary to broadcast corrections from one reference station at each shore station.

22.6 Effect on Other Systems

SBAS and Eurofix are aimed at sectors other than marine, so any effect on these systems of putting out DGNSS corrections on AIS may be considered negligible. However, the MF Beacon system is provided for exactly the same user base but, since the systems have quite different properties, they must be seen as complementary. The approach of using MF beacons as a source of DGNSS corrections has the advantage of avoiding any need for further regulatory action, since the MF broadcasts are fully covered by ITU and IEC recommendations and AIS has the SOLAS carriage requirement.

22.7 Recommendations

1. The shore authority implementing the BAS DGNS_COR should derive its correction data from existing MF beacon installations wherever possible, to minimise infrastructure costs.

2. A comparison between the alternative designs is given in the table below:

Criteria	Alternative A	Alternative B	Alternative C
Time to alarm	Longest	Medium	Shortest
Data transfer delay (to AIS station)	Longest	Medium	Shortest
Resulting Channel load	Highest (1)	Low	Low
Cost, investment	Low (2)	Low (2,3)	High
Cost, operation	Low	Medium	Low
Availability	Medium (5)	High (4)	High
Accuracy	Medium (5)	Medium (5)	High

(1) The time for data transfer and reporting needs to be less than 10 seconds in order to meet the TTA requirement. Therefore, the repetition interval needs to be of the order of 1-2 seconds resulting in increased channel load.
(2) If DGNSS MF Beacon system is available.
(3) If communication network is available
(4) Dependent on the quality of the network
(5) Depending on distance to MF Beacon Reference station (spatial decorrelation)

3. Alternative A is a low cost alternative with medium availability and the highest channel occupancy.

4. Occupancy of AIS channels by DGNSS broadcasts should be acceptable as long as a single correction source is used and corrections for one system are provided.

However the primary, reporting function of AIS must not be impaired and the total local load on the VDL must be considered. This can be ensured by using FATDMA allocated slots for transmission of the DGNSS correction data and by prudent planning of the FATDMA scheme employed by the competent authority (see appropriate chapter of these Guidelines).

22.8 Further information

Detailed information on the AIS shore infrastructure design relevant for the BAS DGNS_COR, in particular with regard to interfacing, can be obtained from the IALA Recommendation on AIS shore infrastructure and network aspects related to the AIS Service.

23. Aids to Navigation Functionality at a Base Station

Messages received at a base station, or into a base station network, from AIS AtoN units may be used by the shore infrastructure in various ways decided by the competetent authority, including the following:

- To provide information on AtoN position and status at a VTS or other traffic centre
- To provide information on AtoN position and status at an AtoN maintenance facility
- To provide information on weather, tide, sea state at an AtoN location.

This data may be displayed, stored, manipulated, or disseminated as required, outside the base station or base station network. Stored data may be used for subsequent analysis or for maintaining a legal record of AtoN status history.

As an option, an AIS base station may transmit message 21 (AtoN Report Message). The message will be initiated with a VDM sentence from higher layers. Refer also to Chapter 6 above.

As another option, an AIS base station may transmit a message 8 to an AtoN AIS station for control of an AtoN signal, such as a racon, marine traffic signal, or high intensity lighting.

24. Configuration considerations for the AIS Service

24.1 Introduction to Configuration Issues of the AIS Service

Up to this chapter the "building blocks" and principle capabilities of the AIS and the AIS Service of a competent authority have been described in generic terms. As introduced in the introduction chapter to Part E, there are two dimensions of configuration of the AIS Service of a competent authority. While the preceeding chapters focused on issues related to transfer the general AIS entities into a concrete environment of a competent authority, thereby configure the generic AIS entities to fit that concrete environment, this chapter focusses on how to configure the AIS Service of a competent authority *for run-time* in accordance with the fundamental technical principles and technical rule base adhered to during the development of the AIS.

This chapter builds in particular on the concepts and contents of the following parts and chapters:

a) Part A: General introduction, in particular the list of BAS and Figure 1.2 in Chapter 1
b) Part D, in particular Chapters 12 (LSS functionality) and 13 (ASM functionality)

This chapter may create the impression, that most issues addressed would be relevant only for "larger" AIS Services, and "smaller" AIS Services are not required to consider this issues. In this regard "smaller" and "larger" can be understood in terms of numbers of shore stations, degree of internal and external connectivity, or coverage area. While the complexity of a "larger" AIS Service increases with the number of shore stations and its internal and external connectivity, *the complexity of an AIS Service is mainly determined by the range of functionality it provides*. Therefore, even "smaller" AIS Services may recognize the need to consider the issues introduced in this chapter, once these "smaller" AIS Services provide a large range of functionality.

