Document Revisions (Title style)

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**Working towards**

**IALA Guideline No. ####**

**On**

**VHF Data Exchange System (VDES)**

**Edition 1**

**[Date issued]**

**[Previous Edition; Date issued]**

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

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VHF Data Exchange System (VDES)

# Introduction

VHF VHF Data Exchange System (VDES) is a technological concept developed by the IALA e-NAV Committee and now widely discussed at ITU, IMO and other organizations. VDES was originally developed to address emerging indications of overload of VHF Data Link (VDL) of AIS and simultaneously enabling a wider seamless data exchange for e-navigation, potentially supporting the modernization of GMDSS, both processes that are currently developed by IMO. VDES is capable of facilitating numerous applications for safety and security of navigation, protection of marine environment, efficiency of shipping and others. VDES will prospectively have a significant beneficial impact on the maritime information services including Aids to Navigation and VTS in the future. IALA is ideally positioned to coordinate and harmonize the development and implementation of VDES, for benefit of the whole maritime world.

# Background

The purpose of this information paper is to inform IALA Members of VDES, its purpose, the ongoing development of plans and progress in order to consider this opportunity and better utilize it for their future work.

# RATIONALE OF VDES

AIS is now well recognized and accepted as an important tool for safety of navigation and is a carriage requirement for SOLAS vessels (Class-A). However, because of its effective and useful technology, the use of AIS is expanded to vessels not complied with the carriage requirement (Class-B) and other applications such as Aids to Navigation (AtoN), Application Specific Messages (ASM), Search and Rescue Transmitter (SART), Man Over-Board unit (MOB) and EPIRB-AIS. This expanding use of AIS technology has caused significant increase in VHF Data Link (VDL) loading which has become an active concern in IMO and ITU.

Simultaneously, because of increasing demand of radio spectrum for digital communication such as mobile phone and data, ITU now requests more efficient and effective use of radio spectrum. In 2009, ITU issued Recommendation ITU-R M.1842-1 “Characteristics of VHF radio systems and equipment for the exchange of data and electronic mail in the maritime mobile service RR Appendix 18 channels.” This technique will provide higher data rates (up to 32X) than the present AIS and will become core element of VDES. Furthermore VDES network protocol should be optimized for data communication so that each VDES message is transmitted with a very high confidence of reception. Consequently VDES will allow more efficient and effective use of marine VHF spectrum.

Considering this, the World Radio Conference of 2012 (WRC-12) adopted Resolution 360 [COM6/21] (WRC-12) “Consideration of regulatory provisions and spectrum allocation for enhanced Automatic Identification System technology applications and for enhanced maritime radiocommunication” and decided to discuss the matter at WRC-15 under agenda item 1.16.

According to IALA Recommendation A-124 Appendix 18 “VDL Loading Management”, if the VDL loading exceeds 50%, it may have an impact on smooth transmission of AIS station**[[1]](#footnote-1)**. In an ITU-R WP5B meeting (May 2013) it was reported that the VDL loading was already exceeded 64% in the Northern Gulf of Mexico, USA, and was also reached almost 40% in Korea and Japan. It is therefore urgently necessary to allocate new frequencies for new and emerging applications of AIS technology in order to mitigate overloading of AIS VDL.

E-navigation is defined by IMO as “the harmonized collection, integration, exchange, presentation and analysis of marine information onboard and ashore by electronic means to enhance berth to berth navigation and related services for safety and security at sea and protection of the marine environment.” IMO is now developing an e-navigation strategy implementation plan with a target completion year for the plan of 2014. Simultaneously, IMO is conducting a review and modernization of GMDSS with a target completion year of 2018. In the discussion of both matters, one of the common key elements is exchange of information and this will be achieved possibly by digital data exchange.

Digital data exchange can be achieved using a whole multitude of commercially available data links, however global availability and interoperability is an issue. Since VDES is an opportunity for a globally interoperable capability of significantly higher speed and larger volume data exchange than AIS or DSC, and potentially with world wide coverage via Satellite, VDES can become one of core facilitating elements for both implementation of e-navigation and modernization of GMDSS.

One of the short term transition measures to protect the original purpose of AIS could be a migration of ASM from AIS 1 and 2 channels to ASM 1 and 2 channels. The main rationale for the development of VDES is to avoid overloading of AIS VDL and hence to protect AIS main function of safety of navigation. Thereby the AIS 1 and 2 channels will be solely allocated for navigational safety purposes. Other supplemental messages, i.e. ASM such as weather info, could be moved to ASM 1 and 2 channels. AtoN authorities now broadcasting ASM using AIS 1 and 2 channels should consider to use the new frequencies, ASM 1& 2 and IALA will coordinate and provide guidance for the transition in the form of a recommendation on intermediate transition measures, until a full VDES system can be in place.

Since VDES has higher speed and robust data exchange capability with potential for worldwide coverage, there may be numerous benefits to AtoN services and VTS. Virtual AtoN could be deployed beyond a limit of VHF range such as the high seas, or remote/polar areas. VTS could exchange more comprehensive data with ships than the present AIS can provide. Machine readable digital data will enable a navigational display to portray navigational safety information graphically, assisting to overcome language barriers between VTS operator and mariners. AtoN authorities will be able to develop various applications for their use and make advanced services available to ship using VDES. IALA will coordinate and harmonize development and implementation of such applications.

However, just like new applications of AIS, e.g. class B AIS, AIS AtoN, ASM, AIS SART, AIS MOB, EPIRB-AIS and multitude of international and regional ASM, were rapidly and easily developed, generating a risk of overloading of AIS VDL, new VDES applications will be developed easily and rapidly not only by AtoN authorities but also other actors. There is a risk that such rapid expansion of VDES applications could cause confusion in the maritime society and the data links quickly reach their capacity limits. Therefore, there will be need of an international body that will monitor, coordinate and control if necessary, the development and implementation of VDES applications. IALA is in a good position to undertake the task of monitoring, coordinating and harmonizing the evolving applications, while IMO is capable of imposing relevant control measures where needed.

