Executive Summary

The Second Workshop on International Standardization of VDES was held from 20th to 24th January 2014 in Tokyo, co-hosted by the Ocean Policy Research Foundation and the Japan Coast Guard. Thirteen overseas experts and twenty-four Japanese experts in the field of AIS and maritime radiocommunication participated in the meeting.

On the first day, the presentation and panel discussion was held at the Nippon Zaidan building in Tokyo and seven experts and one JCG officer made presentations regarding VDES. At the Panel Discussion, seven experts discussed various matters on VDES presided over by the moderator. There were about 130 attendees and they asked various questions after each presentation.

The meeting was also held at the Nippon Zaidan Foundation building on the second, third and last day. The agenda covered various technical and operational fields of VDES. The participants made an active and eager discussion on the agenda and developed the conclusion which is attached at the end of this executive summary.

The technical tour to the Tokyo-wan Vessel Traffic Service (VTS) Centre was carried out on 23rd January 2014. The experts observed practical VTS operation and maritime radiocommunication conducted by the centre. They also enjoyed Japanese tradition of cuisine and landscape along the way as well as other social events held during the Workshop.
CONCLUSION

THE SECOND WORKSHOP,

RECALLING that the First Workshop on International Standardization of Next Generation AIS that was decided to be called VHF Data Exchange System (VDES) by the First Workshop, was so successful with many outcomes regarding e-navigation, modernization of GMDSS and other maritime activity;

ALSO RECALLING that by the report of the First Workshop, the concept of VDES was well recognized and widely discussed in maritime society including IMO, ITU and IALA;

RECOGNIZING that ITU-R WP5B now conducts the study on VDES that is provisionally supported by IMO and, in conjunction with ITU and IMO, IALA is also actively involved in the study and makes significant contribution to the study;

ALSO RECOGNIZING that the 2015 World Radiocommunication Conference (WRC-15) will discuss and decide the regulatory matters under the Agenda item 1.16;

HAVING NOTICED that taking the opportunity of the First Workshop or e-navigation testbed, various testbeds and projects for the development of VDES were started or planned;

HAVING ALSO NOTICED that there are a number of VDES testbeds in progress with preliminary results that support the development of VDES;

HAVING FURTHER NOTICED that the number of overseas experts at the Second Workshop is more than doubled compared with the First Workshop, showing the importance of the development of VDES;

CONCLUDES

1. More study, research or test is required in order to develop international standards on VDES;

2. Details including data volume of user requirements presented measures by common methodology should be identified for the development of VDES using the IALA e-NAV Committee working documents as the basis of the identification;

3. Coordination of operation of VDES, especially shore side stations may be
necessary for the implementation of VDES and operation concept should be developed for the coordination;

4. Commercial usage of VDES that can contribute to the purpose of e-navigation may be included depending on priority of communication (to be developed);

5. Sharing of the results of testbed, study, research or project on VDES in accordance with the IALA Guideline 1107 is valuable and useful for further development of VDES;

6. Guidance on the operational use of the VDES will be required to encourage effective implementation of the system;

7. The workshop highlighted the need to develop means to ensure data quality, integrity, encryption and authentication;

8. Considering the successes of the First Workshop, the initiative taken by the Ocean Policy Research Foundation (OPRF) to host the Second Workshop is greatly appreciated;

   ENCOURAGES

1. Authorities, organizations and manufactures to conduct more study, research, testbed or project on VDES and to share the results with international society;

   RECOMMENDS

1. The Japan Coast Guard to immediately report the results of the Second Workshop to the intersessional meeting of the AIS and Communication Working Group of the IALA e-NAV Committee in March 2014 and IALA should continue the development of VDES by inter-acting with the Workshop;

   AND INVITES

1. The Ocean Policy Research Foundation to consider the continuation of the Workshop.
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Report of 2\textsuperscript{nd} Workshop on International Standardization of VDES

1. Background
Automatic Identification System (AIS) technology is very useful and effective and the usage of AIS is now expanding rapidly. However due to this rapid expansion, it has been identified that there will be a possibility that the AIS VHF Data Link (VDL) will be overloaded in future. At 2012 World Radiocommunication Conference (WRC-12) International Telecommunication Union (ITU) adopted Resolution 360\textsuperscript{[COM6/21]} (WRC-12): Consideration of regulatory provisions and spectrum allocations for enhanced Automatic Identification System technology applications and for enhanced maritime radiocommunication, and decided to consider this matter in WRC-15 as 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\textsuperscript{[COM6/21]} (WRC-12).

Responding the situation, the Ocean Policy Research Foundation (OPRF) and the Japan Coast Guard (JCG) considered the necessity of an international meeting for ‘next generation AIS’ development and held the first Workshop on International Standardization of the ‘next generation AIS’ in December 2012 in Tokyo. The first Workshop developed the concept of VHF Data Exchange System (VDES) and identified many functional requirements for VDES.

JCG reported the results of the first Workshop to IALA and then ITU and the International Maritime Organization (IMO) through the International Association of Lighthouse Authorities (IALA). As the result, VDES concept was recognized in the maritime and radiocommunication community and many studies on VDES were started.

Taking the situation into account, the OPRF and JCG decided to hold a second Workshop on International Standardization of VDES and invited overseas and domestic AIS experts from national authorities, institutions and AIS related commercial companies. The second Workshop was held from 20\textsuperscript{th} to 24\textsuperscript{th} January 2014 at the Nippon Zaidan Building in Tokyo, JAPAN. The number of overseas experts was doubled compared with the first Workshop, highlighting the importance of the development of the VDES. The agenda is attached as Annex 1 and list of the participants is also attached as Annex 2.
2. Courtesy call to the JCG
Ten foreign experts made a courtesy call to VADM Kenji Nagamatsu, Director General, Maritime Traffic Department, JCG at the JCG Headquarters on the first morning. VADM Nagamatsu welcomed all experts by expressing his appreciation to the experts for accepting the invitation and coming to Japan. In response, the experts thanked the JCG and OPRF for hosting this valuable workshop.

3. Presentations and Panel Discussion
On the afternoon of the first day, presentations and a panel discussion were held. The first part of this event included presentations from the five overseas experts and three Japanese experts. LCDR Takeuchi, engineer of JCG, introduced each presenter as the master of ceremony. The summary of each presentation is as follows:

3.1. CDR Hideki Noguchi (JCG)
CDR NOGUCHI reported the results of the first Workshop that was held in December 2012. The Workshop was aimed at developing a possible draft for an international standard on next generation AIS. At the first Workshop, the participants first discussed the definition of next generation AIS and developed the basic concept of VHF Data Exchange System (VDES). They then identified the functional requirements for VDES, focusing on the modernization of the Global Maritime Distress and Safety System (GMDSS) and e-navigation. He concluded that the first Workshop was very successful and that he had high expectations for the second Workshop. A copy of his presentation is attached as Annex 3.

3.2. Mr. Stefan Bober (Germany Federal Waterways and Shipping Administration)
At beginning, Mr. Bober showed the success story of AIS and explained the necessity of VDES that could prevent the overload of AIS. He also explained the overview of VDES using the figures of maritime communication that connected between ship - ship, ship - shore and ship - satellite. He then described how VDES could support e-navigation and future GMDSS and showed the roadmap of VDES development. A copy of the presentation is attached as Annex 4.

3.3. Mr. Ross Norsworthy (United States Coast Guard)
Mr. Norsworthy started his presentation by introducing the present channels of marine digital communications in VHF band. He then described some consideration points for new digital service. He explained technical details and guideline for VDES implementation that showed channel plan, modulation methods, and filtering design of VDES. He summarized his presentation by proposing some actions. A copy of the
presentation is attached as Annex 5

3.4. Mr. William Kautz (United States Coast Guard)
Mr. Kautz presented the movement of ITU regarding VDES. He reported the results of WRC-12 that decided the start of study on future AIS and maritime digital communication under the Agenda item 1.16 of WRC-15. He explained that now ITU-R WP5B studied VDES concept for preparing CPM text for WRC-15 with its work plan. He added that WRC-18 will also consider the spectrum allocation for GMDSS modernization and e-navigation. A copy of the presentation is attached as Annex 6.

3.5. Mr. Rolf Zetterberg (Swedish Maritime Administration)
Mr. Zetterberg presented the movement of IALA regarding VDES. He explained the background and IALA procedure of work and then described IALA work on maritime communication system and AIS. IALA is now working with IMO and ITU for developing VDES and e-navigation. He finally explained the IALA future work plan of VDES and pointed out that there was kind of contradiction in IMO regarding e-navigation that was needed to be solved in future. A copy of the presentation is attached as Annex 7.

3.6. Mr. Yasuhiro Nakagawa (Furuno Electric Co., Ltd.)
Mr. Nakagawa started his presentation by describing the current situation of VDES development and then pointed out some considerations on the development of VDES. First is that there is possibility of interference to AIS by the adjacent channel that are planned to use for AIS Application Specific Messages (ASM). Second is slot allocation of VDES for avoiding the slot collision of AIS/ASM/VDE (SAT). Third is optimization for VDES design. A copy of the presentation was attached as Annex 8.

3.7. Mr. Yoshio Miyadera (Japan Radio Co., Ltd.)
At the beginning, Mr. Miyadera introduced his company’s history and products of radio communication. Then he proposed sharing method of terrestrial and satellite VDE that share time slot during satellite downlink. He also insisted the need of study on multipath fading because the effect of multipath on sea surface by maritime mobile VHF station was not well understood. A copy of the presentation was attached as Annex 9.

3.8. Mr. Gaetan Fabritius (CLS)
After introducing CLS, Mr. Fabritius described justifications of satellite VDES. He then said that CLS and European Space Agency (ESA) conducted preliminary study of satellite VDES and planned to launch an experimental satellite after 2015. He invited other interested parties to join the study especially from Japan. A copy of the presentation is attached as Annex 10.
After the presentations, the event moved to the second part which was a questions and answer session from the audience with a panel discussion. The moderator was CDR Noguchi and he invited 7 speakers, Mr. Bober, Mr. Norsworthy, Mr. Kautz, Mr. Zetterberg, Mr. Nakagawa, Mr. Miyadera, and Mr. Fabritius on the stage.

The moderator commenced the session by asking the panel their views on when VDES will be realized. Mr. Bober answered that it was quite challenging to keep the road map on the development of VDES. Mr. Miyadera explained that the frequencies for terrestrial VDE were already allocated and terrestrial VDE was already available. He added that the frequencies for satellite VDES could be allocated by WRC-15. Mr. Zetterberg pointed out that before completing international standards on VDES, many tests would be needed.

The moderator also asked panel members considering the recent news on AIS vulnerability, whether VDES needs to have counter measures against the cyber attacks, such as spoofing. Mr. Norsworthy answered that it is impractical to encrypt AIS because AIS messages should be seen by the AIS equipment on other ships. He also pointed out that spoofing of AIS message can be detected easily from shore station, such as Vessel Traffic Service (VTS), because they have enough data to detect spoofing. Mr. Fabritius also noted that the satellite component of VDES is valuable because it can detect spoofing easily.

The first question from the audience was concerning the persistent coverage for satellite VDES, and if the satellite VDES could be used for 24 hours operation such as maritime surveillance or port management, what satellite constellation would be required and the status of allocation of specific slots. Mr. Miyadera answered that his proposal for satellite slot allocation is for Low Earth Orbit (LEO) and if using Medium Earth Orbit (MEO) satellite such as Iridium, it needs higher frequencies.