For the present state of the development of the AIS, this chapter must remain incomplete. Therefore, identified issues can only be highlighted, and questions can only be raised. However, *this chapter will eventually constitute the "best international practise" in regard to the run-time configuration of an AIS Service of a competent authority.*

24.2 The Configuration of an AIS Service and the Internal Basic AIS Services

Within the definition of the AIS VDL as given in Recommendation ITU-R M.1371-1 (and as clarified by the IALA "Technical Clarifications on Recommendation ITU-R M.1371-1") certain functionalities are labeled "functional" and / or "system management" (refer to Table 13 of above Recommendation, as clarified). The concept of the Basic AIS Services has been introduced, amongst other reasons, to tackle complexity when planning and operating an AIS Service. This holds true in particular in regard to configuration and run-time management.

Therefore, there are defined "external" BAS which, in general, correspond with the "functional" capabilities of the AIS, and "internal" BAS which correspond with its "system management" capabilities. As "system management" implies, some "internal"

BAS may be needed to properly provide any or all "external" BAS in a given concrete environment of an AIS Service. Therefore, depending on the concrete environment of an AIS Service *the proper configuration of these "internal" BAS may be essential to the delivery of "external" BAS*.

24.3 The Configuration of an AIS Service and its layered structure

While it is expected that most of the run-time configuration can be dealt with automatically in line with the general concept of the AIS as a hands-off system, there may be circumstances, where manual, i. e. human interaction, with the AIS Service of a competent authority would be required. This holds true in particular with the "internal" BAS: Their proper operation must be guaranteed and confined within the framework of the AIS Service; higher levels such as integration into VTS (compare Figure 1.1 in Chapter 1), would be neither interested nor capable to deal with the configuration details and the various run-time states of the AIS Service.

While each intermediate layer of the AIS Service layer stack (compare Figure 1.2 in Chapter 2) would allow treatment of certain run-time aspects of the AIS Service, and while the AIS Service concept was *designed to treat those run-time aspects at the lowest possible layer*, *there may be run-time conditions which would end up at the AIS Service Management level* (which is why the name was chosen): "The buck stops with the ASM". Because of the ultimate need for human interaction, the Human-Machine-Interface of the ASM would become an important entity within the AIS Service of a competent authority.

The allocation of run-time configuration functionality to certain layers of the AIS Service will be detailed in a future edition. Presently there is already a broad functionality designation, including configuration functionality, in the Chapters 12 (Logical Shore Station layer) and 13 (ASM layer).

24.4 Minimum Service Configuration of an AIS Service of a Competent Authority

After having presented the overview on most of the options for a competent authority to configure its AIS Service, the following questions arise:

- Is there a "minimum" service configuration of external / internal BAS, which are essential to even the most essential AIS Service, a competent authority could ever possibly provide?
- What combination of external / internal BAS does constitute this "minimum"?
- Many competent authorities would not stay with the "minimum" service configuration for various reasons. Hence, what would be the "next higher levels" above the "minimum" configuration in terms of configuration of external / internal BAS?
- Is there a way of internationally and comparable defining these "next higher levels"?
- Is there a "maximum" configuration? And what does it constitute?
- Between the "minimum" and the "maximum" service configuration, is there a logical "tree" of configuration levels? I. e. once a competent authority decides that a certain configuration level is required for its AIS Service what options remain for enhancing the configuration of its AIS Service level at some future time? (This question is based on the fact, that what may be sophisticated and therefore

"higher" for one administration may be a necessary minimum for an other administration.)

This section will address these issues in a future edition.

24.5 The Concept of Service Levels

A way to achieve the goal introduced by the previous section may be the definition of Service Levels. A Service Level would then comprise a set of internal / external BAS supported by the AIS Service in the area of responsibility of the competent authority. The Service Level definitions could be structured in accordance with the "logical tree" concepts introduced in the section above and could be labeled in accordance with their relative position in that tree.