# ROAD MAP

It is anticipated that VDES may be implemented in two parts, terrestrial VDES and satellite VDES. Some radio manufactures have already started to develop the prototype VDE transceivers, based on Recommendation ITU-R M.1842-1. Such prototypes will be available to support testing in 2014. If WRC-15 approves to allocate new frequencies for VDES, because of the present technical development and urgency of protection of AIS VDL, terrestrial VDES could be implemented first, even before satellite assets are available, as satellite launches require larger timeframes – yet initiatives are underway to facilitate demonstration missions. Theoretical studies, for example, sharing study for land mobile stations of VHF, are underway in ITU. It is expected that such studies will be completed during the development of the ITU Recommendations for VDES so that a fully featured VDES including the satellite aspects can be facilitated by approximately 2018.

Figure 1 provides a possible roadmap for the development of VDES.

ANNEX D provides considerations on a possible roadmap for transition between different stages of operational availability – and the requirements to the system, that can be derived to support transition phases.

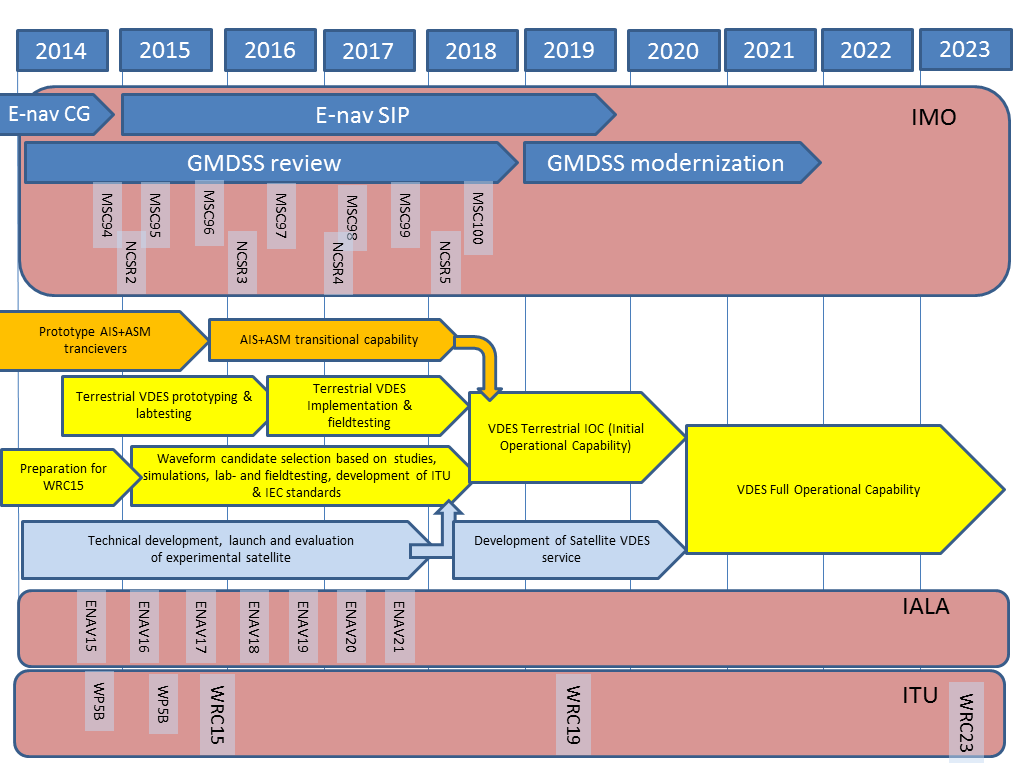


Figure 1 - Possible Roadmap for the development of VDES

# TECHNICAL FEATURES

The IALA e-NAV Committee and ITU-R WP5B have developed the concept of VDES. The VDES integrates the function of AIS, ASM and VDE and includes the channels for these functions with satellite transmission and reception. A proposed arrangement of the globally available channels and usage is shown in Table 1. Further studies and testing will be required for a final arrangement of the channels.

