e-NAV13 Input

Agenda item 10.3

Task Number 19

Author(s) WG3 & WG4

annex 1

Plan for future VHF data communications

# 1 Summary

This liaison note describes IALA’s plan for the future development of the VHF Data Exchange System (VDES), and to inform ITU-R WP 5B of the use planned by IALA of VHF channels of Appendix 18 for the purpose of data communications, taking into account the result of WRC-12, and Agenda item 1.16 for WRC-15.

## 1.1 Related documents

– Document 5B/801, “Three Essential Elements of e-Navigation Communications” (original IALA reference number was Liaison Note e-Nav10-output-18)

– Annex 36 to Document 5B/727, IALA Maritime Radio Communication Plan edition 1 (MRCP)

– Annex 35 to Document 5B/727, IALA World Wide Radio Navigation Plan (WWRNP).

# 2 WRC-12 outcome

## 2.1 Long range AIS

The WRC-12 has identified channels 75 and 76 for the reception of automatic identification system (AIS) emissions of long-range AIS broadcast messages (Message 27, defined in Recommendation ITU‑R M.1371).

## 2.2 Digital channels identified by WRC-12

WRC-12 identified channels inside Appendix 18, which could be used for digital systems from 1 January 2017.

However the availability of these channels is not the same over all 3 ITU Regions and all would be shared with fixed and mobile services.

Six channels have been identified worldwide for digitally modulated emissions in accordance with Recommendation ITU-R M.1842. These are Channels 24, 84, 25, 85, 26 and 86, corresponding to the frequency bands 157.200-157.325 and 161.800-161.925 MHz.

Channels 80, 21, 81, 22, 82, 23 and 83 corresponding to the frequency bands 157.025‑157.175 MHz and 161.625-161.775 MHz are also available for digitally modulated emissions in accordance with Recommendation ITU‑R M.1842, except in Region 2.

## 2.3 AIS experiments

WRC-12 identified the frequency 160.900 MHz for experimental use for future applications or systems (e.g. new AIS applications, man over board systems, etc.). If authorized by administrations for experimental use, the operation shall not cause harmful interference to, or claim protection from, stations operating in the fixed and mobile services.

WRC-12 has identified the channels 27, 28, 87, and 88 for possible testing of future AIS applications without causing harmful interference to, or claiming protection from, existing applications and stations operating in the fixed and mobile services.

## 2.4 Future WRC Agenda item

The WRC-12 established a new Agenda item for the AIS for WRC-15:

Agenda item 1.16

to consider regulatory provisions and spectrum allocations to enable possible new Automatic Identification System (AIS) technology applications and possible new applications to improve maritime radiocommunication in accordance with Resolution 360 (WRC‑12)

More specifically this Resolution in its “resolves” portion quotes:

1 to consider, based on the results of ITU‑R studies, modifications to the Radio Regulations, including possible spectrum allocations, to enable new AIS terrestrial and satellite applications, while ensuring that these applications will not degrade the current AIS operations and other existing services;

2 to consider, based on the results of ITU‑R studies, additional or new applications for maritime radiocommunication within existing maritime mobile and mobile-satellite service allocations, and if necessary to take appropriate regulatory measures.

WRC-12 has also established a new Agenda item for WRC-18 dealing with the modernization of the GMDSS and the e-navigation:

“to consider regulatory actions, including spectrum allocations, to support GMDSS modernization and implementation of e-navigation in accordance with Resolution 359 (WRC‑12)”.

# 3 Description of VHF data communications requirements

## 3.1 Background

Prior to WRC-12, IALA created Document 5B/801 “Three essential elements of e-Navigation communications”, which originated in IALA as output document e-Nav10-output-18.

Two of these essential elements were concerned with AIS and with VHF channels for data exchange. (The third of these essential elements is MF radio communications, near 500 kHz. It is not considered in this paper, which is restricted to VHF matters.)

The objective of Document 5B/801 was to secure at WRC-12 additional AIS channels for satellite detection, and additional VHF channels to relieve the loading on AIS1 and AIS2 with the objective of optimizing the use of AIS1 and AIS2 for their original purpose. The result of WRC-12 was in accordance with these objectives.