A first crude approach for different Service Level definitions could be: "Listen-Only-AIS-Service"; "Rudimentary-Transmit-Capability-AIS-Service"; "Intermediate Transmit Capability AIS-Service"; "All BAS supported AIS-Service"

Different competent authorities may wish to provide different Service Levels to the maritime community in their respective area of responsibility. Similar to other maritime information services, eventually, there will be a general requirement to publish the AIS-related services supported by a competent authority in its respective area. To publish the Service Level Provided, e. g. as Notices to Mariners, would be a simple and uniform way to convey to the mariner an overall idea of the AIS-related services provided (By analogy, compare the Categories I, II, III for the services supporting final approach and landing of aircrafts in civil aviation.)

The concept of AIS Service Levels may also be helpful when considering initialization, fall-back and termination processes of an AIS Service of a competent authority as a whole. The result of such a consideration may be the requirement, that an AIS Service should never drop below a certain AIS Service Level again, after it has been started once. This in turn would result in concrete technical requirements in regard to the reliability of the AIS Service as a whole.

Also, reliability of an AIS Service may be expressed in terms of AIS Service Levels Provided.

This section will address these issues in a future edition.

24.6 The General and the Default Run-time Configuration of an AIS Service as a whole

While the above sections dealt with the necessary or possible prerequisites and possible concepts to do run-time configuration as well as with the various dimensions of configuration options, *the concrete run-time configuration settings, as such, should now be considered*.

Of particular interest are a) general run-time configuration considerations of an AIS Service as a whole and b) special run-time configuration considerations of individual BAS.

With regard to the run-time considerations of an AIS Service as a whole (general), the following questions arise:

- Is there such a thing as a internationally recommended default run-time configuration for the AIS Services of all competent authorities, which would be independent of AIS Service Level Provided? I.e. is there a default run-time configuration, an AIS Service as a whole would start its technical operation from and to which it would return upon "reset"?
- If so, how would it look like?
- If not, would there be internationally recommended default run-time configurations for individual AIS Service Levels, at least? I.e. is there a default run-time configuration, a given AIS Service Level would start its technical operation from and to which it would return upon "reset"?
- If so, how would they look like?

This section will address these issues in a future edition.

24.7 Special Run-time Configuration Considerations

While the above sections would introduce more summary concepts, considerations to special run-time configurations should be given to individual external and internal BAS:

Considerations with regard to the Special Run-time Configuration of the external BAS INT_TDMA
Considerations with regard to the Special Run-time Configuration of the external BAS INT_DSC
Considerations with regard to the Special Run-time Configuration of the external BAS ATON_DAT
Considerations with regard to the Special Run-time Configuration of the internal BAS BASE_DAT
Considerations with regard to the Special Run-time Configuration of the Internal BAS FATDMA
Considerations with regard to the Special Run-time Configuration of the Internal BAS ASGN_RATE
Considerations with regard to the Special Run-Time Configuration of the Internal BAS ASGN_SLOT
Considerations with regard to the Special Run-Time Configuration of the Internal BAS DGNS_COR
Considerations with regard to the Special Run-Time Configuration of the Internal BAS related to Channel Management (CH_TDMA; CH_DSC; PWR_LEV)

This section will address these issues in a future edition.

24.8 Mutual exclusive Run-Time Configuration settings of different BAS

During the development of the AIS it was discovered that some BAS may be mutual exclusive at least in part or when employing certain run-time configurations. Therefore, great care should be taken when combining run-time configuration settings.

The following list provides some of these combinations where this was already discovered:

- FATDMA and ASGN_SLOT
- CH_TDMA and CH_DSC
- CH_TDMA or CH_DSC and ASGN_SLOT
- (list may not be complete)

The cautionary statements in regard to run-time configuration, when employing these BAS simultaneously, will be included in a future edition of this document.

Part F: Introduction to the Idea of the Basic AIS Services (BAS)

25. Basic AIS Services (BAS)

25.1 Introduction

The purpose and functions of the AIS can be expressed in terms of services provided to the recipient. The most fundamental services of the AIS are called Basic AIS Services (BAS). They support higher levels above the AIS Service as such (refer to Figure 1.1 in Chapter 1) and applications using these services. The BAS make use of the diverse features of the AIS VDL(as described in Recommendation ITU-R M.1371-1 in connection with the IALA Recommendation on Technical Clarifications of Recommendation ITU-R M.1371-1) and the diverse features of the different AIS stations. Throughout the previous chapters the concept of the BAS together with some of their benefits have been mentioned. This chapter provides a summary introduction.