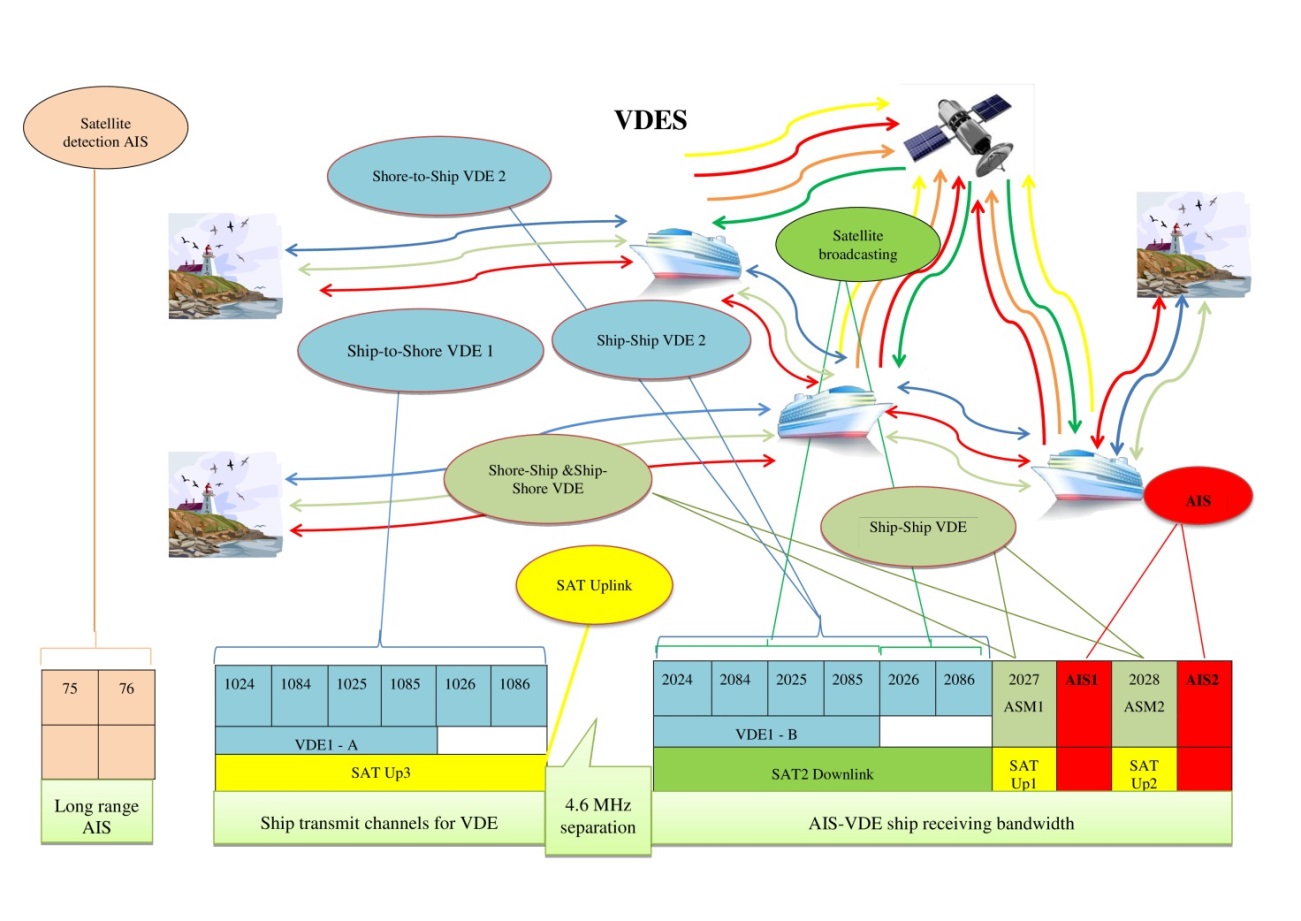
Table 1

RR Appendix 18 channels for VDES applications: AIS, ASM, VDE

|  |  |  |  |
| --- | --- | --- | --- |
| RR Appendix 18 channel number | | Transmitting frequencies (MHz) | |
|  | | Ship stations (ship-to-shore)  (long range AIS)  Ship stations (ship-to-satellite) | Coast stations  Ship stations (ship-to-ship)  Satellite-to-ship |
| AIS 1 | | 161.975 | 161.975 |
| AIS 2 | | 162.025 | 162.025 |
| 75 (long range AIS) | | 156.775 (ships are Tx only) | N/A |
| 76 (long range AIS) | | 156.825 (ships are Tx only) | N/A |
| 2027 (ASM 1) | | 161.950 (2027) | 161.950 (2027) |
| 2028 (ASM 2) | | 162.000 (2028) | 162.000 (2028) |
| 24/84/25/85 (VDE 1)  24  84  25  85 | 24/84/25/85/26/86 (Ship-satellite, satellite-ship)  24  84  25  85  26  86 | 100/150 kHz channel  (24/84/25/85, lower legs (VDE1-A) merged) Ship-to-shore  (24/84/25/85/26/86,) Ship-to-satellite | 100/150 kHz channel  (24/84/25/85, upper legs (VDE1-B) merged) Ship-to-ship, Shore-to-ship (24/84/25/85/26/86,) Satellite-to-ship |
| 157.200 (1024) | 161.800 (2024) |
| 157.225 (1084) | 161.825 (2084) |
| 157.250 (1025) | 161.850 (2025) |
| 157.275 (1085) | 161.875 (2085) |
| 157.300 (1026) | 161.900 (2026) |
| 157.325 (1086) | 161.925 (2086) |

# FUNCTIONALITIES

Since VDES is designed for higher data exchange capability than AIS with worldwide coverage, various functionalities can be considered. The radio links enabled by robust VDES and their use by ships, shore stations and satellites are illustrated pictorially in Figure 1.



**Figure x: VDES radio links**

Table 2 provides a summary of the proposed technical assignment of various VHF channels for communication including protocol and types of messages to meet the functionality required by user needs.

# CONCLUSIONS

Just as internet has changed the world drastically, e-navigation will have a significant impact on the maritime community, and VDES may be the globally interoperable key to the introduction of e-navigation. Its capability of higher speed digital data exchange with potential for world wide coverage may pave the way for implementation of e-navigation and modernization of GMDSS. However, just as internet has not only had good effects but also adverse side-effects, the development and implementation of VDES must be undertaken with great caution, or it is at risk of causing confusion and jeopardizing the safety of navigation. IALA is ideally positioned to coordinate and harmonize the development and implementation of VDES, just like IALA did with AIS, in cooperation with other international organizations, for the benefit to the whole maritime world.

1. Technical Guidelines for VDES Implementation
2. **The History of Data Transmission in the VHF Marine Band**

The VHF marine band (Appendix 18 of the International Radio Regulations) was initially used for transmission of voice communications by FM (frequency modulation of the carrier) on 25 kHz channels, which is the most-inefficient means of communications in the international maritime service because voice speech is slow and lacks intelligibility, especially with varying languages and accents in the noisy marine radio environment. For this reason, the ITU (International Communications Union) introduced the first marine data transmission system, DSC (Digital Selective Calling) in accordance with Recommendation ITU-R M.493, to help ensure that calling and distress communications attempts were successful. VHF DSC transmits data at 1200 bits per second using digital two-tone FSK modulation, slow by modern data standards, but very robust. At the request of the IMO (International Maritime Organization), to improve safety of navigation, ITU introduced another VHF data transmission system, the AIS (Automatic Identification System) in accordance with Recommendation ITU-R M.1371, which provides navigation and identification data for ships, shore stations, aids to navigation and search and rescue devices at 9600 bits per second using digital GMSK modulation. At the request of some Administrations, to improve spectrum efficiency for VHF Data Exchange (VDE), ITU introduced a standard, Recommendation ITU-R M.1842, with options for 25 kHz, 50 kHz and 100 kHz channels at data rates up to 307.2 kbps using digital modulation waveforms that had been proven by ETSI (European Technical Standards Institute). Appendix 18, in its current revision by the World Radio Conference 2012 (WRC-12), approves all three data transmission methods in accordance with the approved ITU standards (Recommendations ITU-R M.493, M.1371 and M.1842) and designates channels for their use. Consequentially, both voice and data communications now coexist in the VHF marine band.

