e-NAV14 Input

Agenda item 10.3

Task Number 14

Author(s) Canadian Coast Guard – Jean-Francois Coutu

Alternative Frequency Arrangement for VDES.

# Summary

Following the identification of concerns identified from the chosen usage of allocated frequencies for VDES at ITU WRC-12, Canada would like to propose a possible alternative usage of the same allocated frequencies that may address some of these concerns.

## Purpose of the document

The aim of this document is to identify some potential alternative solution for VDES in order to find the best possible design with the most acceptable compromises for both shore and ship implementation. More studies and test benches are required in order to identify the best solution.

## Related documents

The following related documents should be considered:

* [Ref1] e-NAV14-xx Brest Output 02 Draft Information Paper on VDES ver4.0.docx
* [Ref2] e-NAV14-xx Brest Output 03 WD Toward Preliminary Draft Rec ITU-R M VDES.docx
* [Ref3] e-NAV14-xx Brest Output 04 Technical Guidelines for VDES Implementation.docx

# Background

Following the International Telecommunication Union (ITU) World Radio Conference 2012 (WRC-12), existing channels were identified to be re-assigned to expand and improve digital communications in the VHF marine band. The combination of these frequencies and the AIS is now called VDES.

* Two duplex channels were identified to augment the capacity of terrestrial AIS (ch27 and ch28).
* Two simplex channels were identified to augment the capacity of satellite AIS detection (ch75 and ch76).
* Six duplex channels were identified to augment the digital data transfer capacity of VHF marine band communications (ch24, ch84, ch25, ch85, ch26, ch86). The six channels are referred to as VDE (VHF Data Exchange)

The ITU WP5B, in collaboration with IALA developed a system design for VDES. This design is well documented in the referenced documents above; and will not be repeated here. Canada’s assessment of the proposed VDES design reveals some drawbacks that may be considered critical:

* The VDES current design proposal has VDE and AIS frequencies very close to each other. So much so, that the two systems need to be interfaced in order for one not to interfere with the other. This makes the availability of the VDE dependent on the VDL load of the AIS which may vary in time. This introduces uncertainty in the availability and reliability of the VDE conduit to transmit MSI data, especially from shore to ship which is foreseen to be the bulk of usage of the VDE.
* At the shore station, the proximity of the frequencies will result in the AIS being deaf or desensitized while data is transmitted on the VDE. This is unacceptable by shore authorities. It may be possible to reduce this problem using advanced isolation techniques, but this should be properly evaluated, especially the impacts on AIS, before making a final decision on the VDES design.
* The current VDES proposal moves ASM messages to the 2 new AIS frequencies. We believe that this move is not sufficient to curb AIS VDL loading, even in the future, since the bulk of future AIS loading is believed to come from the addition of new devices wishing to use AIS in some innovative matter such as on fishing nets, icebergs, MOB, SART, etc. Furthermore, since the 2 new AIS frequencies are interleaved with the current AIS frequencies, a base station wishing to ensure reception of an ASM will need to make a slot reservation on all 4 frequencies, thus moving ASM to adjacent frequencies would have little to no impact on the available slots for ship based AIS transponders.
* As mentioned in [Ref3] “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)”

This document proposes an alternate VDES design for consideration that is based on the following fundamental principles:

1. No changes shall be needed to be made to the existing ship borne AIS equipment.
2. VDE will be used to transfer MSI information.
3. VDE will be mostly used to transfer information from shore to ship.
4. The system must also support ship-to-shore and ship-to-ship data exchange.
5. VDE and AIS should be two independent systems being able to work in full-duplex with each other on ship and on shore, thus reducing the inter-dependencies between the two systems. Shore transmission on the VDE should be available independently of the AIS VDL load.
6. VDE data transmission availability should be ensured within the system itself. This means that VDE is independent from other systems in accessing the available bandwidth.
7. Resolving the actual AIS loading problem should be the main purpose of using the newly assigned AIS frequencies (AIS 5 & 6).
8. VDE should be compatible with all WRC-12 decisions, including the revision of Appendix 18 in which the four simplex channels 2078, 2019, 2079 and 2020 were added