## 3.2 VHF data communications

VHF data communications will provide robust high-speed data exchange between ships and between ship between ship and shore, and between ships and satellites. The AIS system is not capable of handling, nor is intended for, this high-speed data exchange.

Taking into account the channels identified by WRC-12 as described in 2.2 above, channels 24, 84, 25, 85, 26, and 86 will use the modulation technique described in Recommendation ITU-R M.1842, and will be used for future VHF digital data, and ship-to-shore data exchange.

These may be used as discrete data communications channels, or a number may be combined into a single wide-bandwidth channel.

**3.3 VDES (VHF Data Exchange System) integrates functions of AIS, ASM and VDE**

VDES considers both WRC-15 Agenda Item 1.16 and WRC-12 revisions to Appendix 18 which address the need to protect the integrity of the AIS VDL by moving AIS applications and ASM (Application Specific Messages) to other channels and the designation of some of the duplex channels previously designated for VPC (VHF Public Correspondence) for digitally modulated emissions in accordance with Recommendation ITU-R M.1842 (which describes VDE (VHF Data Exchange)). The VDES integrates the functions of AIS, ASM and VDE and includes the channels used for these functions. The arrangement of the frequencies, channels and usage is shown in Table 1, including the provision for satellite broadcasting. **Table 1**

**Appendix 18 channels and frequencies for VDES (AIS, ASM and VDE) with provision for satellite broadcasting**

|  |  |  |
| --- | --- | --- |
| Channel number in Appendix 18 | Transmitting frequencies (MHz) for ship and coast stations | |
| Ship stations (ship-shore)  Ship stations (long range AIS) | Coast stations  Ship stations (ship-ship)  Satellite broadcasting 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 (VDE 1) | 157.200 (1024) | 161.800 (2024) |
| 84 (VDE 2) | 157.225 (1084) | 161.825 (2084) |
| 24/84 (VDE 3) | 50 kHz channel  (1024/1084, merged) | 50 kHz channel  (2024/2084, merged) |
| 2024/2084 (SAT 1) | N/A | 50 kHz channel\*  (2024/2084, merged)  (For satellite broadcasting to ship) |
| 25/85/26/86 (VDE 4)  25  85  26  86 | 100 kHz channel  (25/85/26/86, lower legs, merged) | 100 kHz channel  (25/85/26/86, upper legs, merged) |
| 157.250 (1025) | 161.850 (2025) |
| 157.275 (1085) | 161.875 (2085) |
| 157.300 (1026) | 161.900 (2026) |
| 157.325 (1086) | 161.925 (2086) |