1. **Technical Considerations for Successful VDES Implementation**

It should be noted that the ITU standards for data transmission in Appendix 18 identify the specific channels for data transmission and specify the timing of and maximum time durations for data transmissions. This level of specificity, e.g., the selection of the channels, the timing for the transmissions and the maximum durations of the transmissions, etc., is needed to preserve the integrity of both the data service and the other services in Appendix 18, including the GMDSS. Noting that AIS, DSC and voice communications have been successfully operating in Appendix 18 along with the GMDSS for many years, it is expected that VDES will also be successful if it is implemented in accordance with ITU standards. For example, the current working document toward a preliminary draft revision of Recommendation ITU-R M.1842-1 provides a draft new Annex 5 to specify the channel access scheme, transmission timing and maximum transmission duration on the channels specified for VDE in Appendix 18. These specifications are designed to ensure that GMDSS VHF voice radio communications[[2]](#footnote-2), DSC calls[[3]](#footnote-3) and DSC distress alerts[[4]](#footnote-4) are successful during VDES transmissions. To mitigate consequential instantaneous receiver desensitization from each opposite VHF transmitter, it is important to follow the installation guidelines provided by IMO, e.g., COMSAR/Circ.32 for antenna installations. For example, one manufacturer who supplies both GMDSS VHF voice radios and AIS specifies a minimum separation of 4m vertical distance between the two VHF antennas at the same horizontal position or more than 17m separation when the antennas are at the same horizontal level, which provides about 41 dB of isolation between the two VHF antennas. By contrast, a separation of only 1.5m provides only 20 dB of isolation.

1. **Selection and Use of Frequencies for VDES**

VHF data exchange system (VDES) considers both WRC-15 Agenda item 1.16 and WRC-12 revisions to RR Appendix 18, including both terrestrial and satellite components, which address the need to protect the integrity of the AIS VDL by moving AIS applications and ASM to other channels and the designation of some of the duplex channels previously designated for VHF public correspondence (VPC) for digitally modulated emissions in accordance with Recommendation ITU‑R M.1842 (which describes VDE). The VDES integrates the functions of AIS, ASM and VDE and includes the channels used for these functions.

ANNEX B describes different channelplans and the deliberations by IALA, that led to the recommended channelplan described in Table 1 and Figure 1 of this guideline.

Additionally it is noted that more channels are available in some Regions, see RR Appendix **18** footnotes w, x, y. An example of the possible utilization of these channels is given in Table 2.

**Table 2**

**VHF data exchange – table of regional frequencies (MHz)**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Regional VDE (Regions 1 and 3)** | | | | | | |
| Ship transmit | 1080  157.025 | 1021  157.050 | 1081  157.075 | 1022  157.100 | 1082  157.125 | 1023  157.150 | 1083  157.175 |
| Ship received | 2080  161.625 | 2021  161.650 | 2081  161.675 | 2022  161.700 | 2082  161.725 | 2023  161.750 | 2083  161.775 |
|  | Can be used separately and/or as 50 kHz channel(s) or as one 100 kHz channel | | | |  | Can be used separately or as one 50 kHz channel | |
| NOTE – The VHF channels shown above are a contiguous set in RR Appendix **18**. They comprise a contiguous frequency block, and thus are amenable to protection by a single selective filter in the receiver. | | | | | | |

Note from Figure 1 that the AIS-VDE ship receiving range is 161.800-162.025 MHz, which includes channels 2024 to AIS2. This arrangement makes it possible to prevent VDES receiver blocking from the VHF voice radio transmitter by means of a bandpass filter at the input of the VDES receiver (Figure 2 below).

**IMPORTANT FOR ADMINISTRATIONS TO CONSIDER:** The plan to protect the VDES receiver with a bandpass filter is potentially conflicted (in the future) by the WRC-12 revision of Appendix 18 in which the four simplex channels 2078, 2019, 2079 and 2020 were added (covering the range of 161.525-161.600 MHz), which would permit ship borne VHF voice radios to transmit on the upper side of the 4.6 MHz separation shown in Figure 1. Historically, marine VHF ship borne voice radios were not permitted to transmit above 157.425 MHz. Voice communications on these channels will block AIS because of their long duration, while properly interleaved data will have a minimal impact. Administrations who are concerned about this potential impact on the AIS should consider proposals for appropriate revision of Appendix 18 by the WRC-15.

1. **An Example VDES Internal Architecture**

It may not be necessary to have a single box solution, however an example of a single box architecture (to support Table 1) is shown below in Figure 2. Note that the VDES is protected from receiver blocking due to ships VHF voice transmissions by the 161.800-162.025 MHz bandpass filter.

**FIGURE 2**

**Example VDES Functional Diagram**



It should be noted that the AIS-VDE transmitter will need to be designed to support the complex waveforms used in Recommendation ITU-R M.1842-1, e.g., QAM waveforms have peak-to-average power ratios of over 10 dB. To minimize the receiver desensitization effects on the VHF voice radio from the VDES transmitter broadband noise floor, the power level in the resonant circuit of the VDES transmitter frequency source, e.g., the Tx VCO, should be as high as practical, e.g., a power level of +10 dBm or higher is recommended.