The second question from the audience was regarding the plan for launching the VDES satellites. Mr. Fabritius noted that a small demo-satellite will be launched in a few years. Mr. Norsworthy also commented that the future vision encourages the business on satellite VDES and the frequency allocation for satellite VDES are required.

The third question had two issues. The first issue was about the influence of high VDL loading, such as has been reported for the Gulf of Mexico. The second issue was about the practical usage of high speed data exchange of VDES. With regards to the question on the influence of high VDL loading Mr. Bober said that there could be the problem in the communication between a shore station and a ship station, but not ship to ship. Mr. Norsworthy pointed out that the high VDL is not the problem for navigational safety
perspective as the impact for ship to ship is simply a reduction in the range of the system – vessels will still receive information on those vessels closest to them. On the other hand, high VDL loading is a problem for the communications aspect of AIS. With regards to the practical use of VDES Mr. Bober pointed out that maritime communication via VDE is one of the examples of the possible usage of VDES. Mr. Tetreault of the United States Army Corps of Engineers (USACE) noted that USACE already provides valuable information including the number of vessels approaching the lock, the water level in the inland waterway, and the weather information for inland waterway users by ASM and that these ASM will be candidates for VDES information. Mr. Zetterberg pointed out that there is a problem to develop VDES in the optimized way because how it is going to be used is still unclear in the e-Navigation process of IMO.

The fourth question was about the influence of frequency masking from adjacent channels to the current AIS channels / proposed VDES channels. Mr. Nakagawa noted that VDES channel plan must be carefully considered in order not to impair the main function of AIS. Mr. Miyadera also noted that the presentation made by Mr. Norsworthy was a useful reference to this question.

The fifth question was about the slot collision detection method in the VDE communication protocol for terrestrial and satellite VDES as proposed by JRC. Mr. Miyadera explained that the terrestrial VDE link would use only limited slots when satellite VDE downlink was available and that Carrier Sense Time Division Multiple Access (CSTDMA) could be used for the detection of satellite downlink.

The sixth question was regarding the timing of modulation and demodulation of VDE. Mr. Norsworthy answered that VDES is looking to use an efficient modulation such as Differential 8-Phase Shift Keying (D8PSK) or 16 Quadrature Amplitude Modulation (16-QAM).

Finally, the moderator expressed his appreciation to the speakers for their presentations and for answering various questions and to the audience for participating in this event. The panel discussion was concluded and the session adjourned.

4. Opening of the meeting
CDR. Noguchi took the role of the chair and introduced CAPT. Igarashi, Director Aids to Navigation Engineering Division, JCG, who welcomed every participant and expressed his appreciation to the presenters of the panel discussion held on the 1st day of the workshop. He stressed that the result of this workshop will have an important role on the international standardization of VDES.
After the remarks, LCDR Takeuchi took the role of the secretariat and informed the participants of the administration matters during the workshop.

5. Approval of the agenda
The provisional agenda was approved.

6. Development of VDE radio
Four presentations were made at this session.

Mr. Imada of JRC presented their study on multipath fading for VDES. In the presentation, he showed the initial results of simulation on the characteristics of the VHF multipath fading for maritime mobile. He also demonstrated the physical simulation system equipment which drew the interest of all participants. His presentation slide is attached as Annex11.

Mr. Johan Lindborg of SAAB provided a presentation on the research into AIS spectrum mask by using the existing SAAB SDR AIS base station. In the presentation, he also pointed out a number of matters to be defined in the international standards of VDES, including:

- deciding on a channel plan,
- selecting the most effective waveforms,
- determining radio performance required for each waveform,
- defining the number of concurrent transmitters required,
- identifying duplex requirements, and
- discussing the possibilities of a one or two box solution.

His presentation slide is attached as Annex12.

Mr. Jan Safar of the General Lighthouse Authority (GLA) introduced the current project regarding VDE channel sounding. He noted that GLA plan to conduct a short sea trial as part of the project. His presentation slide was attached as Annex13.

Then, Mr. Nakagawa made a presentation on TDMA slot allocation for VDES. In his presentation, Mr. Nakagawa noted that Furuno has started a project to simulate TDMA slot allocation to overcome interference in the frequency channels of VDES. He highlighted that this project has recently commenced, and that the report of the study will be provided at a later date.
Each presentation generated discussion on the aspects of the technical standards required for VDES.

Following the presentations and discussions, the participants agreed that:

- Initial work regarding VDES is encouraging, and there are a number of projects currently underway. The results of these projects should be forwarded to ITU WP5B, ideally for the May 2014 meeting.
- There is a need to consider the practical application of the VDES further, and Priority for trials should focus on designating the frequencies for ASM and the allocation the frequencies for satellite VDES at WRC-15.
- While it will be important to determine the final channel plan and waveform for the VDES, this work is not required to be completed by WRC-15. What will be required is to ensure that sufficient progress has been made in the tests to validate the use of the spectrum.

The Chair asked the participants if somebody planned other VDES study or research. Mr. Norsworthy informed that the study on VDES was also planned in the US. Mr. Miyadera noted studies that were occurring in Korea. A brief overview of the work was presented by Mr. Miyadera.

7. Terrestrial VDES technical aspect
After the first agenda, Mr. Miyadera proposed new ideas on transmission of VDES ASM. The participants agreed that every new idea or proposal on ASM transmission is welcomed and considered in the future meeting.

The following technical methods were discussed for slot allocation of VDES.

- CSTDMA
- Incremental Time Division Multiple Access (ITDMA)
- CSTDMA for the entry to VDES communication and ITDMA for transmission of data

The participants agreed that they would consider the slot allocation method following the workshop.

Regarding the VDES ASM, the participants agreed that VDES ASM will be mainly transmitted from shore stations though, some VDES ASM may also be transmitted from shipboard stations. At the present time it is difficult to identify the ratio or percentage of
VDES ASM from ship and shore stations.

8. Satellite VDES technical aspect
Regarding the sharing proposal made by JRC presentation on the first day, some participants expressed a concern that four time slots allocation for satellite downlink may be overly generous and could limit the terrestrial slot allocations. Responding to the concern, Mr. Miyadera explained that the number of time slots is flexible and if needed, allocation of time for satellite downlink can be applied in not only TDMA frame level but also multiframe or superframe level.

Mr. Lindberg asked if any coordination exist among satellite service providers regarding satellite downlink. Ms. Browning of exactEarth and Mr. Fabritius answered that the coordination among satellite service providers is challenging but possible, however before finalizing the coordination approach, the operation concept is needed.

The Chair asked if there are any other sharing studies in progress or planned. Mr. Norsworthy informed that ITU-R WP5B already asked other radiocommunication sectors, such as the land mobile sector, and there was no opposition to VDES. Mr. Fabritius also informed that ESA and CLS have invited the partner of their study on satellite VDES but there is no reply yet.

Mr. Zetterberg also asked if the funding for VDES satellite is possible. Mr. Fabritius confirmed that the funding is always a problem for satellite business but, considering AIS satellite case, he said that it would be possible.

9. Application and data volume
The Chair asked the participants regarding proposed VDES application. The participants answered that the following examples are to be considered in the application of the VDES:

- As an addition to AIS ASM used in inland waterways to provide hydro-dynamic data and bathymetry data
- Route exchange (as per the Mona Lisa concept)
- Provision of Under Keel Clearance data in support of real-time data input for UKC management systems.
- Provision of Pilot information
- Indication of navigational intention to assist with collision avoidance

Mr. Haugen of Kongsberg pointed out that the IMO e-navigation Correspondence Group
has already identified user requirement and that this becomes the reference of VDES application. Ms. Browning informed that the WG 3+4 of IALA e-NAV Committee already studied the e-navigation user requirement for VDES, as well as the Canadian Coast Guard study and the working document is still remain in the WG 3+4.

The Chair asked the participants if it is envisaged that commercial usage of VDES would be allowed. The participants agreed that if the commercial usage is related to the purpose of e-navigation, i.e. safety, security, efficiency of navigation and protection of marine environment, it may be allowed.

Regarding the commercial usage, Mr. Miyadera also asked if e-mail would be allowed in VDES application since ITU-R M.1842-1 already identified that one of the usage of VDES is e-mail. The participants agreed that e-mail related to operations (public correspondence) may be allowed, however personal e-mail would not be considered in the usage of VDES.

Then the Chair asked if a coordination body is needed for the implementation of VDES. The participants agreed that such coordination will be needed.

LCDR Takeuchi provided a presentation on data volume of safety related information as assessed by the JCG. His presentation was attached as Annex14. In the presentation he introduced the data flow of safety related information including weather information and streaming video on the web provided by JCG. Based on the calculations, he concluded that VDES will have enough capacity for safety related information but not for streaming video. To address the limitations, he concluded that the streaming video will need to be downsized. After his presentation, participants noted that more study on data volume in different cases would be welcomed to the development of VDES. In concluding the discussion on data volume, the participants agreed that common methodology to measure data volume was required.

Mr. Fabritius introduced the Movimar project, which is being conducted in Vietnam with the support of France. This project highlights a possible application of VDES, especially satellite VDES, in the fishing community.

10. Authentication & Encryption
In reference to the Trend Micro report on vulnerability of AIS problem, the Chair asked the participants if authentication or encryption of VDES messages is needed. Mr. Norsworthy pointed out that, in the case of AIS, it is not good idea to encrypt data which everyone supposes to get. He also noted that it is the responsibility of shore station authorities to validate the information from ships. He added that the shore authorities
easily identify AIS stations using MMSI, so the authentication is possible. However some participants pointed out that the current MMSI has problems for the identification and other identifier such as IMO hull number is better to use. Looking to the concept of authentication for VDES, it was agreed in principal that authentication should be considered, as well as additional verification aspects, such as forward error checking, to validate data.

The Chair asked the participants if the cancellation message will be required for VDES if there was a situation where incorrect data was being provided. Participants agreed that cancelation message would have issues, especially noting that the ‘cancellation’ aspect could also be hacked. The discussion concluded that a cancellation message will not be needed since it may jeopardize the safety of navigation.

Then, the Chair asked the participants the position of each country on the free provision of the AIS data on the internet, which IMO MSC condemned. The positions were different from countries to counties. Ms. Carson-Jackson of the Australian Maritime Safety Authority (AMSA) pointed out from the legal point of view that it is not possible to stop the free provision of AIS data by privately owned AIS receivers. Dr. Fukuto of the National Maritime Research Institute noted that free provision of AIS data contributed to the safety navigation in Osaka-bay, Japan where AIS data and radar information were open to public. Mr. Zetterberg noted that AIS data collected by the Swedish Maritime Administration can be sold to organizations that provide value-added applications.

LCDR Takeuchi pointed out that it was appropriate to authenticate VDES messages on the application layer. The participants agreed it.

LCDR Takeuchi also commented that public key authentication was a possible solution to authenticate VDES messages. Responding to the comment, Ms. Browning pointed out that an actual key exchange was the problem. Dr. Haley of the University of South Australia noted that the development of vehicle safety system faced a similar problem with key management. He also pointed out that key management should be done by traffic management (competent) authorities.

11. Testbeds
The Chair invited the participants to share the information about testbeds for the development of VDES. Some participants informed of testbeds or project regarding VDES which they knew or their organization planned. The participants agreed that the result of testbeds and projects should be shared in accordance with the IALA Guideline 1107 “Reporting of results of e-Navigation testbeds”. JCG made the list of testbeds / projects using the template from the IALA Guideline. The list is attached as Annex16. Mr.
Norsworthy stressed that the results of each testbed should be sent to ITU.