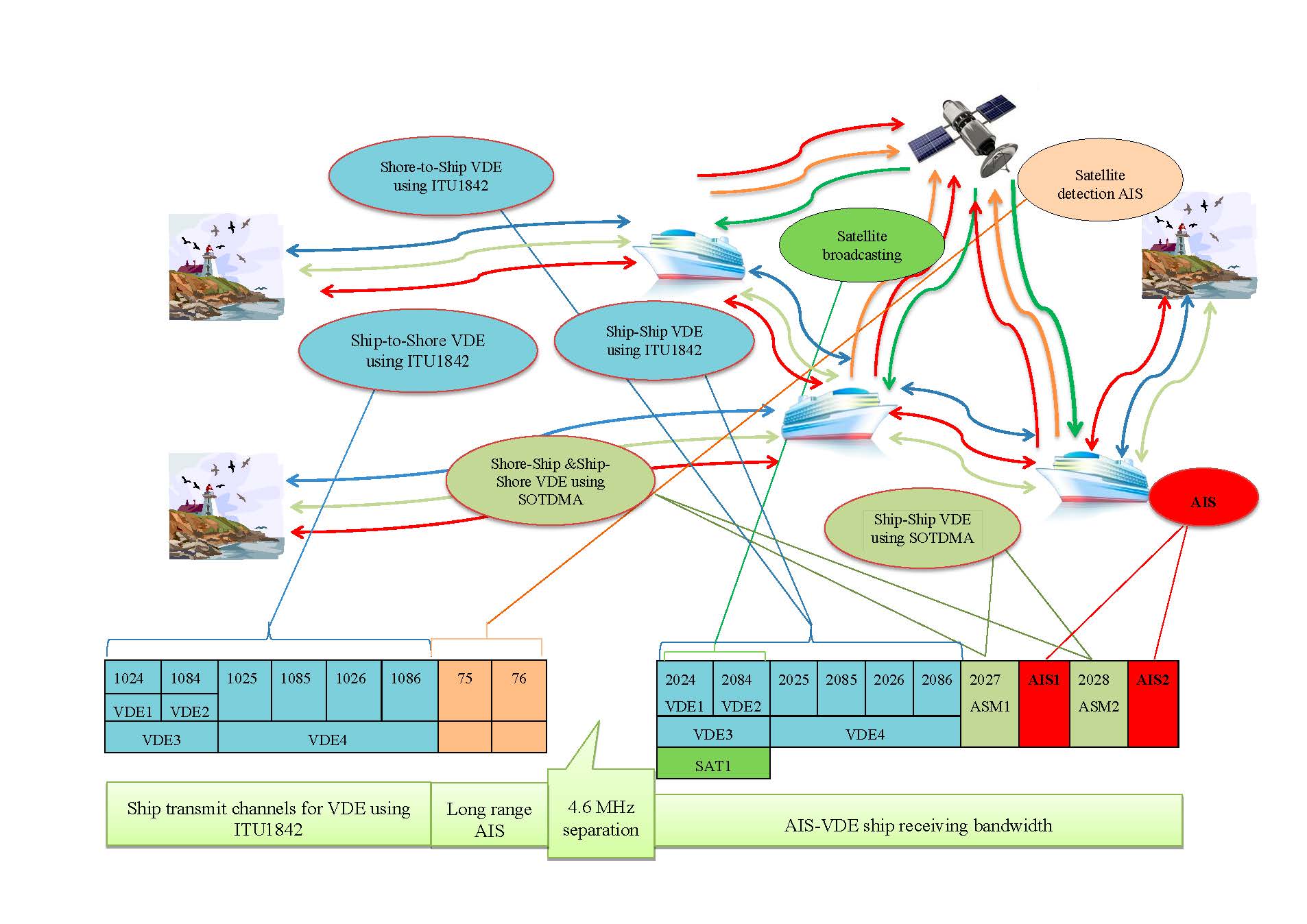
– A typical scheme would be to allocate the four channels 25, 85, 26, and 86 for data exchange (in accordance with Annex 4 to Recommendation ITU-R M.1842) in areas such as ports and crowded waterways, with the other two channels (24 and 84) allocated to operation (in accordance with either Annex 1 or Annex 3 to Recommendation ITU R M.1842,) along the coastline between these areas. Note that there is a provision for satellite downlink (satellite broadcasting to a ship, a group of ships or to all ships) on the 50 kHz channel 2024/2084.

– Where a number of the 25 kHz channels are combined, a typical scheme might have a 100 kHz bandwidth, allowing a much higher data throughput than a single 25 kHz channel.

To support satellite downlink for radiocommunication applications outside coastal coverage areas, it will be necessary to designate suitable channels. Candidate channels may be channels 2024/2084 (161.800 and 161.825 MHz) combined making a 50 kHz bandwidth.

The various functionalities of VDES and their uses by ships, shore stations and satellites are illustrated pictorially in Figure 1.**Figure 1**

**Illustration of the functionalities of VDES**

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**3.4 Rationale for the Integration of AIS, ASM and VDE**

The rationale for the integration of AIS, ASM and VDE is that this integration would accomplish the following objectives:

• **Protect the integrity of the AIS VDL (VHF Data Link)**

The AIS (as a SOLAS requirement) was intended primarily for “Navigation Safety/Collision Avoidance.” Increased use of AIS Application-Specific Messages (ASM) and other AIS applications and devices competes with this main purpose.

• **Increase the loading capacity of the AIS VDL**

Future AIS overload is anticipated as AIS applications, equipment types and installations increase. The AIS VDL can safely support the increased loading if non-safety-related AIS communications are moved to new channels (VDE).