1. **Analysis of Signal Levels Between VDES and VHF Voice Radios**

Figure 3 is a graphical representation of the transmission spectrum of a typical VHF marine voice radio transmitter, referred to the antenna connector of the radio, based on measurements taken from several manufacturers of these radios. Note that the power level at the VDES antenna connector will have to account for transmission losses in the antenna cables, isolation between the VDES antenna and the VHF radio antenna, and must also consider the different frequencies of interest between the VDES and the VHF radio transmitter. Table 3 shows the power levels delivered to the VDES (Figure 2) from the VHF marine voice radio transmitter (Figure 3). This table illustrates the need for the protection of the VDES receiver with the bandpass filter (which is absent in the current AIS) and for the installation of the two VHF antennas to achieve the highest practical isolation. Note that protection of the VDES is considered here and is achieved in this manner because voice communications by the VHF voice radio require it to be keyed for much longer duration than the VDES, whereas protection of the VHF voice radio from the VDES is achieved by controlling the timing and maximum durations of the VDES transmissions. The duty cycle of each transmitter should be low to support a large population sharing the same data link and minimizing the interference on voice communications.

**FIGURE 3**

**Typical VHF Marine Voice Radio Transmitter**

**Power, Spurious and Noise Levels**



Note: The noise floor levels are typical for radios currently in production. Some installed radios may be 10-20 dB better.

**TABLE 3**

**Power Levels Delivered to the VDES (ref. FIGURE 2)**

**From the VHF Radio Transmitter (ref. FIGURE 3)**

|  |  |  |  |
| --- | --- | --- | --- |
| **VHF Tx Output** | **Antenna**  **Isolation** | **VDES Input**  **(2 cable losses = 3db)** | **VDES Rx Input**  **(Rx Filter = 40dB/2dB)** |
| **+44 dBm**  **@157.4 MHz** | **20 dB** | **+21 dBm** | **-19 dBm** |
| **+44 dBm**  **@157.4 MHz** | **41 dB** | **0 dBm** | **-40 dBm** |
| **-66 dBm**  **@162.0 MHz** | **20 dB** | **-89 dBm** | **-91 dBm** |
| **-66 dBm**  **@162.0 MHz** | **41 dB** | **-110 dBm** | **-112 dBm** |
| **-71 dBm**  **@162.0 MHz** | **20 dB** | **-94 dBm** | **-96 dBm** |
| **-71 dBm**  **@162.0 MHz** | **41 dB** | **-115 dBm** | **-117 dBm** |

1. **Conclusion**

ITU has recognized the efficiency and the necessity for digital communications, has produced technical standards and has revised the VHF marine band (RR Appendix 18) to designate channels for data transmission. It is recognized that both analog voice communications and digital communications will share the band. This document illustrates how the design and installation of the new VDES (Figure 1) should address the compatibility and interoperability of both systems. The VDES, as envisioned by IALA and presented to ITU, addresses the identified need to protect AIS along with essential digital communications contributions for e-Navigation and GMDSS Modernization.

1. Usecase considerations provided by IALA to ITU on selection of channel plan for VDES

## Channel Plan A

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 1024  157.200 | 1084  157.225 | 1025  157.250 | 1085  157.275 | 1026  157.300 | 1086  157.325 |
| VDE1 | | | |  | |
| SAT up3 | | | | | |

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 2024  161.800 | 2084  161.825 | 2025  161.850 | 2085  161.875 | 2026  161.900 | 2086  161.925 | 2027  161.950 | AIS1  161.975 | 2028  162.000 | AIS2  162.025 |
| VDE1 | | | |  | | ASM1 |  | ASM2 |  |
| SAT Downlink | | | | | | SAT up1 | AIS1  uplink | SAT up2 | AIS2  uplink |

## Channel Plan B

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 1024  157.200 | 1084  157.225 | 1025  157.250 | 1085  157.275 | 1026  157.300 | 1086  157.325 |
| VDE1 | | | |  | |
| SAT up3 extension | | | | SAT up3 | |

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 2024  161.800 | 2084  161.825 | 2025  161.850 | 2085  161.875 | 2026  161.900 | 2086  161.925 | 2027  161.950 | AIS1  161.975 | 2028  162.000 | AIS2  162.025 |
| VDE1 | | | | Innovative  Applications | | ASM1 |  | ASM2 |  |
| SAT Downlink | | | |  | | SAT up1 | AIS1  uplink | SAT up2 | AIS2  uplink |

## Channel Plan C

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **1024** | **1084** | **1025** | **1085** | **1026** | **1086** | 4. 6  MHz | **2024** | **2084** | **2025** | **2085** | **2026** | **2086** | **2027** | **AIS 1** | **2028** | **AIS 2** |
| **157.200** | **157.225** | **157.250** | **157.270** | **157.300** | **157.325** | **161.800** | **161.825** | **161.850** | **161.875** | **161.900** | **161.925** | **161.950** | **161.975** | **162.000** | **162.025** |
| SAT3 uplink | | VDE-simplex | | | | SAT downlink | | | | | | ASM1 | Collision avoidance | ASM2 | Collision avoidance |
| SAT1  uplink | SAT2  uplink |

CHANNEL PLAN PERFORMANCE AGAINST USE CASES















1. demonstration objectives in support of the development of VDES

**The need for a VDES demonstration objective**

Before VDES can play any role in the implementation of e-Navigation or support a modernized GMDSS, it must first be fully developed, demonstrated and validated and the allocation of frequencies for the system must be ensured.

The design, prototyping, demonstration and validation activities needed for VDES will require coordinated research & development as well as testbed activities involving competing suppliers, real users, national authorities and information service providers working together. Some activities are needed to support the claim for frequency allocations needed for the system to become a reality.