The detailed description of the Basic AIS Services as such will be contained in Vol. II of these Guidelines, which will be available in a future edition.

25.2 Subdivision of the Basic AIS Services

The BAS are subdivided into "external" and "internal". The "external" BAS are those BAS which deliver net information from and to ships and shipboard applications, the direction of the data flow depending on the nature of the BAS.

The "internal" BAS are those which are needed in particular to perform the "system management" functionality as defined by Recommendation ITU-R M.1371-1, Annex 2, Table 13. They do not deliver net information about ships and shipboard applications, but some "internal" BAS may be needed to provide "external" BAS at all under certain circumstances. The "internal" BAS are contained and managed within the AIS Service and may be triggered and / or configured by higher levels of shore-based infrastructure.

A list of "external" and "internal" BAS is given in Chapter 1. All available BAS will be described in detail in the IALA AIS Guidelines (Vol. II, from Edition 1.2).

25.3 Motivation for the description of the Basic AIS Services

The description of the Basic AIS Services can serve the following purposes.

25.3.1 The Basic AIS Services as the interface between operational and technical considerations

"External" BAS produce, transfer, and accept information to and from higher levels that are not themselves part of the AIS Service. The functionality of higher level services and AIS applications are built upon the capabilities of these services. This is illustrated by Figure 1.1 in Chapter 1 and by Figure 25.1 below.

The "external" BAS are the services the AIS Service delivers to *the recipient's side ashore* at the interface between the AIS Service and "higher", application-oriented levels. Therefore, their description also takes into account the processing at the fixed

AIS stations, the Physical AIS Shore Station (PSS), the Logical AIS Shore Stations (LSS), and the AIS Service Management (ASM).

Therefore, the BAS are also the basis for an assessment of the usefulness of the AIS Service for a particular intended application in terms of accuracy, frequency, reliability etc.

25.3.2 The Basic AIS Services as a means to convey consistent relevant information from the recipient's point of view

When making use of the potential of the AIS by setting up an AIS shore infrastructure, which is integrated into e. g. a VTS environment, the VTS (re-)designer, who formerly had not been involved in shipborne equipment issues at all, will now need to receive and use information on the AIS shipborne installation, its shipborne information sources and also the shipborne information sinks *in addition* to the knowledge on shore installations as explained in previous chapter.

This is due to the fact, that the introduction of the AIS as an automated, co-operative system triggers the integration of shipborne and VTS technologies, which formerly existed more or less independently of each other. The same applies – in principle, but more on an operational level with less technical sophistication – to the VTS operator(s).

The situation is further complicated by the fact, that relevant information is distributed in a variety of relevant documents, the number of which may still be growing and which are maintained by various international or regional organisations. This was illustrated in Chapter 2. It becomes obvious that it may be difficult to identify all relevant documents for a particular issue at hand, keep track of them or even control them to reflect the intent and current status of the AIS.

The BAS description aim at making available *every relevant* information for a given issue at hand for a system (re-)designer using the AIS Service.

This description of the BAS does not make redundant the referenced documents, i.e. the appropriate international standards, nor do they introduce new system features. However, each description of a BAS integrates, in a comprehensive and highly accurate manner, all information items from various sources into functional terms that are essential to understand what this BAS is delivering.

25.3.3 The Basic AIS Services as the functional, technical interface between the AIS Service and higher technical levels

Besides being the means to assess the operational usefulness and features of the AIS Service to higher levels and applications, the BAS – in their precise technical description – constitute the functional, technical interface between the AIS Service and higher technical levels. This is indicated in Figure 25.1 in regard to the only physical accesssible interface between the higher levels, applications, and the AIS data transfer network. For the same reason, the BAS constitute the major use cases of the Logical AIS Shore Station layer (refer to Chapter 12).

25.3.4 The Basic AIS Services as a means to encapsulate complexity

The BAS descriptions are also the basis for an assessment of the characteristics of a particular AIS service for a particular intended application in terms of accuracy, frequency, reliability, fallback arrangements etc. An individual BAS, considered as one consistent and prudently partitioned set of functionality of the whole AIS Service may be investigated on its own, thus allowing a concentrated assessment of this particular functionality.