• **Enhance data communications and spectrum efficiency**

Designating new channels for VDE will provide higher data rates (up to 32X) than AIS, e.g., for use in e-Navigation. The VDE network protocol is optimized for data communications (vs. AIS for navigation) so that each VDE message is transmitted with a very high confidence of reception. Integration with AIS also benefits VDE by automatically identifying and locating ship and shore stations.

• **Use WRC -12/15/18 provisions for additional frequencies**

**3.5 Spectrum efficiency and data exchange considerations**

Recommendation ITU-R M.1842, and the ETSI standard EN 300392-2 v3.2.1, from which it was derived, provide methods for spectrum-efficient and robust digital communications for ASM and VDE on the channels in Table 1. The methods for transmission on 25 kHz channels are shown in Table 2, and the methods for transmission on 50 kHz and 100 kHz channels are shown in Table 3.

**Table 2**

**Comparison of AIS and VDE Data Transfer Methods on 25 kHz Channels**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | AIS1 and AIS2  (25 kHz Channels) | VDE Data Transfer Methods  For 25 kHz Channels | | |
| ITU Standard and Digital Modulation | ITU-R M.1371  GMSK | ITU-R M.1842  Annex 1  π/4 DQPSK | ITU-R M.1842  Annex 1  π/8 D8PSK | En 300392-2 v3.2.1 Section 5.11\*  8-OFDM + 16-QAM |
| Data Rate | 9.6 kbps (1X) | 28.8 kbps (3X) | 43.2 kbps (4X) | 76.8 kbps (8X) |
| Sensitivity | -107dBm | -107dBm | -107dBm | -107dBm |
| Co-channel rejection (CCR) | 10dB | 19dB | 25dB | 19dB |
| Adjacent channel rejection (ACR) | 70dB | 70dB | 70dB | 70dB |
| AIS Message types | 1, 2, 3, 5, 18, 19 … | 6, 7, 8,12,13,14 … | 6, 7, 8,12,13,14 … | 6, 7, 8,12,13,14 … |
| Rationale | Optimum choice for recurring position reports in a ship-ship navigation safety environment. | Provides high (3X) data transmission. Inferior CCR (+9dB) and range discrimination. | Provides high (4X) data transmission. Inferior CCR (+15dB) and range discrimination. | Highest (8X) data rate for a 25kHz channel (compress multi-slot messages to a single slot). |

**Table 3**

**Comparison of Data Transfer Methods for VDE by WRC-12 (refers to Rec. ITU-R M.1842)**

|  |  |  |  |
| --- | --- | --- | --- |
|  | VDE Data Transfer Methods  For 25 kHz Channels | VDE Data Transfer Methods  For 50 kHz and 100 kHz Channels | |
| ITU Standard and Digital Modulation | ITU-R M.1842 Annex 1  π/4 DQPSK or π/8 D8PSK | ITU-R M.1842 Annex 3  16-OFDM + 16-QAM | ITU-R M.1842 Annex 4  32-OFDM + 16-QAM |
| Data Rate | 28.8 kbps (3X) or 43.2 kbps (4X) | 153.6 kbps (16X) | 307.2 kbps (32X) |
| Sensitivity | -107dBm (ship/shore stations) | -103dBm (ship stations) | -98dBm (ship stations) |
| Co-channel rejection (CCR) | 19dB or 25dB | 19dB | 19dB |
| Adjacent channel rejection (ACR) | 70dB | 70dB | 70dB |
| Message types | AIS 6, 7, 8,12,13,14 and ASM | VDE messages TBD | VDE messages TBD |
| Rationale | Provides higher (3X or 4X) data transmission than AIS. Inferior CCR (+9dB or +15dB) and range discrimination compared to AIS. | Provides much higher (16X) data transmission than AIS. Inferior CCR (+9dB) and range discrimination compared to AIS. | Provides much higher (32X) data transmission than AIS. Inferior CCR (+9dB) and range discrimination compared to AIS. |

## 3.6 IALA “VHF data exchange” (VDE) plan

IALA plans to use six VHF data channels 24, 84, 25, 85, 26, and 86 plus channels 27 and 28 (which have been identified for “possible testing of future AIS applications”) for an international scheme to be known as “VHF data exchange” (VDE).