12. Any other business
Mr. Miyadera kindly informed that Korean institute had also conducted a study on VDES and developed prototype. He said that he would invite the Korean institute to attend the intersessional meeting in March if possible.

Mr. Miyadera also noted out that the sharing method of terrestrial and satellite VDE proposed by him at the panel discussion on the first day was just a possible method, and invited participants, especially satellite companies, to continue more study on the modulation used by satellite VDE.

Mr. Yauchi of the Oki Consulting Solutions Co. Ltd. invited manufacturers to develop the 25kHz and 100kHz VDE modem and to combine it with AIS.

After the discussion, the participants developed the Executive Summary of the workshop and produced eight conclusions and one recommendation. The Executive Summary was attached on the beginning of the report.

13. Official Reception
The official reception of the workshop hosted by the JCG and the OPRF was held at the restaurant of the Nippon Zaidan Building in the evening of 21st January 2014. After the opening speech of VADM Nagamatsu, the participants and guest enjoyed conversation on the aspect of VDES development, and deepened their friendship.

14. Technical tour
The technical tour to the Tokyo-wan Vessel Traffic Service Center, Yokosuka, Kanagawa, was conducted on 23rd January 2014. Following the presentation that introduced the history and operation of the center, the participants observed the VTS operation room, noting especially the usage of AIS for VTS. The staff of the center commented that AIS is very useful and valuable for the operation and contributes the safety of navigation significantly. The participants were impressed with software using AIS that automatically detects a ship in danger such as overspeed, course departing from the traffic channel, course that could lead to grounding, dragging the anchor. When an alert arises, the VTS operator sends the warning using AIS message. On the return journey, the participants had an opportunity to enjoy Japanese tradition and culture at the Kotokuin temple.
15. Closing the meeting
The Chair expressed his appreciation to the participants for their contributions to the workshop. He added that very good results were achieved by the contributions. The participants responded by saying that they were most grateful to the JCG and the OPRF for hosting the workshop, especially to the Chair and the secretariat of JCG officers and an interim for their hard work. The Chair wished everyone a safe journey home and then declared the meeting closed.
Agenda Item

1. Adaption of agenda

2. Development of VDE radio

3. Terrestrial VDES

4. Satellite VDES

5. Applications & Data Volume

6. Authentication & Encryption

7. Testbeds
PARTICIPANTS

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Swedish Maritime Administration

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Mr. Jan SAFAR  
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United States  Mr. William David KAUTZ  
United States Coast Guard

Mr. Ross Walter NORSWORTHY  
United States Coast Guard

Mr  . Brian TETREAULT  
United States Army Corps of Engineers
Results of 1st Workshop

CDR Hideki NOGUCHI
Japan Coast Guard

20 January 2014
Workshop for International Standardization of VDES
1st Workshop

- Name: Workshop on International Standardization of Next Generation AIS
- Date: 3rd – 7th December 2012
- Venue: Nippon Zaidan building
- Participants: 26 experts from 6 countries (Australia, Canada, Germany, Japan, UK, US)
Agenda

- Definition of next generation AIS
- Next generation AIS in GMDSS
- Next generation AIS in e-navigation
- Application of next generation AIS
Definition of next generation AIS

- AIS: ITU-R M.1371-4
- VDE: ITU-R M.1842-1

VHF Data Exchange System (VDES)

VHF Data Exchange System (VDES) is VHF maritime data communication system that includes functions of AIS, facilitates e-navigation, supports GMDSS modernization and general maritime communication.
VDES in GMDSS

IMO/ITU EG 8 (Sep, 2012) agreed that the following new equipment, systems and technologies (extract only VDES related) might be included in the modernized GMDSS.

- AIS, included satellite monitoring of AIS and additional AIS channels for identification but not alerting;
- VHF data systems;
- Application Specific Messages over AIS or VHF data systems;
- Man Overboard Devices;
- AIS and GNSS-equipped EPIRBs.
VDES in GMDSS

Referring to the list, the 1st Workshop agreed that the following functions could be included. VDES could:

- include alerting function with nature of distress using existing message;
- include acknowledgement using existing message;
- be able to receive distress alert and acknowledgement;
- include reliability on latency of the data being transmitted;
- include locating and identification capability;
- include data communication capability between ship-ship, ship-shore and ship-SAR aircraft and support subsequent communication;
VDES in GMDSS

- include MSI promulgation;
- be capable of urgency and safety alerting/ acknowledging and communication;
- be capable of transmitting messages with the priority of distress, urgency, safety and general;
- provide access to data or data base for assist SAR automatically and autonomously.
VDES in e-navigation

Before the 1st Workshop, IMO e-navigation Correspondence Group identified the following e-navigation solutions for shipboard, SAR and shore-based users.

- Improved, harmonized and user-friendly bridge system
- Means for standardized and automated reporting for shipboard users
- Improved reliability, resilience and integrity of bridge equipment and navigation information
- Integration and presentation of available information in graphical displays on board received via communication equipment
- Information management
VDES in e-navigation

- Improved access for relevant information for SAR
- Improved reliability, resilience and integrity of bridge equipment and navigation information provided by shore-based users
- Improved and harmonized shore-based systems and services
- Improved communication of VTS service portfolio

The 1st Workshop agreed that some solutions for shipboard users might be applied to shore-based users.
VDES in e-navigation

Corresponding with the solutions, the 1st Workshop identified the following VDES functions for e-navigation. VDES should:

- use high level interface (e.g. IEC 61162-450);
- use common phrase of communication;
- permit text message;
- use S-100 and Common Maritime Data Structure (CMDS);
- use common templates;
- use automatic timing based on events;
- use machine to machine communication;
- use user-friendly human interface;
VDES in e-navigation

- provide multiple access to information network amongst ships and shore users;
- have the ability to cross check multiple sources of critical navigation information;
- use a standard management method for incorrect data;
- use automation in action, integrity and interface;
- enable automatic updates based on events;
- access the update status by globally available means;
- use short text message;
- use additional data beyond voice communication (machine to machine communication)
VDES in e-navigation

- prioritize SAR message in slot management;
- enable gathering necessary information from different data sources shore and onboard;
- provide efficient remote access to ship owners;
- provide an automated record of data transfer;
- use automatic selection of access means;
- use automatic exchange of data and information;
- use automated access to shore based data base of information regarding navigation and others (e.g. metrological, hydrographical, traffic);
VDES in e-navigation

- use automated broadcast of information regarding navigation and others;
- use automatic and autonomous data communication;
- use automatic and accurate logging of data communication.
Overarching functions

The 1st Workshop also discussed and identified other functions. VDES should:

- provide an acknowledgement of message;
- use S-100, Common Maritime Data Structure and high level interface (e.g. IEC61162-450);
- use self-diagnostic and heartbeat function;
- use Recommendation ITU-R M. 1842-1 (update);
- have secure communication capability.
Conclusion

- 1st Workshop developed the concept of VDES.
- 1st Workshop triggered the development of prototype radio.
- The result was reported to IALA and then ITU and IMO.

⇒ High expectation for 2nd Workshop
Second Workshop
Provisional Agenda

- Development of VDE Radio
- Terrestrial VDES
- Satellite VDES
- Application and Data Volume
- Authentication and Encryption
- Testbed
AIS today
VDES concept
VDES applications
Roadmap

VDES – VHF Data Exchange System
Overview

RTCM Paper 061-2014-SC123-103
WSV.de
JCG

Wir machen Schifffahrt möglich.
AIS – a successful story

- IMO introduced AIS in 2002
- Mandatory for SOLAS vessel
- Other users like fishing fleet, inland shipping, recreational vessel, etc.
- AIS equipment like AIS AtoN, AIS SART, AIS MOB, EPIRB AIS, „innovative use“
- AIS shore based infrastructure for VTS, ship reporting, others
- AIS tracking by satellite

-> More than 100,000 AIS stations globally
AIS – a successful story

AIS today
VDES concept
VDES applications
Roadmap

Workshop
VDES
20.-24.2014
Tokyo
AIS – a successful story

- expanding use of AIS technology causes significant load of the AIS channels
- emerging high VDL loading in busy areas
  - Gulf of Mexico 64%
  - Korea 40%
  - Japan 40%
- future introduction of e-Nav with the expected need for more data exchange

-> existing AIS will not be able to cope future requirements for data exchange
VDES concept addresses the need for additional capacity for digital data exchange

- protecting the original function of AIS identification, position reporting and tracking
- provides capability for maritime data exchange for safety, security, efficiency and the protection of the environment
- globally interoperability and availability
- dedicated to maritime safety communication

-> support of e-Nav, maritime data communication and modernization of GMDSS
VDES concept integrates several function of VHF Data Exchange: AIS

Function of AIS: - Automatic Identification System -
AIS remains unchanged for its original purpose

- **functions:**
  - identification of ships
  - position reporting and tracking
  - navigational ship data
  - support of search and rescue

- **technical characteristic:**
  - radio channel AIS 1, AIS2, Ch 75 and CH 76
  - all tailored messages, e.g. msg 1,2,3,4,5,9,18,21,23
  - some ASM remains, at least for transitional phase
  - channel management might be restricted

-> AIS stays as it is, however considers other functions of the VDES
VDES concept integrates several functions of VHF Data Exchange: AIS + ASM

Function of ASM: - Application Specific Messages -
Most of the existing application specific messages and new messages will be moved to new channels called ASM

• functions:
  – IMO defined ASM  
  – regional ASM  
  – allows for “real” communication including acknowledgement  
  – high reliability of message reception

• technical characteristic:
  – radio channel ASM 1, ASM2,  
  – higher capacity than AIS channels  
  – message structure as for msg 6,7,8,12,13,14,25,26

-> ASM with more capacity and better reliability of message delivery
VDES concept integrates several functions of VHF Data Exchange: AIS + ASM + VDE

Function of VDE: - VHF Data Exchange - Terrestrial -
VDES concept: – VDE terrestrial–

VHF Data Exchange provides higher capacity data transmission with different message structure than AIS and ASM

• functions:
  – higher capacity data exchange
  – terrestrial exchange ship<->ship and ship<->shore
  – allows for “real” communication including acknowledgement
  – high reliability of message reception

• technical characteristic:
  – 6 international radio channel
  – additional regional channels
  – channel merging for higher data rate

-> VDE terrestrial for higher volume data exchange
VDES concept integrates several function of VHF Data Exchange: AIS + ASM + VDE + Sat

Function of VDE: - VHF Data Exchange – Satellite –
- Uplink -
VDES concept integrates several function of VHF Data Exchange: AIS + ASM + VDE + Sat

Function of VDE: - VHF Data Exchange – Satellite – Downlink -
VDES concept: – VDE satellite –

VDE satellite provides VHF Data Exchange beyond the radio coverage range of a shore infrastructure or where no shore infrastructure exists

• functions:
  – data exchange outside shore station range
  – data exchange ship<->satellite<->shore
  – satellite uplink and satellite downlink
  – allows for “real” communication including acknowledgement

• technical characteristic:
  – satellite with VDE capability
  – shares channels with VDE terrestrial
  – satellite have VDE receiver and transmitter

-> VDE satellite enables global coverage including polar regions
VDES applications