Such coordinated R&D and testbed activities will need clear objectives and timelines and will need funding support to bring the relevant parties together and meet the timelines of the ITU and IMO processes.

This note describes specific demonstration objectives and milestones with regards to VDES, in support of focussing research & industry efforts into joint, coordinated testbed activities, to meet the relevant deadlines.

* 1. Considerations on a draft roadmap

It is anticipated that VDES may be implemented in several stages. Some radio manufactures have already started to develop prototype VDE transceivers that have the capability of VHF digital data exchange (VDE) function and such prototypes are expected to be available for testing in 2014. Several modulation schemes are being proposed, to generate an efficient system, reduce equipment costs and avoid causing harmful interference to – or being troubled by interference from – other services in the maritime VHF band such as satellite, the existing AIS, DSC and VHF voice communication. To ensure a high probability of information delivery, robust protocols also need to be further developed.

For WRC-15 to approve the allocation of the proposed frequencies for VDES, in light of the urgency to protect the AIS VDL, supporting studies, field trials and even partial implementation may be necessary

To facilitate a satellite frequency allocation for the VDES, sharing studies involving land mobile VHF stations are underway in ITU. It is expected that such studies will be completed during the development of the ITU Recommendations for VDES so that final decisions by WRC-18 can facilitate a fully featured VDES including the satellite aspects.

In order to ensure a coherent and globally interoperable system, comparative studies, field trials involving testbeds and harmonization of the results will be needed to fully develop the system and ensure a safe, efficient and globally interoperable implementation.

Demonstration objectives and milestones in support of the development of VDES

## General objectives

### Testbed locations – are required to establish VHF data link characteristics in all of the different modes of operation (ship to ship, shore to ship etc.) through varying seasons, weather conditions and over locations with differing topographical features and traffic densities. Locations which include a transition across the boundary between terrestrial and satellite coverage should also be included. These measured data can then be input into models to estimate the theoretical link performance for differing transmission schemes.

### Defined Testbed areas – supported by competent authorities within which there is permission to transmit across all of the proposed VHF channels using a variety of modulation schemes within defined transmitter power limits. A list of these test bed areas with government and regulatory support shall be provided to manufacturers which will encourage fast track development and testing of the prototypes.

### As a starting point general guidance for the technical aspects of the VDES can be found in the Preliminary Draft New Recommendation ITU-R M.[VDES] (e-NAV14-17.1.3.4).

### The reflector email discussion group is being used to input ideas and pose questions on possible modulation / encoding schemes, allow peer review and report on the outcome of testing these schemes. In this way a body of knowledge will be built up to support the eventual decision on the final scheme to be used which will input into the VDES technical standard.

#### All schemes proposed in the discussion group will undergo the same scrutiny.

#### Members of the group will be expected to act in the common good, with the sole aim of developing the best solution for the VDES.

#### Discussions will be moderated by one or more technical experts who will be the ultimate arbitrator and refer any contentious issues to WG3/4.

### Plans for conducting VDES testbeds and the planned operational context and validation activities should be announced, and documented results of the testbeds should as soon as possible be reported on the IALA testbed website <http://e-navigation.net> (refer to IALA Guideline on The reporting of results of e-Navigation testbeds e-NAV14-17.1.7.1) A copy of the summary monthly reports and links to the locations containing the detailed testbed results will be provided on e-navigation.net.

### A summary of analyses carried out and proposed new testbeds are included in the table in Annex A to this document. The table will be updated at each WG3/4 meeting.

## Definition of testbeds and operational scenarios to validate terrestrial VDES (Q3 2014)

Parties willing to set up one or more testbed activities related to the development of VDES should seek to initiate such testbeds by Q3 2014 and, and should as a minimum:

### Plan one or more operational scenarios relevant to the implementation of e-Navigation for testing information services using VDES as the communication link.

### Develop a validation scheme for demonstrating the operational efficiency and effectiveness of VDES as a communication link, where possible involving comparison between alternative modulation schemes and design solutions.

### Testing on the ASM frequencies will be particularly valuable to the upcomming ITU WRC 2015 process.

### Accessing interference with other services issues in the VHF band should be considered in the planning of testbeds.

### Plan to perform initial operational testing in the timeframe Q4 2014 – Q2 2015

### Provide the initial results of the testbeds to the IALA e-Navigation committee, as well as reporting relevant findings to the ITU WRC 2015 through relevant national representation no later than their respective deadline for comments to WRC-15 (expected to be several months before WRC-15 to be held 2nd – 27th November 2015), in support of the allocation of frequencies for VDES.

## Proof of concept VDES stations ready for field testing (Q4 2014)

### Manufacturers or research institutions willing to participate in developing and evaluating possible designs for VDES shipborne, shorebased and as well as satellite VDES stations and associated transmission protocols are encouraged to deliver the first proof of concept platforms for field testing in operational testbeds no later than Q4 2014.

### Several modulation schemes are currently proposed for different parts of the VDES. Where possible, the prototypes should either accomodate the comparative testing of several options for modulation arrangements, or document the rationale behind any specific choices of modulation, in support of evaluating and harmonizing chosen solutions to achieve a globally interoperable system.

## Definition of testbeds and operational scenarios to validate Satellite VDE (Q4 2015)

Parties willing to set up one or more testbed activities related to the development and validation of full VDES capabilities including a satellite component should seek to initiate such testbeds by Q4 2015, and should:

### Plan for one or more operational scenarios, including relevant needs for information security (authentification, integrity, confidentiality) relevant to the implementation of e-Navigation, testing the function of information services using satellite VDE as well as terrestrial VDES as the communication link;

### Encourage the participation of several manufacturers in the same - or a number of coordinated - R&D or testbed projects addressing the same objectives, to ensure interoperability and broad industry support for the achieved results.