This holds true although there are interactions between certain BAS. Since these interactions will be clearly identified, they may be considered one by one, instead of being overwhelmed by the sheer complexity of the AIS Service as a whole.

25.3.5 The Basic AIS Services as a means to understand and handle complex configuration states of the AIS Service as a whole

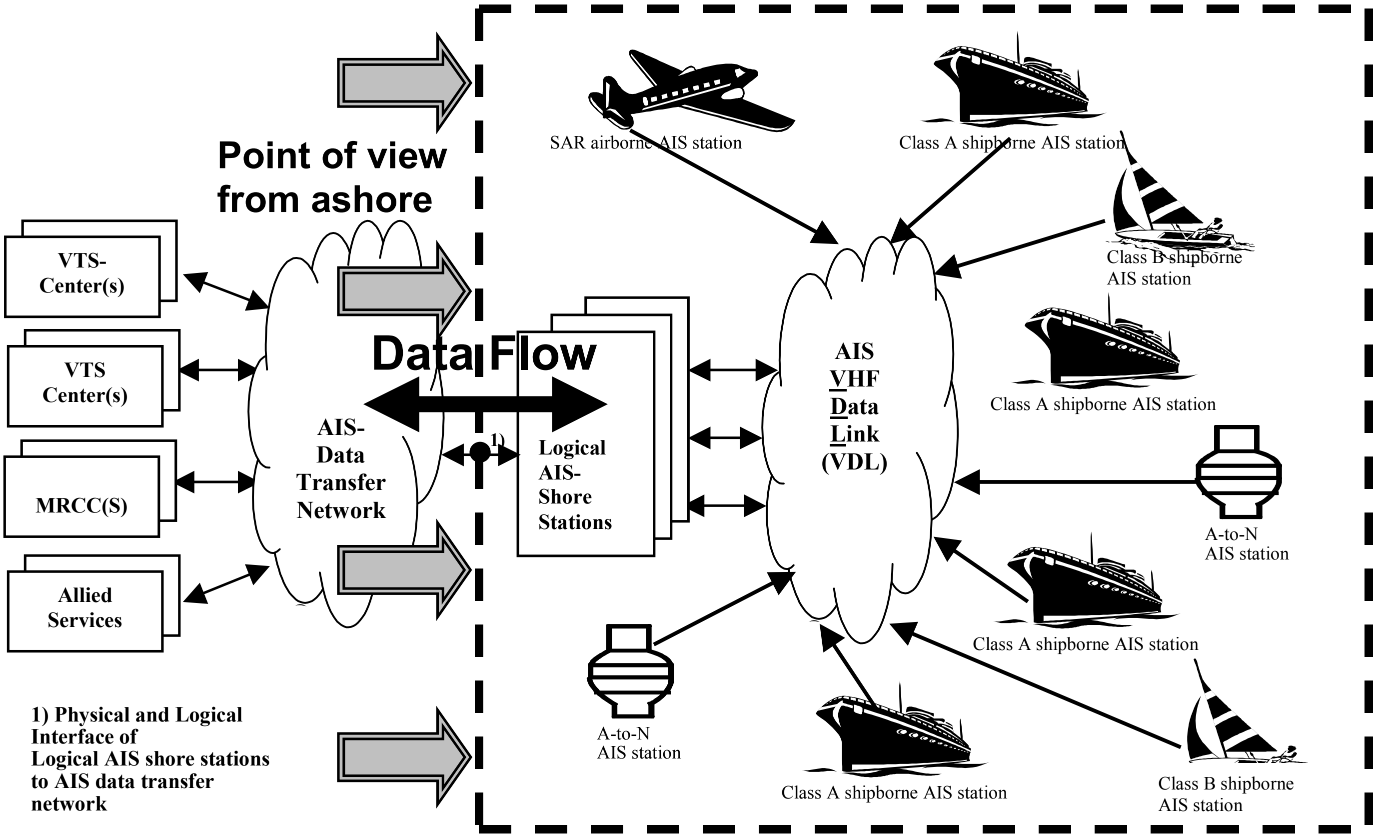
As introduced in [new] Chapter 24 [was Chapter 18], the BAS may also serve as a convenient means to understand and handle complex configuration states of the AIS Service as a whole because of the above features of the BAS, in particular because they encapsulate complexity.