VDES is designed to provide a higher, robust and global data exchange in the maritime VHF mobile band

VDES can support all services which require data exchange between ships and between ships and shore

VDES aims to support:
• AIS
• ASM exchange
• e-Navigation
• enhanced maritime communication
• modernized GMDSS
# IALA Plan for future VHF Data Communication

<table>
<thead>
<tr>
<th><strong>Sub-group</strong></th>
<th><strong>VHF Data Communications (including VDE)</strong></th>
<th><strong>AIS</strong></th>
<th><strong>AIS long range</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Radio channels</strong></td>
<td><strong>Data communications using existing AIS protocol</strong></td>
<td><strong>Data communications using ITU standard protocol</strong></td>
<td><strong>AIS for safety of navigation</strong></td>
</tr>
<tr>
<td></td>
<td>- Channels 27 and 28</td>
<td>- Channels 24, 84, 25, 85, 26, 86</td>
<td>- AIS-1 &amp; AIS-2 (simplex)</td>
</tr>
<tr>
<td></td>
<td>- World-wide dedicated channels (WRC-15 target)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Functionality</strong></td>
<td><strong>Marine safety information</strong></td>
<td><strong>General purpose data exchange</strong></td>
<td><strong>Safety of navigation</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Marine security information</strong></td>
<td><strong>Robust high speed data exchange</strong></td>
<td><strong>Maritime and inland distress and safety communications (Subject to inclusion in GMDSS Modernization by IMO)</strong></td>
</tr>
<tr>
<td></td>
<td><strong>SSRMs</strong></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td><strong>General purpose information communication</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Message types for AIS protocol</strong></td>
<td><strong>IMO SN.1/ Circ.289 international application specific messages</strong></td>
<td><strong>Vessel identification</strong></td>
<td><strong>Space detection of AIS</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Regional application specific messages</strong></td>
<td><strong>Vessel dynamic data</strong></td>
<td><strong>Other messages for support of future SAR</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Base Station</strong></td>
<td><strong>Vessel static data</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Sub functionality</strong></td>
<td><strong>Area warnings and advice</strong></td>
<td><strong>Voyage related data</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Meteorological and hydrological data</strong></td>
<td><strong>Aids to Navigation</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Traffic management</strong></td>
<td><strong>Base Station</strong></td>
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<tr>
<td></td>
<td><strong>Ship-shore data exchange</strong></td>
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<tr>
<td></td>
<td><strong>Channel management</strong></td>
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</tr>
</tbody>
</table>
VDES support of e-Navigation

e-Navigation aims to enhance berth to berth navigation and related services for safety and security at sea and for the protection of the marine environment

Supported IMO prioritized e-Nav solutions

- standardized and automatic reporting
  - use internationally standardized messages like ASM “Extended ship static and voyage related date”, “Dangerous cargo indication”

- improved reliability, resilience and integrity of navigation information
  - Met-hydro data, tidal window, area notice, berthing data, clearance time to enter port

- improved communication of VTS Service Portfolio
  - route information, navigational intention,
VDES support of future GMDSS

For the modernization of GMDSS IMO may consider the functions of VDES

- position information by AIS
- assisting SAR operation AIS SART, AIS MOB, EPIRB AIS
- global coverage through satellite
- capability for promulgation of MSI like Navigational warnings, Notices to Mariner, ice boundary
- receiving acknowledgement from ships
- via terrestrial and satellite downlink and uplink

-> requires robust and reliable data exchange capability in machine readable form
VDES roadmap

AIS today

VDES concept

VDES applications

Roadmap

2013

Development of prototype VDE transceiver

2014

Draft, development and finalization of ITU and IEC standards for VDES

2015

Practical Implementation of VDE transceiver

2016

Data migration/Initial Operation Capability (IOC) of VDES

2017

VDES preparation for WRC-15 including studies

2018

Technical development, launch and evaluation of experimental satellite

2019

Development of satellite VDES service

2020

Full Operation Capability (FOC) of VDES

IALA Conference

IMO MSC.92 MSC.93 MSC.94 NSCR.1 NSCR.2

ITU WP.5B WP.5B WP.5B WP.5B

Development of eNAV strategy implementation plan

GMDSS Review

GMDSS Modernization

Workshop VDES 20.-24.2014 Tokyo
Thank you for your attention

Stefan Bober
German Traffic Technologies Centre
Tel. +49 261 9819 – 2231
E-Mail: Stefan.Bober@wsv.bund.de
<table>
<thead>
<tr>
<th>AIS today</th>
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<tr>
<td>VDES concept</td>
</tr>
<tr>
<td>VDES applications</td>
</tr>
<tr>
<td>Roadmap</td>
</tr>
</tbody>
</table>

Workshop
VDES
20.-24.2014
Tokyo
Technical Details and Guidelines for VDES Implementation

2nd Workshop on VDES
Tokyo, Japan
20-24 January 2014

By: Ross Norsworthy
Contributions from: Stefan Bober, IALA e-NAV Committee
Data transmission in the VHF Marine Band

Sharing resources between voice radio and digital data communication

Efficient use of spectrum of RR Appendix 18

-> Initially only analog voice radio communication used the VHF maritime mobile band: ITU RR Appendix 18
Initially only analog voice radio communication in VHF maritime mobile band RR Appendix 18

Example: Duplex channel No 20

Data transmission in the VHF Marine Band

Channels in the low frequency range of the VHF maritime mobile band

Channels in the high frequency range of the VHF maritime mobile band
Data transmission in the VHF Marine Band

Sharing resources between voice radio and digital data communication

Efficient use of spectrum of RR Appendix 18

- Initially only analog voice radio communication used the VHF maritime mobile band: ITU RR Appendix 18

- Introduction of digital systems:
  - DSC – Digital Selective Calling (ITU-R M.493)
    Channel 70 for distress safety and calling (1200 bps)
  - AIS – Automatic identification system (ITU-R M.1371)
    Channel AIS 1, AIS 2, 75, 76 (9600 bps)
  - VDE – VHF data exchange (utilizing ITU-R M.1842)
    Channels 24, 84, 25, 85, 26, 86 (302.2 kbps)
Digital data communication systems implemented in VHF maritime mobile band today

Channels in the low frequency range of the VHF maritime mobile band

<table>
<thead>
<tr>
<th>Function</th>
<th>Channel No.</th>
<th>Frequency MHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>DSC</td>
<td>70</td>
<td>156.525</td>
</tr>
<tr>
<td></td>
<td>75, 76</td>
<td>156.775, 156.800, 156.825</td>
</tr>
</tbody>
</table>

156.025 MHz

Channels in the high frequency range of the VHF maritime mobile band

<table>
<thead>
<tr>
<th>Function</th>
<th>Channel No.</th>
<th>Frequency MHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>AIS 1</td>
<td>28</td>
<td>161.975, 162.000</td>
</tr>
<tr>
<td>AIS 2</td>
<td>28</td>
<td>162.025</td>
</tr>
</tbody>
</table>

162.025 MHz
Data transmission in the VHF Marine Band

Request: Additional capacity for digital data exchange

WRC 12 identified globally available channels for digital communication (more regional channels are available):
  • testing future AIS applications, e.g. ASM
    Channels 27, 87, 28, 88
  • utilization digital data communication systems, e.g. VDE
    Channels 24, 84, 25, 85, 26, 86

Channel usage according to Resolution 360 (WRC 12)
  • protection of AIS VDL
  • enhanced AIS technology application
  • enhanced maritime radio communication, terrestrial and satellite
Data transmission in the VHF Marine Band

Channels globally available for digital data communication systems in VHF maritime mobile band

### Existing data communication systems

<table>
<thead>
<tr>
<th>Function</th>
<th>Channel No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>DSC</td>
<td>70</td>
</tr>
<tr>
<td>AIS LR</td>
<td>75</td>
</tr>
<tr>
<td>AIS LR</td>
<td>76</td>
</tr>
<tr>
<td>AIS</td>
<td></td>
</tr>
<tr>
<td>AIS 1</td>
<td></td>
</tr>
<tr>
<td>AIS 2</td>
<td></td>
</tr>
</tbody>
</table>

### New data communication systems

<table>
<thead>
<tr>
<th>New data communications</th>
<th>New AIS applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>24 84 25 85 26 86</td>
<td>27 87 28 88</td>
</tr>
</tbody>
</table>

Legend:
- **Function**
- **Channel No.**
Considerations for implementation of new digital data services

• Voice and data communications coexist in VHF marine band
  - Voice, DSC and AIS successfully operating in Appendix 18

• Precautions are necessary to preserve the integrity of existing voice and data communication
  - ensure that VHF voice radio, DSC, AIS are not impaired

• Data communication should not be adversely impacted by voice radio or other digital data communication

• Considerations for integrity of services
  - Transmission timing
  - Limitation of maximum transmission duration
  - Selection of channels/frequencies
  - Frequency selective filters
  - Antenna installation
Technical details and guidelines for VDES implementation

VDES design should ensure that its digital data transmissions will not harmfully effect other services

Example AIS:
Very short transmission duration
- One time slot has 26 ms duration, the duty cycle is low
- Effect on voice radio communication
  ITU-R M.2169: effect of short infrequent transmission of data burst on the intelligibility of human speech is tolerable
- Effect on DSC calls and DSC distress alerts
  DSC calls and alerts are repeated if not acknowledged; DSC uses forward error correction coding for robust data transfer
Technical details and guidelines for VDES implementation

Example AIS:
Selection of channels/frequency separation
- AIS channels are at the upper end of the upper leg of Appendix 18 where no ship voice radio transmissions occur
Selection of channels for data transmission
AIS 1 and AIS 2 in the higher frequency range

<table>
<thead>
<tr>
<th>Channel No.</th>
<th>Frequency MHz</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>DSC 70</td>
<td>156.525 MHz</td>
<td>Ship station analog voice transmission</td>
</tr>
<tr>
<td>AIS 1</td>
<td>161.975 MHz</td>
<td>AIS 1</td>
</tr>
<tr>
<td>AIS 2</td>
<td>162.025 MHz</td>
<td>AIS 2</td>
</tr>
</tbody>
</table>

Legend:
- **Function**
- **Channel No.**
- **Frequency MHz**

Technical details and guidelines for VDES implementation
Selection of channels for data transmission
AIS Long Range channel 75 and 76 are tx only
Technical details and guidelines for VDES implementation

Example AIS:
Selection of channels/frequency separation
- AIS channels are at the upper end of the upper leg of Appendix 18 where no ship voice radio transmissions occur

- the utilization of receiving filter is not possible due to AIS channel management (full VHF band, but no longer used)

- voice radio transmissions may desensitize AIS reception due their long duration and the absence of filter
Technical details and guidelines for VDES implementation

Example AIS:
Antenna separation
- to avoid receiver desensitization caused by other VHF transmissions
- Difficult to implement on ships due to space constrains
- Guideline COMSAR/Circ.32 VHF antenna
  vertical separation > 2 m, horizontal separation > 5 m
- typical: 1.5 m vertical separation -> 20 dB
  4.0 m vertical separation -> 41 dB
  17.0 m horizontal separation -> 41 dB
  (tx power + 44 dBm; rx sensitivity -107 dBm)
- good solution for shore infrastructure as there is more space for antenna separation at an antenna mast
Technical details and guidelines for VDES implementation