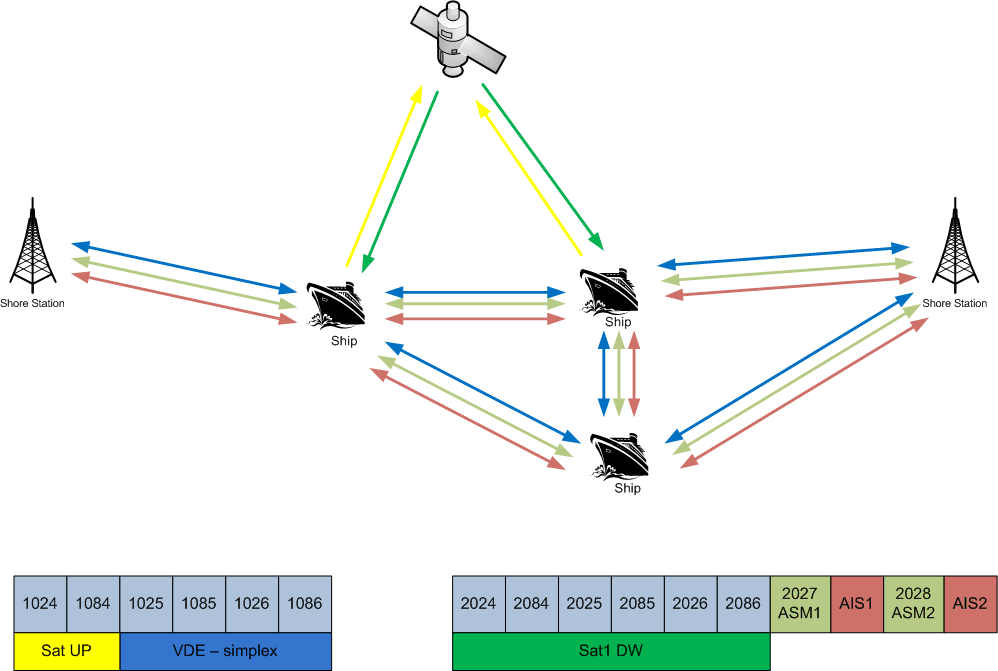
The Canadian Coast Guard would welcome any ideas or comments on how to improve this design. Additional requirements may wish to be added to the ones listed above.

# Discussion

The alternative VDES design proposal is very simple. It is resumed in the table below and the diagram on the next page. It consists of:

1. A simplex, 100khz wide-band channel located on channels 25A-85A-26A-86A for terrestrial VDE communications. Using ITU-R M.1842-1 based modulation, this channel may be able to reach data transfer speed up 307.2kbps. The access scheme would be SOTDMA as with AIS.
2. A 100khz wide-band channel located on channels 24B-84B-25B-85B for VDE satellite download.
3. A 50khz wide-band channel located on channels 24A-84A for VDE satellite upload from ships.
4. Two AIS “ASM” channels located on channels 27B and 28B to offload AIS 1 & 2.
5. Two AIS “long range” channels located on channels 75 and 76 for AIS satellite detection.

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| **Channel number in**  **Appendix 18** | **Transmitting frequencies (MHz) for ship and coast stations** | |
| Ship stations (ship-to-shore)  Ship stations (long range AIS)  Ship stations (ship-to-sat) | Coast stations  Ship stations (ship-to-ship)  Satellite-to-ship[1] |
| **AIS 1** | 161.975 | 161.975 |
| **AIS 2** | 162.025 | 162.025 |
| **75 (long range AIS)** | 156.775 (ships Tx only) | N/A |
| **76 (long range AIS)** | 156.825 (ships Tx only) | N/A |
| **2027 (ASM 1)** | 161.950 (2027) | 161.950 (2027) |
| **2028 (ASM 2)** | 162.000 (2028) | 162.000 (2028) |
| **2024/2084/2025/2085/2026/2086**  **(Sat downlink)**  **150khz channel** | N/A | (24/84/25/85/26/86, upper legs merged) |
| **2025/2085 (SAT Up link)**  **50 khz channel** | (1024/1084, merged) | N/A |
| **1025/1085/1026/1086 (VDE)**  **100 kHz channel** | (25/85/26/86, lower legs, merged - simplex) | (25/85/26/86, lower legs, merged - simplex) |