**3.7 Proposed guideline for sharing studies for VDES service**

WRC-15 Agenda Item 1.16 requires sharing studies for use of the channels with other services. In the case of the Appendix 18 channels identified for VDES, these maritime channels are shared with terrestrial services based on geographical separations and signal level boundary conditions such that the signal level from one service does not interfere with the other service. Studies should be based on the required signal levels for service areas for each service and the degree of protection in terms of C/I (carrier-to-interference, co-channel) required by each service.

For example:

Land mobile radio services generally require a signal level (field strength) of +39 dB(µV/m) (39 dB above one microvolt per meter) at the service area boundary with a C/I of 10 dB (interfering signal must be 10 dB lower than the desired signal) to provide a reliable service in a terrestrial environment. Maritime services, on the other hand, due to a different environment, generally require +17 dB(µV/m) at the service area boundary with a C/I of 12 dB. This is based on marine VHF radio requirements. In this example, the sharing criteria would be that the maritime service area boundary would be the shore lines and water lines on the navigable waterways in which there would be a minimum of +17 dB(µV/m) of field strength from the maritime service and no more than +5 dB(µV/m) of field strength from the land mobile service. In the case where the maritime VDE service was from a satellite downlink, the maximum field strength from the maritime VDE satellite service would be constrained to be no more than +29 dB(µV/m) in the service areas of the land mobile services in order to provide the required 10 dB C/I protection at the service area boundary defined by the minimum signal level of +39 dB(µV/m). This example demonstrates the viability of sharing the frequencies between the two services because of the margin of 12 dB between +29 dB(µV/m) and +17 dB(µV/m). In this arrangement, the land mobile services that share the maritime Appendix 18 channels must be geographically set back from the water’s edges such that their signal levels at the water’s edges does not exceed +5dB(µV/m).

Further studies should:

* include references to relevant ITU standards;
* review of signal levels, co-channel performance levels and protection ratios for the various VDES channels and for the land mobile services that may share the VDES channels;
* review of the required power flux density levels and required link margin for SAT 1 and
* finalize sharing criteria for all the services on all the VDES channels.

# 4 Functional Characteristics of the VDES

VHF data communications will provide robust high-speed data exchange between ships, between ships and shore, and between ships and satellites . The AIS system is not capable of handling, nor is intended for, this high‑speed data exchange.

AIS 1 and AIS 2 should be reserved for “Navigation Safety/Collision Avoidance” purposes (as a SOLAS requirement) and therefore the Application-Specific Messages (ASM) and other “non‑critical communications” should be moved to new channels of RR Appendix 18 to avoid deleterious loading of the AIS VDL. This problem increases as more different types of equipment using AIS technology are developed, more vessels are equipped and more AIS applications are developed and implemented. Among the channels identified by WRC-12 the channels 2027 and 2028 which are the upper legs of the duplex channels 27 and 28, are the suitable candidates for these new applications using AIS technology.

In order to further facilitate these new applications that will improve maritime radiocommunications there will be a need for a satellite downlink in the VDES. These requirements include facilitating standardized and automated reporting and improved communications when a ship is outside coastal coverage areas. These communications include, but are not limited to, dissemination of Maritime Safety Information, weather warnings, route planning, dissemination of regional reliability of PNT, and space weather warnings that might affect radionavigation and radiocommunication in general.

In particular the satellite downlink would facilitate radiocommunications in the Polar regions. This downlink may also be used to complement NAVTEX and SafetyNET globally, and especially in the Polar regions. It is also envisioned that it could enable a satellite based augmentation system (SBAS) specified for high latitudes.