How to implement VDE and ASM? --> proposal:
Similar approach to AIS and apply lessons learned:
- selection of channels
  -> simplex channel for ASM in upper leg of Appendix 18 where no ship transmissions occur
  -> duplex channel for VDE ship to shore and shore to ship
Selection of channels for data transmission

**Ship station analog voice transmission**

<table>
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<tr>
<th>Function</th>
<th>Channel No.</th>
<th>Frequency MHz</th>
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<tbody>
<tr>
<td>DSC</td>
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<tr>
<td>AIS LR</td>
<td>75</td>
<td>156.775</td>
</tr>
<tr>
<td>AIS LR</td>
<td>76</td>
<td>156.825</td>
</tr>
</tbody>
</table>

**Coast station analog voice transmission**

<table>
<thead>
<tr>
<th>Function</th>
<th>Channel No.</th>
<th>Frequency MHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>VHF Data Exchange</td>
<td>1024</td>
<td>157.200</td>
</tr>
<tr>
<td></td>
<td>1084</td>
<td>157.225</td>
</tr>
<tr>
<td></td>
<td>1025</td>
<td>157.250</td>
</tr>
<tr>
<td></td>
<td>1085</td>
<td>157.275</td>
</tr>
<tr>
<td></td>
<td>1026</td>
<td>157.300</td>
</tr>
<tr>
<td></td>
<td>1086</td>
<td>157.325</td>
</tr>
</tbody>
</table>

**Channels in the low frequency range of the VHF maritime mobile band**

**Channels in the high frequency range of the VHF maritime mobile band**
Technical details and guidelines for VDES implementation

How to implement VDE and ASM? → proposal:
Similar approach to AIS and apply lessons learned:
- selection of channels
  - simplex channel for ASM in upper leg of Appendix 18 where no ship transmissions occur
  - duplex channel for VDE ship to shore and shore to ship
- transmission timing
  - TDMA for AIS, ASM, VDE terrestrial, VDE satellite
- maximum transmission duration
  - short burst like AIS however much higher data rate for more data transfer in the same time period
## Short transmission bursts due to high data rate

- Much data in one transmission packet to keep duration and duty cycle low.

<table>
<thead>
<tr>
<th>ITU Standard and Digital Modulation</th>
<th>AIS1 and AIS2 (25 kHz Channels)</th>
<th>For 25 kHz Channels VDE Data Transfer Methods</th>
<th>VDE Data Transfer Methods For 50 kHz Channels</th>
<th>VDE Data Transfer Methods For 100 kHz Channels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data Rate</td>
<td>9.6 kbps (1X)</td>
<td>43.2 kbps (4X)</td>
<td>153.6 kbps (16X)</td>
<td>307.2 kbps (32X)</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>-107dBm</td>
<td>-107dBm</td>
<td>-103dBm (ship stations)</td>
<td>-98dBm (ship stations)</td>
</tr>
<tr>
<td>Co-channel rejection (CCR)</td>
<td>10dB</td>
<td>25dB</td>
<td>19dB</td>
<td>19dB</td>
</tr>
<tr>
<td>AIS Message types</td>
<td>1, 2, 3, 5, 18, 19 …</td>
<td>6, 7, 8, 12, 13, 14 … and ASM</td>
<td>VDE messages TBD</td>
<td>VDE messages TBD</td>
</tr>
<tr>
<td>Rationale</td>
<td>Optimum choice for recurring position reports in a ship-ship navigation safety environment. Provides high (4X) data transmission. Inferior CCR (+15dB) and range discrimination. 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.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Technical details and guidelines for VDES implementation

How to implement VDE and ASM? –> proposal:
Similar approach to AIS and apply lessons learned:
- selection of channels
  -> simplex channel for ASM in upper leg of Appendix 18 where no ship transmissions occur
  -> duplex channel for VDE ship to shore and shore to ship
- transmission timing
  -> TDMA for AIS, ASM, VDE terrestrial, VDE satellite
- maximum transmission duration
  -> short burst like AIS however much higher data rate for more data transfer in the same time period
- Filter
  -> Bandpass filter to protect from voice radio transmissions
Filter to protect the receiver from blocking from voice radio transmissions

Design example of a single unit architecture of an VDES station. Other technical solutions may be possible.

- Bandpass filter protect from receiver blocking
- AIS-VDE transmitter supports complex waveforms like QAM
Important for administrations to consider

The AIS and VDES ship receiving range is in the upper leg of App 18 frequencies, i.e. 161.800 – 162.025 MHz. This arrangement allows for bandpass filter to prevent VDES receiver blocking from VHF voice radio transmissions.

WRC 12 revision of App 18 to designate simplex channels 2078, 2019, 2079, 2020 (161.525 to 161.600 MHz) for voice radio transmission on ships.

Voice radio transmission on those channels will block AIS and VDES reception because of their long duration.
Technical details and guidelines for VDES implementation

On board: ship transmission on channel 2078, 2019, 2079, 2020 will block AIS reception

---

### Channels in the low frequency range of the VHF maritime mobile band

<table>
<thead>
<tr>
<th>Channel No.</th>
<th>Frequency MHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>75</td>
<td>156.775</td>
</tr>
<tr>
<td>16</td>
<td>156.800</td>
</tr>
</tbody>
</table>

### Channels in the high frequency range of the VHF maritime mobile band

<table>
<thead>
<tr>
<th>Channel No.</th>
<th>Frequency MHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>1078</td>
<td>156.925</td>
</tr>
<tr>
<td>1079</td>
<td>156.975</td>
</tr>
<tr>
<td>1080</td>
<td>157.000</td>
</tr>
</tbody>
</table>
Important for administrations to consider

The AIS and VDES ship receiving range is in the upper leg of App 18 frequencies, i.e. 161.800 – 162.025 MHz. This arrangement allows for bandpass filter to prevent VDES receiver blocking from VHF voice radio transmissions.

WRC 12 revision of App 18 to designate simplex channels 2078, 2019, 2079, 2020 (161.525 to 161.600 MHz) for voice radio transmission on ships.

Voice radio transmission on those channels will block AIS and VDES reception because of their long duration.

AIS and VDES reception will be harmfully impaired by voice radio transmission on channels 2078, 2019, 2079, 2020.

-> Consider revision of RR Appendix 18 at WRC 15 (prohibit Ch. 2078, 2019, 2079, 2020 for ship voice radio transmission)
Consideration of Channel Plan A
Technical benefits for Channel Plan A

• In Channel Plan A, the AIS and VDES ship receiving range is a contiguous channel group in the upper leg of App 18 frequencies, i.e. 161.800 – 162.025 MHz. This arrangement allows for a bandpass filter to prevent VDES receiver blocking from VHF voice radio transmissions.

• Other plans require either VDE or ASM to be received on the lower leg of App 18 frequencies in which voice radio transmissions will block reception of VDE and/or ASM.

• For Channel Plan A, if placement of antennas on ships meets IMO guidelines (COMSAR/Circ. 32 VHF antenna), unimpaired receiver sensitivity is obtained (see next two slides).
Typical VHF Marine Voice Radio Transmitter
Power, Spurious and Noise Levels

This diagram is for analogue VHF, a transmitter using MQ DQPSK or similar modulation is likely to have higher noise sidebands.
Power Levels delivered to the VDES from the VHF Radio Transmitter (ref. previous figure)

To achieve high isolation btw. VHF voice radio and VDES
- separate antenna for antenna isolation
- additional receiver bandpass filter

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

Typical antenna isolation with vertical separation:
- Antenna separation: 1.5 m, 4.0 m
- Antenna isolation: 20 dB, 41 dB
Channel Plan A optimizes technical requirements for VDES implementation

Channel Plan A assures coexistence of VHF voice radio, DSC, AIS, ASM and VDE (terrestrial & satellite)

### Channels in the low frequency range of the VHF maritime mobile band

<table>
<thead>
<tr>
<th>Function</th>
<th>Frequency MHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>DSC</td>
<td>156.525</td>
</tr>
<tr>
<td>AIS LR</td>
<td>156.775</td>
</tr>
<tr>
<td>AIS LR</td>
<td>156.800</td>
</tr>
<tr>
<td>AIS LR</td>
<td>156.825</td>
</tr>
<tr>
<td>VHF Data Exchange</td>
<td>157.200 - 157.325</td>
</tr>
</tbody>
</table>

### Channels in the high frequency range of the VHF maritime mobile band

<table>
<thead>
<tr>
<th>Function</th>
<th>Frequency MHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>VHF Data Exchange</td>
<td>161.800 - 162.025</td>
</tr>
<tr>
<td>ASM 1</td>
<td>161.950</td>
</tr>
<tr>
<td>AIS 1</td>
<td>161.975</td>
</tr>
<tr>
<td>ASM 2</td>
<td>162.000</td>
</tr>
<tr>
<td>AIS 2</td>
<td>162.025</td>
</tr>
</tbody>
</table>

**Legend:**

- **Function:**
- **Channel No.**
- **Frequency MHz**
Summary of facts - proposed actions

- Increasing need for efficient spectrum use
- Digital data communication will serve this need
- ITU standard for digital data exchange (ITU-R M.1842)
- WRC 12 revised RR Appendix 18 to allow digital communication
- Analog voice and digital communication share VHF marine band
- VDES addresses the need for compatibility and interoperability of analog voice radio communication and digital data exchange

- Revise RR Appendix 18: ensure protection of AIS (prohibit Ch. 2078, 2019, 2079, 2020 for ship voice radio transmission)

- Select Channel Plan A: optimizes technical guidelines
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MARITIME RADIOCOMMUNICATIONS
WRC-15 AGENDA ITEM 1.16
VHF DATA EXCHANGE SYSTEM

Bill Kautz – U.S. Coast Guard
Telecommunications Manager
IALA e-NAV Committee - AIS/COMMS WG Vice Chair
Discussion

• WRC-12 Results
• WRC-15 Agenda Item 1.16
• Resolution 360 (WRC-12)
• ITU-R WP5B - VHF Data Exchange VDES
• ITU-R WP5B - Conference Preparatory Meeting (CPM) Situation
• ITU-R WP5B Agenda Item 1.16 Work Plan
• VDES Timeline
• WRC-18 Future Maritime Agenda Items
• WRC-15 and WRC-18 Maritime Opportunities
World Radio Conference (WRC-12) Results

– Exclusive Utilisation of AIS 1 and AIS 2 by the maritime mobile service in Region 2 and 3 (in 2025)
– Allocation for the mobile satellite service for the channel 75 and 76 in order to detect the Message 27 of AIS for the Long Range AIS
– Identification of the channels 27, 28, 87, 88 for testing future AIS applications, e.g. Application Specific Messages (ASM)
– Identification worldwide of channels 24, 84, 25, 85, 26, 86 for utilization of digital systems
WRC-15 Agenda Item 1.16

• 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);
WRC-12 Resolution 360

- **Resolution 360 (WRC-12): Consideration of regulatory provisions and spectrum allocations for enhanced Automatic Identification System technology applications and for enhanced maritime radiocommunication**
WRC-12 Resolution 360 Resolves to invite WRC-15

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.
ITU-R Working Party 5B

VHF Data Exchange System (VDES)

• Significant support internationally at ITU, IMO and IALA to protect the AIS VDL and as a VHF Data solution

• Concept includes:
  – AIS 1 and 2 (Navigation – as originally intended)
  – AIS 3 and 4 (Satellite – space detection of AIS)
  – ASM 1 and 2 (Application Specific Messages, MSI)
  – VHF Data (General Data Comms) *Channels 24, 84, 25, 85, 26, 86*

*Potential for future Distress capabilities*
• In November 2013 the frequency/channel arrangement remain under discussion and has to be reedited after agreement.
• There are three channelling plans for VDES under studies.
• The only agreement is that the VDES terrestrial and satellite component will be deployed in the following channels: 24, 84, 25, 85 26, 86.
• Ship and Shore transmit arrangements and the transition period have to be decided.
CPM TEXT METHODS

• **METHOD A:** After the transitional period [1 January 2019], RR Appendix 18 CH27 and CH28 will be split into four simplex channels, CH1027, CH1028, CH2027 and CH2028. CH2027 and CH2028 will be assigned for the ASM application.