25.4 Concluding remarks

As such, Volume II will be of benefit to manufacturers, system integrators, and users alike. It provides a basic understanding of what services AIS can deliver. What services it cannot deliver, and what are the proper conditions under which the service can be used. It will describe the basic AIS services that support the design of AIS based applications that directly serve the needs of the mariner, vessel traffic service, and littoral state.

The BAS are described in a common format.

Figure 25.1: The Idea of the Basic AIS Service (BAS) descriptions



ANNEX 1

Abbreviations / acronyms

AIS	Universal Shipborne Automatic Identification System
AIS 1	161.975 MHz (87b – 2087)
AIS 2	162.025 MHz (88b – 2088)
ARPA	Automatic Radar Plotting Aid
ASCII	American Standard Code for Information Interchange
ASM	AIS Service Management
ATA	Automatic Tracking Aid
AtoN	Aid to Navigation
AUSREP	Australian Reporting system
AWP	Advised Waypoints
BAS	Basic AIS Services
BIIT	Built-in Integrity Test
BIOS	Basic Input/output System
COG	Course over Ground
COLREGS	IMO Collision avoidance Regulations
CPA	Closest Point of Approach
DAC	Designated Area Code
DG	Dangerous Goods
DGNSS	Differential Global Navigation Satellite Service
DSC	Digital Selective Calling
DTE	Data Terminal Equipment
ECDIS	Electronic Chart Display and Information System
ECS	Electronic Chart System
EEZ	Exclusive Economic Zone
EPFD	Electronic Position Fixing Device
EPFS	Electronic Position Fixing System
ETA	Estimated Time of Arrival
FATDMA	Fixed Access Time Division Multiple Access?
FI	Function Identifier
GLONASS	Global Navigation Satellite Service
GMDSS	Global Maritime Distress and Safety System
GNSS	Global Navigation Satellite Service
GPS	Global Positioning System
Gyro	Gyrocompass
HDG	Heading
Hex	Hexadecimal
HS	Harmful Substances
HSC	High Speed Craft
IAI	International Application Identifier
IBS	Integrated Bridge System
ID	Identification, Identifier
IEC	International Electrotechnical Commission
IFI	International Function Identifier
IFM	International Function Message
IMO	International Maritime Organisation
INS	Integrated Navigation System
ITDMA	Incremental Time Division Multiple Access
ITU	International Telecommunications Union
ITU-R	International Telecommunications Union – Radiocommunications Bureaux
Loran-C	Long-range Navigation (version C)
LSS	Logical AIS Shore Station
MF	Medium Frequency
MID	Maritime Identification Digits
MKD	Minimum Keyboard and Display
MMI	Man Machine Interface
MMSI	Maritime Mobile Service Identity

MP	Marine Pollutants
MSC	IMO Maritime Safety Committee
NMEA	National Marine Electronics Association
NUC	Not Under Command
NWP	Next Waypoint
OOW	Officer Of the Watch
PC	Personal Computer
PI	Presentation Interface
PPU	Personal Pilot Unit
PSS	Physical AIS Shore Station
RAI	Regional Application Identifier
RAIM	Receiver Autonomous Integrity Monitoring
RCC	Rescue Coordination Centre
REEFREP	Great Barrier Reef & Torres Strait ship reporting system
RF	Radio Frequency
RIATM	Restricted In Ability To Manoeuvre
ROT	Rate of Turn
Rx	Receiver / receive
SAR	Search And Rescue
SME	Shipborne Mobile Equipment
SOG	Speed Over Ground
SOLAS	Safety Of Life At Sea
SOTDMA	Self Organising Time Division Multiple Access
SRS	Ship Reporting System
TCPA	Time to Closest Point of Approach
TDMA	Time Division Multiple Access
TEZ	Tanker Exclusion Zone
TSS	Traffic Separation Scheme
Tx	Transmitter / transmit
UMTS	Universal Mobile Telecommunication System
UTC	Universal Time Coordinated
VDL	VHF Data Link
VDM	VHF Data Message
VDO	VHF Data-link Own-vessel Message
VHF	Very High Frequency
VTS	Vessel Traffic Services
WGS84	World Geodetic Survey 1984
WIG	Wing In Ground
WRC	World Radiocommunication Conference