## Terrestrial VHF DATA Exchange (VDE)

The re-assignment of channels 25A, 85A, 26A and 86A would be used for terrestrial data exchange. The current proposal is to group channel channels 25A, 85A, 26A and 86A to create a wide-band 100Khz channel using highly efficient modulation (such as proposed in ITU-R M.1842-1) to achieve transfer data rates up to 307.2kbps.

We anticipate that **the great majority of data transferred using the proposed channels would be from shore to ship** to provide MSI information to ships. This proposal to **use the lower band frequencies of the proposed channels in simplex mode** (25A-85A-26A-86A) would allow enough separation from AIS for co-location and **simultaneous use of both systems without risk of interference**.

Possible use could include broadcast of water levels, lock orders, buoys status, met/hydro, advisories, air gap, GPS and DGPS status, recommended routes updates, weather warnings, etc. More data intensive applications could also be considered, such as updated bathymetry and ice charts, tide & current modeling results, squat calculations and recommended route based on projected fuel consumption.

## VDE Satellite Downlink

The re-assignment of channels 24B, 84B, 25B, 85B, 26B and 86B would be used for satellite data download. The current proposal is to group channel channels 24B, 84B, 25B, 85B, 26B and 86B to create a wide-band 150Khz channel.

We anticipate that the great majority of data transferred using the proposed channels would beto provide MSI information to ships.

Possible use could include broadcast of met/hydro, advisories, recommended routes updates, weather warnings, etc.

## VDE Satellite Uplink

The re-assignment of channels 24A and 84A would be used for satellite data upload from ship to satellite. The current proposal is to group channel channels 24A and 84A to create a wide-band 50Khz channel.

We anticipate that the great majority of data transferred using the proposed channels would beto acknowledge the MSI information sent to ships on the VDE satellite download, to request particular MSI from shore based authority or to report particular ship information to shore authorities.

## Offloading AIS1 & 2 with Channels 27B and 28B

It is believed that offloading of AIS channels 87B and 88B will be **especially beneficial to shore authorities** monitoring vessel activity on the AIS because it will ensure them that they will receive more ships, more often. This is because **AIS channels over-loading has very little effect on the ships.** The AIS built-in slot reuse algorithm will automatically choose to “interfere” with ships that are the farthest away to preserve information of the closest vessels. Of course this is on purpose since AIS equipped vessels are mostly concerned with targets within the immediate surroundings of the ship.

CCG considers that the use of ch 27B and ch 28B would be sufficient to achieve the desired results of offloading the AIS channels 87B and 88B. The re-assigned simplex channels (ch 27B and ch 28B) should be easily integrated in the existing AIS system since AIS already uses a tunable transmitter. Additional receivers would need to be added but the channels being adjacent to existing AIS channels, it is expected that filtering would be simple and easily achievable.

Different modulation schemes (such as proposed in ITU-R M. 1841-1), especially more efficient ones, than the one currently used for AIS (ITU-R 1371 GMSK) should be considered for channels 27B and 28B. CCG believes that the implementation of **more efficient modulation scheme for the new channels is essential** to reach the desired benefits of augmenting the capacity of the AIS for shore authorities.

The off-loading of current AIS channels would be achieved by moving certain AIS messages to the newly assigned frequencies. The CCG made two observations regarding this strategy:

* In our experience, the messages targeted to be moved to the new channels are almost equally broadcasted from shore than from ships.
* Additionally, the AIS stations of shore-based authorities are deaf while transmitting (because of the proximity of the channels).