• **METHOD B:** Channel 87 and 88 could be used as ASM channels with an effective date TBD.

• **METHOD C:** CH2027 and CH2028 will be assigned for the ASM application with an effective date TBD.
<table>
<thead>
<tr>
<th>CPM SITUATION</th>
<th>Transmitting frequencies (MHz) for ship and coast stations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ship stations (ship-to-shore)</td>
</tr>
<tr>
<td><strong>Channel number in RR Appendix 18</strong></td>
<td></td>
</tr>
<tr>
<td>AIS 1</td>
<td>161.975</td>
</tr>
<tr>
<td>AIS 2</td>
<td>162.025</td>
</tr>
<tr>
<td>75 (long range AIS)</td>
<td>156.775 (ships are Tx only)</td>
</tr>
<tr>
<td>76 (long range AIS)</td>
<td>156.825 (ships are Tx only)</td>
</tr>
<tr>
<td>2027 (ASM 1)</td>
<td>161.950 (2027)</td>
</tr>
<tr>
<td>2028 (ASM 2)</td>
<td>162.000 (2028)</td>
</tr>
<tr>
<td>Option 2</td>
<td>157.375 (87)</td>
</tr>
<tr>
<td>88 (ASM 2)</td>
<td>157.200 (1024)</td>
</tr>
<tr>
<td>84</td>
<td>157.250 (1025)</td>
</tr>
<tr>
<td>25</td>
<td>157.275 (1085)</td>
</tr>
<tr>
<td>85</td>
<td>157.300 (1026)</td>
</tr>
<tr>
<td>26</td>
<td>157.300 (1026)</td>
</tr>
<tr>
<td>86</td>
<td>157.300 (1026)</td>
</tr>
</tbody>
</table>

- **AP18 Approved for AIS**
- **CPM Method A AND C**
- **CPM Method B**
- **CPM Agreed data channels**
## Regional VHF Data Exchange Channels (Proposed)

### Regional VDE (Regions 1 and 3)

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Ship receive</td>
<td>2080 161.625</td>
<td>2021 161.650</td>
<td>2081 161.675</td>
<td>2022 161.700</td>
<td>2082 161.725</td>
<td>2023 161.750</td>
<td>2083 161.775</td>
</tr>
</tbody>
</table>

- 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.
## Agenda Item 1.16 Work Plan

<table>
<thead>
<tr>
<th>2014</th>
<th></th>
</tr>
</thead>
</table>
| WP 5B 13th meeting May 2014 | 1. Further work on sharing studies and compatibility.  
2. Finalization on the list of candidate frequencies for VDES  
3. Progress on the development of the relevant ITU-R Report and Recommendation for the VDES.  
4. Establish the Regulatory measures needed, taking into account the current proposal for the VDES  
5. Finalization of the draft CPM Report. |
| WP 5B 14th meeting November 2014 | Finalization of all studies quoted to the draft CPM Report for WRC-15. |

<table>
<thead>
<tr>
<th>2015</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>WP 5B 15th meeting May 2015</td>
<td>Finalization of the ITU-R Report on the AIS requirements and on the new additional requirements of maritime-mobile service.</td>
</tr>
</tbody>
</table>
Future Maritime Agenda Items for WRC-18

**WRC-12 Resolution 359** - Consideration of regulatory provisions for modernization of the Global Maritime Distress and Safety System and studies related to e-navigation. **Resolves**

1. to invite WRC-18 to consider possible regulatory actions, including spectrum allocations based on the ITU-R studies, to support GMDSS modernization;

2. to consider possible regulatory actions, including spectrum allocations based on the ITU-R studies, for maritime mobile service supporting e-navigation

*Subject to change at WRC-15*
WRC-15 and WRC-18
Maritime Opportunities

• The Maritime community has a great opportunity to secure additional channels to protect the VDL and to develop a comprehensive terrestrial and satellite system that will significantly enhance AIS and VHF communications.

• Additionally, opportunities exist to enhance Polar communications, modernize the GMDSS, and satisfy e-Navigation requirements.
Thank You!
Development of VDES in IALA

2:nd Workshop on International Standardization of VDES

Rolf Zetterberg
Swedish Maritime Administration
Swedish Maritime Administration - SMA

- SMA responsible for
  - Fairways and AtoN
  - Pilotage
  - VTS
  - Icebreaking
  - Search and Rescue
  - Hydrology

along a 2700 km coastline
Presentation content

- Background
- IALA working procedures
- IALA work on Communication Systems
- IALA work on VDES
- Planning for future work
Background

• Increasing demand for data communication

• e-Navigation accentuates this trend

• IALA important role in development of AIS

• AIS is a low capacity data communication tool
Background

- The success of AIS resulted in a need to increase its capacity

- ITU WRC 2007 invited IALA to contribute to studies on future use of spectrum
IALA working procedures

IALA Assembly
IALA Council
eNAV Committee
Working Group AIS+COMMS
Ad Hoc Drafting Groups

IALA Secretariat
External docs
IALA work on Communication Systems

• Radionavigation Committee
  WG AIS
  WG Future Communication

• AIS Committee

• eNAV Committee
  WG AIS
  WG Communication
IALA work on Communication Systems

- Radionavigation Committee
  WG AIS
  WG Future Communication
- AIS Committee
- eNAV Committee
  WG AIS
  WG Communication

\[\text{WG AIS+COMMS}\]
IALA work on Communication Systems

• Maritime Radio Communication Plan
  - Developed to assist in selection of systems to support e-Navigation
  - To state the IALA vision for use of the spectrum
  - Focus on the need for an agreed infrastructure
  - Guidance to IALA members
IALA and AIS

- IALA developed and updated ITU-R M.1371-x
  - Developed guidelines for implementation and use of AIS

- IALA noted the need for
  - Protection of AIS frequencies
  - Satellite detection of AIS
  - Increased communication capacity in AIS

- IALA organized the collection of AIS ASM and developed guidelines for the use of AIS ASM

- Liaison with ITU, IMO, IEC, RTCM
IALA liaison to ITU, 2008

• “IALA’s vision and strategy for maritime systems propose a significant shift from analogue to digital communications in the VHF maritime band (Radio Regulations Appendix 18), as well as advanced AIS technologies, which IALA believes will greatly contribute toward the modernization of the GMDSS.”
IALA liaison to ITU WP 5B, 2010

• The protection of AIS1 and AIS2 channels for the safety of navigation as well as distress and safety communications. In addition, allow AIS transmissions by SAR aircraft.

• AIS channels for satellite tracking (channels 75 and 76).

• Additional channels for the next generation of AIS. IALA envisaged the necessity of a next generation of AIS, which would require two additional channels for low volume TDMA digital communications using AIS techniques.

• Spectrum resources for application of the VHF Data Service as described in Recommendation ITU-R M.1842-1 annexes 3 and 4. IALA envisaged e-Navigation would require a minimum capacity of 150 kHz equivalent to six 25 kHz channels.
IALA liaison to ITU WP 5B, 2011

• IALA requests that ITU designate RR Appendix 18 channels 27 and 28 for AIS 5 and AIS 6 and the contiguous group of the 6 channels 24, 84, 25, 85, 26 and 86 for the VHF Data Exchange of safety and security related information
IALA input to IMO eNAV CG (2011)

• Essential elements on e-Navigation Communication
  - Next generation AIS;
  - VHF Data exchange;
  - 500 kHz Digital broadcast
### NEXT GENERATION AIS

<table>
<thead>
<tr>
<th>AIS channels (simplex or duplex pairs)</th>
<th>AIS-1 &amp; AIS-2 (simplex) Safety of Navigation</th>
<th>AIS-3 &amp; AIS-4 (simplex) Vessel tracking and future SAR</th>
<th>AIS-5 &amp; AIS-6 (duplex pairs) Data Communication</th>
<th>Channel 70 (simplex) AIS Channel Management</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Purpose</strong></td>
<td>• Safety of navigation</td>
<td>• Space detection of AIS</td>
<td>• Marine safety information</td>
<td>• Management of VHF VDL in harmony with current ITU-R M.822-1</td>
</tr>
<tr>
<td></td>
<td>• Maritime and inland distress and safety communications</td>
<td>• Future SAR</td>
<td>• General purpose information communication</td>
<td></td>
</tr>
<tr>
<td><strong>Frequency allocation</strong></td>
<td>• Allocated / needs to be dedicated</td>
<td>• New / dedicated channels required</td>
<td>• New / shared channels required</td>
<td>• Allocated and dedicated</td>
</tr>
<tr>
<td><strong>AIS Message types</strong></td>
<td>• Vessel identification</td>
<td>• Space detection of AIS</td>
<td>• Regional AIS binary messages</td>
<td>• TDMA system management messages e.g. Message 20, Message 22, Other messages for support of coordinating channel sharing</td>
</tr>
<tr>
<td></td>
<td>• Vessel dynamic data</td>
<td>• Other messages for support of future SAR</td>
<td>• S/N Circ 289 international AIS binary messages</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Vessel static data</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Aids to Navigation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Typical applications</strong></td>
<td>• Ship to ship collision avoidance</td>
<td>• Detection of vessels by coastal states beyond range of coastal AIS base stations</td>
<td>• Area warnings and advice</td>
<td>• Channel switching</td>
</tr>
<tr>
<td></td>
<td>• VTS tools</td>
<td></td>
<td>• Meteorological and hydrological data</td>
<td>• FATDMA allocation</td>
</tr>
<tr>
<td></td>
<td>• Tracking of ships</td>
<td></td>
<td>• Traffic management</td>
<td>• Assignment</td>
</tr>
<tr>
<td></td>
<td>• Locating in SAR</td>
<td></td>
<td>• Channel management of AIS channels and future VHF digital data channels</td>
<td></td>
</tr>
<tr>
<td><strong>Proposed channels in Appendix 18</strong></td>
<td>• As now</td>
<td>• Channels 75 and 76</td>
<td>• Future distress alerting</td>
<td>• As now but requires Appendix 18, Footnote 1, and ITU-R M.822 modification</td>
</tr>
</tbody>
</table>
The name

• IMO didn´t accept the term ”Next Generation AIS” – ”no decision on a new AIS”

• IALA choosed to use VDE -VHF Data Exchange for the new functionality

• AIS and VDE – two complementary systems. The Tokyo-meeting 2012 proposed VDES - VHF Data Exchange System, accepted by IALA
IALA and VDES

• Continued work based on the outcome of WRC 2012
  - Updated plan for a VHF Data Exchange System to ITU WP 5B
  - Information paper on VDES
  - Information paper on Technical Guidelines for implementation of VDES
Future work

• Continued work on the draft Recommendation

• Propose and coordinate studies and test

• Provide supporting material to ITU WP 5B

• Keep IALA members informed to enable a timely implementation
Complications

• Draft SIP (IMO eNAV CG)
  ...seamless transfer of electronic information/data between ship and shore and vice versa and between ship to ship and shore to shore.