## 4.1

To summarize the VDES plan:

1) ASM 1 and 2:

a) the duplex channels 27 and 28, which have been identified by WRC-12 for testing of future AIS applications, will be used for “radiocommunications involving, but not limited to, area warnings and meteorological and hydrographic data, as well as channel management of AIS, future VHF digital data, and ship-to-shore data exchange”:

i) these may use the same message structures and TDMA technology similar to AIS;

ii) this use for terrestrial data exchange will not prevent the use of these channels for satellite applications as referred in AI-1.16 of WRC-15;

2) VDE4:

b) the four contiguous channels 25, 85, 26, 86 will be used for data exchange using the modulation technique described in Annex 4 to Recommendation ITU‑R M.1842:

i) these may be used as separate channels or combined into a single 100 kHz broadband channel;

3) VDE1 and VDE2:

c) the two contiguous channels 24 and 84 may also be used for data exchange along the coastlines and waterways using the modulation techniques described in Annex 1 or Annex 3 to Recommendation ITU-R M.1842;

4) VDE 3:

d) the combination of channels 24 and 24 may also be used for data exchange along the coastlines and waterways using the modulation techniques described in Annex 1 or Annex 3 to Recommendation ITU-R M.1842;

5) SAT1

e) the two contiguous channels 2024 and 2084 may also be used for data downlink  
 between satellites and ships.

6) AIS

a) the existing AIS frequencies AIS-1 and AIS-2 (both are simplex channels) will be used exclusively for safety of navigation, primarily position reporting and identification, ship to ship and ship to shore;

b) the simplex channels 75 and 76 will be used for satellite detection of AIS using AIS Message 27, long range AIS broadcast message.

**Table 4 “VDES Communications including AIS, ASM and VDE” provides a summary of the technical assignment of various VHF channels for communication including protocol and types of messages to meet the functionality required by user needs.**

**table 4**

****VDES communications including AIS, ASM, and VDE****

|  | ***VHF Data Communications (including ASM and VDE)*** | | ***AIS*** | |
| --- | --- | --- | --- | --- |
| **Sub-group** | ***Data communications for ASM*** | ***Data communications for VDE*** | ***AIS for safety of navigation*** | ***AIS long range*** |
| **Radio channels** | * *Channels 27 and 28* * *World-wide dedicated channels (WRC-15 target)* | * *Channels 24, 84, 25, 85, 26, 86 for VDE* * *Channels 2024/2084 for VDE satellite downlink* | * *AIS-1 & AIS-2 (simplex)* | * *Channels 75 and 76 (simplex)*    + *WRC-12* |
| **Functionality** | * *Marine safety information* * *Marine security information* * *SSRMs* * *General purpose information communication* | * *General purpose data exchange* * *Robust high speed data exchange* * *VDE satellite downlink* | * *Safety of navigation* * *Maritime locating devices* | * *Satellite detection of AIS* * *Possible support of future SAR* |
| **Message types**  **for AIS protocol** | * *IMO SN.1/ Circ.289 international application specific messages* * *Regional application specific messages* * *Base Station* |  | * *Vessel identification* * *Vessel dynamic data* * *Vessel static data* * *Voyage related data* * *Aids to Navigation* * *Base Station* | * *Satellite detection of AIS* * *Possible support of future SAR* |
| **Sub functionality** | * *Area warnings and advice* * *Meteorological and hydrographic data* * *Traffic management* * *Ship-shore data exchange* * *Channel management* | * *High message payload* * *Satellite downlink* | * *Ship to ship collision avoidance* * *VTS* * *Tracking of ships* * *Locating in SAR* * *VDL control (by Base Station)* | * *Detection of vessels by coastal states beyond range of coastal AIS base stations* |

## 4.2 Outcome

This plan will provide a robust high-speed VHF data exchange capability. Additionally, this plan will thus address the present problem of increasingly congested conditions on AIS-1 and AIS-2, enable much better satellite detection of AIS even in crowded sea areas, and ensure that marine safety information can be disseminated effectively.

# ****5 Action planned by IALA****

IALA intends to take the following action:

– contribute to the VHF portion of the Working document toward a preliminary draft new Report ITU-R M.[COM-ENVIRO]-Worldwide Maritime Radiocommunication Plan (Annex 19 to Document 5B/167) in accordance with the content of this paper and provide further liaison support to ITU;

– consider the potential need for addressing migration issues (including backward compatibility);

– at the appropriate times, initiate communications via the IALA Council with ITU.

* Provide technical support and analysis for sharing studies under WRC-15 Agenda Item 1.16;
* Provide expert assistance to ITU in drafting the new international technical standard for VDES;

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