From these two observations, the CCG concludes that **most benefits would be reached if a more efficient modulation scheme was chosen** (such as proposed in ITU-R M. 1842-1) for the new channels 27B and 28B to maximize the listening time of shore-based AIS stations by minimizing the broadcast time of messages. As discussed in the VDE section of this document, additional benefits would be reached by **moving as many broadcasts as possible; especially information carried using ASM messages to farther away frequencies such as VDE**.

As a result, the proposition is to expand the use of ch 27B and ch 28B to allow for additional AIS devices (such as SART, EPIRBs, MOB, etc) as well as ASM messages (msg 6-7-8) and safety related messages (msg 12-13-14) leaving only the collision-avoidance and identification functions of the AIS on existing channels 87B and 88B.

## Satellite AIS Detection (ch 75 & ch 76)

The re-assignment of channels 75 and 76 will augment the capacity of the satellite detection of AIS. The impacts of this re-assignment are negligible as these channels were already assigned as guard-bands of ch16. Studies have demonstrated that using these channels from earth to space has no impact on ch16. The use of those 2 channels would be used for ships to transmit message 27 which is the long-range AIS position report.

## Shore Side VDES Design.

The shore side VDES design should be fairly simple. We assume here that the shore based AIS station is using a software tunable transceiver already able to transmit on new “ASM” channels 27B and 28B. Hence, beside adding (or activating) additional receivers on the AIS base station to enable use of the two additional “ASM” channels, the shore side would need to be equipped with a VDE simplex radio independent of the existing AIS equipment.

The proposed location of the VDE wide-band channel is strategically located on the lower frequencies of the VHF band to keep it as far as possible away from existing transceivers on shore stations and the AIS. As such, RF isolation should be easily achieved. This provides full duplex operation between the VDE and AIS which is highly desirable.

The only downside of this design on the shore based stations is that transmission on the VDE by shore station may interfere with receivers or create desensitization of VHF receivers co-located. The proposed scheme should provide sufficient frequency separation to be able to mitigate these problems with standard isolation technology. For example, 487.5 khz separation with channel 16 and 337.5khz separation with channel 19 is provided.

There is no satellite capability on at the shore VDES station.

## Ship Side VDES Design.

On the ship, the VDES would be implemented by first adding (or activating) additional receivers on the AIS transponder to enable the use of the additional “ASM” channels 27B and 28B. We assume here that the ship based AIS station is using a software tunable transceiver already able to transmit on new “ASM” channels 27B and 28B. Hence, beside adding (or activating) additional receivers on the AIS transponder to enable the use of the two additional “ASM” channels, the ship would need to be equipped with a VDE simplex radio independent of the existing AIS equipment.

The proposed VDE simplex channel is strategically located to allow complete duplex operation with the AIS on-board. It should be easy to isolate the two systems from each other on the ship because of the frequency separation. The following downsides are forecasted for the ship implementation:

1- The VDE reception will be impaired by a VHF transmission from the ship. Depending on the frequency used for VHF transmission, the VDE receiver might be deaf or simply desensitized. This should be tested and measured, but it is believed to be acceptable if VDE is repeating MSI information regularly or if there is an acknowledgment / retransmission / error correction system available for VDE important data.

2- The VDE reception will be impacted by a VDE satellite uplink transmission. This is believed to be acceptable since VDE satellite uplink may only be used outside the range of VDE shore stations. Furthermore, the VDE satellite uplink should only be used for quick and infrequent transmissions.

3- The VDE satellite downlink reception may be interfered with ship AIS or “ASM” transmissions. This is believed to be acceptable because ship AIS transmissions are quick and infrequent transmissions. Furthermore, this may be mitigated if there is an acknowledgment / retransmission / error correction system available for VDE important data.

# Action requested of the Committee

The Committee is requested to use the document as a basis for encouraging members to present studies that evaluate different VDES designs in order to find the best possible solution to meet eNavigation user requirements, both shore-based and ship-borne.

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