### Develop a validation scheme for demonstrating the operational efficiency, effectiveness and information security of the terrestrial VDES as well as satellite VDES as a communictions link, where possible involving comparison between alternative design solutions for VDES

### Seek that the testbed includes

* High density traffic regions as well as low traffic
* Transition regions covering areas with both terrestrial and satellite coverage
* Remote regions such as the polar areas
* A realistic maritime radio frequency environment (including the use of VHF voice, DSC, AIS or other VHF equipment) onboard real ships.
* Several different ships travelling the regions mentioned above

### Plan to include field studies aimed at verification on feasibility of any necessary sharing of frequencies between satellite and terrestrial landmobile or maritime services.

### Plan to perform operational testing in the timeframe Q1 2016 – Q3 2016.

### Provide initial results of the testbeds to the IALA e-Navigtion committee no later than Q3 2016 in support of the standardization of VDES to support the Implemenation of e-Navigation.

## Prototype VDES stations ready for field testing (Q1 2016)

### Manufacturers or research institutions willing to participate in developing and evaluating possible designs for VDES shipborne (and satellite) VDES stations are encouraged to deliver the first prototype platforms supporting terrestrial as well as satellite VDES for field testing in operational testbeds no later than Q1 2016.

Several modulation schemes are currently proposed for different parts of the VDES. Where possible, the prototypes should either accomodate the comparative testing of several options for modulation schemes, or document the rationale behind any specific choice of modulation scheme, in support of evaluating and harmonizing chosen solutions to achieve a globally interoperable system.

1. Considerations on operational availability and transition

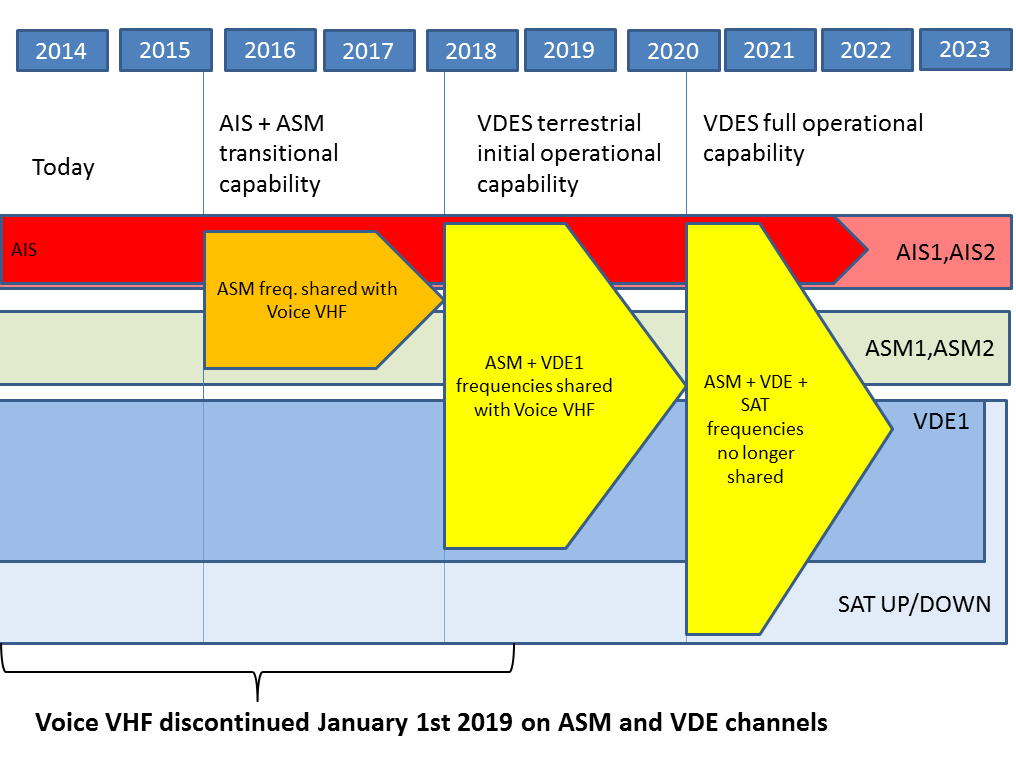


Figure D - Possible roadmap for operational availability

Introducing VDES is expected to happen through 4 operational phases:

1. Today: AIS exists as defined by ITU.R M.1371-5 on the AIS frequencies, and Coastal Stations use the ASM and VDE frequencies for Voice VHF.
2. Past WRC15 - AIS+ASM: Regionally, where there is an urgent need for offloading the AIS VDL from significant ASM traffic, it is recommended to allow the introduction of 4-channel AIS + ASM devices. These devices may receive and transmit ASM on the ASM1 and ASM2 frequencies, using the existing GMSK modulation defined for AIS, but shall discontinue their transmit capability [after January 1st 2019] unless a software upgrade enables them to participate in the modulation and access scheme agreed for the ASM frequencies, when the final VDES recommendation is introduced. Note that the ASM frequencies will need to be shared with the VHF voice service from Coast Stations in many aeas.
3. It is foreseen that the when the VDES is finalized, Initial operational capability can be established quickly after January 1st 2019, replacing any GMSK modulation on the ASM1 and ASM2 frequencies, and introducing terrestrial VDE. Note that both the ASM and VDE frequencies will still need to be shared with the Voice VHF service in many areas.
4. When a satellite service is developed, full operational capability of the VDES including the Satellite frequencies can be achieved. Past January 1st 2019, the ASM, VDE and SAT frequencies should not need to be shared with the Voice VHF service.

This implies, that a transition mechanism is needed, that enables the VDES to be robust to coexist with the Coastal Radio Service *at least* *in the transition period*. Even if the voice VHF allocation ceases in 2019, it may take a long transition period before the operation of all coastal stations on these channels is discontinued.

It is proposed to acknowledge that VDES systems should ‘behave politely’ and adopt to the fact that it is futile to try to transfer data, during a ship-shore VHF voice call via a Coast station, simply by monitoring whether there is so much energy over an extended period of time on a frequency, that it must be considered occupied by a voice call.