• NAV 59 agreed that:
  the work should be based on systems that were already in place (according to the already adopted Strategy for the development and implementation of e-navigation (MSC 85/26/Add.1, annex 20)) and that the development of potential future carriage requirements should therefore be strictly limited;
Thank You!

Rolf Zetterberg
SMA
A study on VDES channels and TDMA slots

20 January 2014
1. Current situation

1.1 AIS
Principle of AIS

- AIS (Class A)

[Diagram showing the principle of SOTDMA and AIS communication between ships]
Consideration for enhanced AIS technology applications and for enhanced maritime radiocommunication
ITU RESOLUTION 360 (WRC–12)

◆ Additional AIS channels may be required 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;

◆ Studies should be carried out to identify additional spectrum needed for emerging AIS terrestrial and satellite operational requirements;
ITU RESOLUTION 360 (WRC–12)

◆ Due to the importance of **AIS** in ensuring the safe operation of international shipping and commerce, it should be properly protected from harmful interference;
IMO COMSAR 17/4/3

Necessity for additional frequencies for AIS

**SUMMARY**

Executive summary: This document shows the necessity for additional frequencies for AIS and supports the ITU study on WRC-15 Agenda item 1.16

Strategic direction: 1.1

High-level action: 1.1.2

Planned output: 1.1.2.12, 1.1.2.19

Action to be taken: Paragraph 9

Related document: COMSAR 17/4
IMO COMSAR 17/4/3

5 The two figures clearly indicate that the AIS slot usage rapidly increased more than 10 per cent in four years in Tokyo Bay area.

Conclusion

8 Considering the above described VDL situation, Japan is of the view that the additional frequencies for AIS will be needed in order to secure the smooth data exchange of AIS and supports the study conducted by ITU under WRC-15 Agenda item 1.16.
1. Current situation

1.2 VDES
VDES:

◆ VDES formula

AIS

+ ASM (Application Specific Messages)

+ VDE/SAT (VHF Data Ex./SATEllite link)

= VDES: VHF Data Exchange System
Channel allocation

Channel allocation for AIS

Maritime VHF radio band

2024  2084  2025  2085  2026  2086  2027  2087  AIS1  2028  2088  AIS2
Channel allocation plan (Under consideration)

Channel allocation for VDES (Upper leg)

Maritime VHF radio band

<table>
<thead>
<tr>
<th>2024 VDE/SAT</th>
<th>2084 VDE/SAT</th>
<th>2025 VDE/SAT</th>
<th>2085 VDE/SAT</th>
<th>2026 VDE/SAT</th>
<th>2086 VDE/SAT</th>
<th>2027 ASM1</th>
<th>2087 AIS1</th>
<th>2028 ASM2</th>
<th>2088 AIS2</th>
</tr>
</thead>
</table>

Channel allocation plan (Under consideration)

Channel allocation for VDES (Lower leg)

Maritime VHF radio band

1024 VDE/SAT 1084 VDE/SAT 1025 VDE/SAT 1085 VDE/SAT 1026 VDE/SAT 1086 VDE/SAT 1027 1087 1028 1088
Figure of VDES (IALA e-NAV WG3+4)

- Satellite detection AIS
- Ship-to-Shore VDE using ITU1842
- Ship-Ship VDE using ITU1842
- Shore-Ship & Ship-Shore VDE using SOTDMA
- VDES broadcasting
- SAT Uplink
- 4.6 MHz separation
- AIS-VDE ship receiving bandwidth
### Summary: Current situation of VDES (plan)

<table>
<thead>
<tr>
<th></th>
<th>AIS</th>
<th>VDES</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Technical Specification</strong></td>
<td>ITU-R M.1371</td>
<td>ITU-R M.[VDES] [T.B.D.]</td>
</tr>
<tr>
<td><strong>Channel</strong></td>
<td>AIS1/2</td>
<td>AIS1/2</td>
</tr>
<tr>
<td><strong>Channel Bandwidth</strong></td>
<td>25 [kHz]</td>
<td>25 [kHz]</td>
</tr>
<tr>
<td></td>
<td>25 [kHz]</td>
<td>25 [kHz]</td>
</tr>
<tr>
<td></td>
<td>50 [kHz]</td>
<td>100 [kHz]</td>
</tr>
<tr>
<td><strong>Access Scheme</strong></td>
<td>SOTDMA</td>
<td>SOTDMA</td>
</tr>
<tr>
<td></td>
<td>SOTDMA [T.B.D.]</td>
<td>RA/CSTDMA [T.B.D.]</td>
</tr>
<tr>
<td><strong>Modulation Scheme</strong></td>
<td>GMSK</td>
<td>GMSK</td>
</tr>
<tr>
<td></td>
<td>GMSK [T.B.D.]</td>
<td>π/4 DQPSK</td>
</tr>
<tr>
<td></td>
<td></td>
<td>π/8 D8–PSK</td>
</tr>
<tr>
<td></td>
<td></td>
<td>16/32 sub</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Carrier (16QAM) [T.B.D.]</td>
</tr>
</tbody>
</table>
Summary: Current situation of VDES development

- VDES channels were allocated.
  - VDES channels are adjacent to AIS channels.

- VDES technical specification is being designed now.
  - Access scheme
  - Modulation scheme
  - Transmitter characteristics
  - Receiver characteristics
  - Etc…
2. Considerations for VDES specification designing

2.1. VDES Channels
## Considerations on VDES channels

- **Ideal AIS TX Spectrum and Typical RX sensitivity level**

<table>
<thead>
<tr>
<th>Power [dBm]</th>
<th>2085</th>
<th>2026</th>
<th>2086</th>
<th>2027</th>
<th>2087</th>
<th>2028</th>
<th>2088</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>30</td>
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**Receiver Sensitivity level**: -107 [dBm]
Considerations on VDES channels

- Ideal AIS TX Spectrum and Typical RX sensitivity level

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Transmitter Carrier Power level: 41 [dBm]

Receiver Sensitivity level: -107 [dBm]
Considerations on VDES channels

- Typical AIS TX Spectrum and RX sensitivity level

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Transmitter Carrier Power level
- 41 [dBm]
-29 [dBm]
-107 [dBm]

Actual TX Spectrum

Receiver Sensitivity level
Considerations on VDES channels

- Radio Link (ideal free space propagation)

\[ L_p = 32 + 20 \log D [\text{km}] + 20 \log F [\text{MHz}] \]

\[ L_{\text{total}} = L_{c_{\text{tx}}} - G_{a_{\text{tx}}} + L_p - G_{a_{\text{rx}}} + L_{c_{\text{rx}}} \]
Considerations on VDES channels

- Radio Link (ideal free space propagation)

![Diagram showing VDES channel considerations]

- TX Power: 41.0 [dBm] (12.5[W])
- RX Power: -72 [dBm] @ 10 [NM]
- RX Power: -52 [dBm] @ 1 [NM]
- Frequency: 160 [MHz]
- Distance: 100[m] 7.5 [dB]

Coax. Cable: RG-14A/U
Considerations on VDES channels

Masking on other channels

- VDE/SAT
- VDE/SAT
- VDE/SAT
- ASM1
- AIS1
- ASM2
- AIS2

Receive Spectrum @ 1 [NM]

Receive Carrier Power level @ 1 [NM]

-52 [dBm]

Receiver Sensitivity level

-107 [dBm]
Considerations on VDES channels

- Masking on other channels

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Receive Spectrum @ 10 [NM]

Receive Carrier Power level @ 10 [NM]
-72 [dBm]

Receiver Sensitivity level
-107 [dBm]
Considerations on VDES channels

- Masking
Considerations on VDES channels

- Masking

Diagram showing the interaction between VDES channels (AIS 1/2, ASM 1/2), ships, and the exchange of ship's information.
Considerations on VDES channels

- Masking
2. Considerations for VDES specification designing

2.2 TDMA slot allocation
Slot allocation

- Slot allocation for AIS stations

CH: AIS1/2

SOTDMA

Time
Slot allocation

- Slot allocation for VDES stations

**CH:**
- AIS1/2

**ASM1/2**

**VDE\text{x}/SATx**

**SOTDMA**

**SOTDMA (T.B.D.)**

**RA/CSTDMA (T.B.D.)**
Slot allocation

Slot allocation variation for a VDES station
Slot allocation

- Reception quality estimate

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R: Good
R: Poor
2. Considerations for VDES specification designing

2.3 Optimization
Optimization for VDES specification designing

◆ Simulation of VDES performance
  - To find the most effective slot allocation/access scheme.
  - To minimize the influence on the other channels.

◆ Parametric analysis
  - Slot allocation/access schemes (SOTDMA, RA/CSTDMA, etc.)
  - Modulation schemes (GMSK, QAM, PSK, etc.)
  - Radio wave propagation (multipath, sea reflection, etc.)
  - Number of Ships
  - Status of ships (Position, COG, SOG, etc.)
3. Summary
Summary

- The VDES detailed technical specification is under consideration.
- These VDES channels (ASMx, VDEx, SATx) are adjacent to existing AIS channels, and thus it is necessary to examine mutual interference matter carefully.
- Furuno starts simulation to resolve these problems. With various parametric analysis, Furuno intends to contribute to the development of VDES specifications.
Thank you!

20 January 2014
- This page is intentionally blank. -
Development of VHF Data Exchange System (VDES)
~ VDE Communication Protocol ~
Second Workshop on International Standardization of VDES
Contents

- About JRC
- Sharing Study between Terrestrial VDE and Satellite VDE Downlink
- Simulation of Multipath Fading
The development of radio communications is the history of JRC.
Marine Electronics

Communication

Navigation

Fishing
Digital Radio Products

- Professional Mobile Radio
- Wireless LAN
- WiMAX Base Station
- Taxi Radio
### VDE Channels

- **Introduction of data communication into VHF Marine**
  - WRC-12 (World Radiocommunication Conference 2012) designated the following channels for VHF Data Exchange

  - **Global VDE channels (total bandwidth) are only 150 kHz (x2)**
  - Considering to use both Terrestrial VDE and Satellite VDE
  - Sharing study is needed

---

#### VDE channels in accordance with Appendix 18 (Rev.WRC-12) of the Radio Regulations

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</table>
| 86          | 157.325           | (Ship TX?)

**Regions 1 and 3 (except China and South African)**
- South African countries
- China
- Global (All Regions)
Development of VDE Protocol

- Japan proposed the following TDMA (Time Division Multiple Access) structure for VDE to ITU-R in 2010
  - Same timeslot length as AIS
  - Using UTC synchronization which is the same as AIS
  - Carrier Sense TDMA

- Proposed TDMA structure has high compatibility with AIS
- Suitable for VDE(S)
Sharing with Satellite

- Proposed method for sharing between terrestrial link and satellite (LEO: low earth orbit) downlink
  - Share TDMA frame (6 timeslots) which using the same channels
  - Normally, terrestrial VDE link uses TN1 (timeslot 1) to TN6
  - Always, LEO satellite VDE downlink uses TN3 to TN6
  - Terrestrial VDE link will use only TN1 and TN2 when satellite VDE downlink is available

  ![Diagram]
  - Satellite downlink
  - Terrestrial (Normal times)
  - Terrestrial (while detecting satellite downlink)

- Simple method using carrier sense
- Further consideration and simulation are needed
Sharing with Satellite

Satellite downlink

Guard period

26.667 ms

Satellite downlink

Terrestrial (Normal times)

Terrestrial (while detecting satellite downlink)

1 TDMA frame = 6 timeslots ( = 160 ms)

Satellite downlink

Terrestrial link
Mobile Communications

- Multipath fading (Interference Fading)
We need detail simulation of maritime propagation to develop the VDE communication protocol. However, no VHF multipath characteristics on the sea, especially which includes the sea surface reflection.