If this is the case, data transmissions should be paused (or deferred to another frequency) until the Voice transmission is over. This way, the devices introduced will not be in conflict with the existing VHF Voice service, even when carried by ships travelling between regions of early adopters of the VDES and areas, where the voice service remains in operation.

This implies, that if just one of the VDE frequencies is in use, it could be desirable for the device to switch to a mode, where the VDE1 (and possibly SAT UP) used in blocks of 25 kHz.

It is unrealistic for the satellite VDE to respect the VHF voice service, but due to the PFD mask applied to protect terrestrial services in the same band, the satellite service will not significantly affect the VHF voice service, only raising the noisefloor slightly.

With the channelplan chosen, the functional diagram suggested in ANNEX A applies a filter protecting the receiver from being blocked by ships own VHF voice transmissions. The shipborne VDES will only listen to the frequencies on the upper leg, and will thus only respect the transmissions from Coast Stations – not ships transmissions - unless the call is full duplex.

This could be accommodated by introducing an ASM, that could (via AIS or ASM) be transmitted by a Coast Station to initiate a guard period where a particular operating channel is unavailable for VDES. This could be part of introducing a ‘channel configuration’ mechanism within the VDES, allowing splitting of the VDE channels into blocks of 25kHz (or other sizes).

These requirements for the VDES system can be derived from this proposal:

1. The terrestrial VDES should be able to detect the carrier of an ongoing Voice VHF call on ASM or VDE frequencies, and cease transmission on this frequency (both upper and lower leg for VDE) until the call is over.
2. The VDE should be able to automatically switch from a default 100 kHz VDE mode to multiple channels of 25kHz (or less), during a VHF voice call on one of the VDE channels.
3. Planned, ongoing and completed testbeds for VDES

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Name** | **Location** | **Time and duration** | **Status** | **Contact person(s)** | **Testbed website** | **Organisation(s) involved** | **Funding programme and budget** |
|  | Korea | in 2014 | Planed |  |  | Korea Research Institute of Ships & Ocean Engineering |  |
| Sesame |  | April 2014  3 years | on-going | Mr. Haugen |  | Kongsberg,The Norwegian Coastal Administration,The Maritime and Port Authority of Singapole |  |
|  | Japan | in 2014 | Planed | Lcdr. Takeuchi |  | Japan Coast Guard ,manifacturers in Japan |  |
| MONALISA |  |  | on-going | Mr. Zetterberg | <http://www.sjofartsverket.se/en/MonaLisa/> | CHALMERS, Danish Maritime Authority, SSPA, Liikennevirasto, Swedish Maritime Administration, GateHouse, SAAB |  |
|  | United States |  | Planed | Mr. Kautz Mr. Tetleault |  | United States Coast Guard, other US government agencies |  |
|  | Australia United Kingdom |  | on-going | Mr. Safar |  | General Lighthouse Authorities, University of South Australia |  |
|  | France or EU | start mid/end 2014 | Planed | Mr. Fabritius |  | TBC, incl. Space Agency, Satellite industry |  |



1. Use cases and estimated bandwidth requirements

Usecase

1. Which users (SOLAS, non-SOLAS, specific group?) – magnitude of user group
2. Ship-ship, ship<->shore
3. Environment – port, coastal, deep sea
4. Range requirement
5. Magnitude of data and frequency of transfer
6. Suitability for ASM / VDE
7. Priority of communication
8. Considerations on peer group information sharing & mesh networking

The diversity in applications that have emerged based on the AIS, indicates that VDES can introduce a very flexible, maritime digital communication capability, which could span SOLAS as well as non-SOLAS vessels, offshore applications, etc. This also offers an opportunity to consider evolving novel and efficient methods of sharing important information between peer grouping of vessels, or exchanging information indirectly over longer distances through multi-hop relaying, similar to the way AIS AtoN may relay an AIS SART message.

This function would reside at a higher logical level, not necessarily within the VDES systems itself, and could potentially encompass other links, such as HF Data Exchange or even satellite communication systems, but the VDES would play a significant role in connecting ships within VHF range, without any cost of communication.



Use cases supported could be:

* Multi hop relaying and Ad hoc networking, extending the coverage of terrestrial broadcast systems or even point to point communication, if the indirect path to a particular recipient can be determined
* Peer group sharing of recently received updates to digital publications, navigational warnings, etc., enabling small vessels to benefit from the HF or satellite capabilities of larger ships at no added cost
* Automated and instantaneous ‘mayday relay’ or other priority messaging from small ship via VDES - and potentially further via HF or satellite connection of larger ship in peer group
* Monitoring the integrity / safety of a peer groups of fleets, or vessels sharing "common purpose” (for instance a group of fishing vessels), rather than each vessel within it, until a vessel leaves the peer group

1. Innovative use of aIS

TBD

1. However, even in this high slot usage situation, a mobile AIS station is designed to avoid losing a target that may pose a danger by using time slots of the most distant stations and therefore the most important function of AIS, i.e. ship to ship anti-collision functionality, is more robust. [↑](#footnote-ref-1)
2. Report ITU-R M.2169 refers to a study of the effects of data burst transmissions on voice radio communications which concludes that the consequential loss of intelligibility of human speech is tolerable if the frequency of occurrence and the length of the data bursts are appropriately limited, e.g., as in AIS. Considering the successful implementation of AIS in the VHF marine radio environment, similar timing limits to AIS are proposed for VDES. [↑](#footnote-ref-2)
3. DSC calls are repeated if they are not acknowledged, since it is understood that a single call may be blocked. [↑](#footnote-ref-3)
4. DSC distress alerts are repeated until acknowledged. Each transmission is 1500ms long and contains five repetitions of the DSC distress call. [↑](#footnote-ref-4)