**Example (Land mobile characteristics)**

- π/4DQPSK (Typical urban)
- 16-QAM (16 sub-carrier, Typical urban)
JRC will measure multipath characteristics for simulation of maritime propagations

Measure multipath propagation at the actual sea areas by experimental test station using chirp signal

Reflects the results of simulation to VDE communication protocols
Thank you for your attention

Bon Voyage!

20 Jan. 2014
Yoshio MIYADERA

http://www.jrc.co.jp/
2nd International Workshop on VDES

Focus on Satellite VDES

Tokyo, 20/01/2014

Gaetan Fabritius
CLS, Head of Maritime Surveillance Team

www.sat-ais.org
Introducing CLS

No need to remind the definition and (very favorable) context for VDES 😊 but...

... reminding what satellite VDE can offer

On-going activities in Europe around satellite VDE

Expected next steps for satellite VDE

Discussion
Created: 21 April 1986 – subsidiary of the French Space Agency (CNES) ⇒ Operating the Argos constellation (Advanced Doppler location)

Core activities:
• Commercial operation of satellite systems for positioning, data collection, ocean observation and surveillance
• Developing added-value applications and services based on satellite remote-sensing data;

Applications to:
• environmental surveillance
• sustainable management of marine resources
• maritime surveillance
• oil and gas

Supported by: Cubic-I (i3) – CLS office in Japan
CLS day to day mission

Receiving, processing, monitoring, distributing and archiving data from satellites

24/7 hotline – On-call service - SLA
No doubt that VDES is a must have (current VDL load jeopardizing existing use of AIS, natural evolution for the current very successful AIS system)

**Main justifications for a satellite component as complement for VDES (COMSAR 17/INF.7):**

- Communicate **beyond terrestrial coverage** & address **polar communication** issues or other remote areas (ex: French territories)
- Address typical **multicast/broadcast information exchange requirements** (e-Nav and modernization of GMDSS), for instance complementing the maritime safety information service and WWNWS (World-Wide Navigational Warning Service) broadcasts, for instance via SafetyNET
  - Ex: Typhoon, oil spill, ice maps, hazard at sea, even speed limit in given areas (ship emissions) etc.
- Serve a **large population of ships** (VHF-only equipped, incl. non-SOLAS)
- Disseminate satellite navigation correction messages towards the Polar regions: this will enable a satellite-based augmentation system (SBAS) such as EGNOS or WAAS at high latitude regions.
- Improve situational awareness for other non-maritime platforms, such as aeronautical platforms receiving the satellite broadcast channel. This can be used for example to disseminate SAR plans.
- Act as an alternative for acknowledgement of a distress alert, or act as an alternative return/acknowledgement link.
- Allow management of AIS networks, allow for signaling to equipment such as AIS-SARTs, Aids to Navigation (AtoN) or AIS devices in general.
- Act as an alternative NAVTEX channel, in particular for the Arctic and Antarctic NAVAREA’s/METAREA’s.
- ...
CLS already deeply involved in VDES definition and design at IALA, ITU and IMO.

Currently under contract with the European Space Agency (ESA) to complete a preliminary study:
- Services definition & requirements
- System design & requirements (space segment)
- Operational concepts (+ orchestration with SafetyNET, NAVTEX broadcasting services + interaction with terrestrial VDE operations)
- ROM price
VDES & corresponding channels

Note: all should be considered work in progress, as much as possible, in line with discussions within EAC.

http://www.cls.fr
Preliminary list of services has been made, focusing on the Arctic use case

Simulations for corresponding space mission:

2 concepts meeting these specific requirements (latency, latency, reliability, availability, geographical coverage, addressed vessel population, minimum bandwidth, encryption, ...):

- 1 satellite (micro) at 850km (deorbiting)
- 2 satellites (nano / 6kg each) on 2 different orbital plans below 600km (compliant with debris regulation)
- Scenarios of interferences with terrestrial and satellite to satellite
- ROM ~3M€/satellite incl. launch & operations (2Years)

Review of possible operational concepts

Roadmap
Example of expected performances: data volume delivered per day to the Arctic

**Best Case**

**Worst Case**
Next steps (1/2)

- Agree on final frequency plan allocation and consolidate sharing studies especially with land mobile systems
- Consolidate services and associated requirements
- Review possible operational concepts, in coordination with terrestrial VDE developments
- Financial viability (business case) and user feedbacks

⇒ Phase II to start Q1 2014
⇒ **ESA & CLS are inviting main stakeholders to join the on-going study in preparation of following-up testbed**
⇒ Letter of interest have been circulated, as per recommendations of Annex 1 of e-NAV14-17.1.7.1 (guideline on testbeds) to involve users and stakeholders at every stage.
- **ESA** is also preparing a demo mission for satellite VDE (procurement Q4 2014 / launch 2016-2017). Other national initiatives are also expected (in Europe and worldwide).

- Planning is fully in line with:
  - e-NAV SIP (3 phases implementation 2014-2020)
  - IMO and ITU milestones
  - European Horizon 2020 R&D framework program

⇒ Towards a dedicated VDES (incl. satellite VDE) testbed in Europe (and more ?)
Possible situation in 2015/2016 (EU testbed)

Small (CubeSat) satellite to validate VHF waveform

Other (terrestrial) project
Why would satellite VDE happen?

- Increasing needs and VDL loading growing issue
- e-Navigation and modernization of GMDSS open the door to new systems
- On-going research activities to demonstrate the technical viability
- Affordable satellite technology serving global needs. This is stimulating national space industries in several countries, towards a possible international cooperation (in kind contributions to a global system).

- This may drive the overall viability of satellite VDE, for instance towards a non-profit (public services) scheme, similar to the Argos system (US, FR, EU, India cooperation).

⇒ We look forward exchanging with all interested parties to share views and take onboard all valuable inputs for the next steps!
Thank you

gfabritius@cls.fr
Investigation of multipath fading for VDES
Contents

1. Radio propagation model and Simulation outcome
   1-1. What’s Multipath?
   1-2. Importance of multipath investigation
   1-3. Workflow
   1-4. Simulation procedures
   1-5. Simulation model
   1-6. Integrated simulation outcome

2. Measurement of multipath fading
   2-1. Measuring method
   2-2. Measurement system introduction

3. Future plan
1. Radio propagation model and Simulation outcome

1-1. What’s Multipath?

Not only direct signal that input from the transmitting antenna to the receiving antenna, there are signals that is reflected from a wall, surface and any objects. These signals are mixed in the receiving antenna, and it may cause to degrade the receiving characteristics significantly.
1-2. Importance of multipath investigation

Points that have to be considered the development of digital mobile communication
  • The level variation due to the fading
  • The frequency variation due to the Doppler shift

However, we found no investigation report of VHF multipath fading for maritime mobile.
→ Can we use the same value of land mobile standard? Is there the maritime characteristic?

Measure against of multipath depend on not only the hardware but also the communication protocol.

Investigate to decide the radio characteristics and communication protocol in the near future is needed.
1-3. Workflow

- Decision of simulation condition
- Development of Simulation environment
- Preparation of Measurement

Actual Measurement

Re-simulation

Future development

Consideration
  - Hardware
  - Characteristics
  - Protocol
1-4. Simulation procedures

A

Environment condition

Choice of landforms

Other simulation condition

Landform modeling

Propagation analysis

Creating the radio path model

B

Modulation and Demodulation model

Each modulation part

Frame construction and send data

Each demodulation part

Radio propagation analysis simulator

References

Integrated simulation outcome

Math calculation simulator
1-5. Simulation model

a. Choice of the radio path and simulation conditions

**Landforms**

<table>
<thead>
<tr>
<th>Places</th>
<th>Calculation condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban</td>
<td>ETSI 300 392</td>
</tr>
<tr>
<td>Hilly terrain</td>
<td>ETSI 300 392</td>
</tr>
<tr>
<td>Harbor</td>
<td>Simulator</td>
</tr>
<tr>
<td>Coast1 (nearby place)</td>
<td>Simulator</td>
</tr>
<tr>
<td>Coast2 (far)</td>
<td>ETSI 300 392</td>
</tr>
</tbody>
</table>
## EX) Environment conditions for simulation

<table>
<thead>
<tr>
<th>Items</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radio propagation of Day and Night</td>
<td>not calculated (VHF band)</td>
</tr>
<tr>
<td>Effects of rain</td>
<td>not calculated (VHF band)</td>
</tr>
<tr>
<td>Effects of sea wave</td>
<td>not calculated (complex wave pattern)</td>
</tr>
<tr>
<td>Radio wave diffraction</td>
<td>Harbor, Coast1, Coast2</td>
</tr>
<tr>
<td>Vessel speed</td>
<td>40knot (High Speed Craft)</td>
</tr>
<tr>
<td>Maximum Doppler freq.</td>
<td>20Hz (HSCs approaches each other)</td>
</tr>
<tr>
<td>Antenna height</td>
<td>Boat : 4.5m, Ship : 45m</td>
</tr>
<tr>
<td>Antenna type</td>
<td>Dipole (λ/2) --- 2.14dBi</td>
</tr>
</tbody>
</table>
b. Simulation model

Entry information of landform, and Simulate the propagation analysis

Ex) TOA – Propagation loss (0uS: Start time of SIM)

- Antenna height: 45m
- Frequency: 160MHz
- The distance between ships: 8.5km
- The distance of shore: 5km
- The number of diffraction: 1
Create the simulation model for math calculation

- Frame construction and send data
- Modulation part
  - $\pi/4$ DQPSK
  - $\pi/8$ D8PSK
  - 16QAM (sub-carrier)
- Demodulator part
- BER measurement
- (Radio path)

<table>
<thead>
<tr>
<th>Items</th>
<th>References</th>
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<tbody>
<tr>
<td>Frame data</td>
<td>- VHF data link protocols for data communication systems (Working document toward a preliminary draft)</td>
</tr>
<tr>
<td></td>
<td>- ETSI 300 392-2</td>
</tr>
<tr>
<td>Demodulation method</td>
<td>- ETSI TR 102 580 V1.1.1 (TETRA2 Designer’s Guide)</td>
</tr>
</tbody>
</table>
1-6. Integrated simulation outcome

\[ \frac{\pi}{4}\text{DQPSK} \]

\[ 16\text{QAM} \]

(16 sub-carrier)
\( \pi /4 \text{DQPSK} \)

- Typical Urban

**BER curve for TU**
(Various facing velocity)

**Example**

- Max. Doppler freq = 5 – 45 Hz
- 22.3 dB
π/4DQPSK
- Hilly Terrain

BER curve for HT
(Various facing velocity)
16QAM (16 sub-carrier)
- Typical Urban

BER curve for TU
(Various facing velocity)

Max. Doppler freq
= 5 – 45Hz

Example
16QAM (16 sub-carrier)
- Hilly Terrain

BER curve for HT
(Various facing velocity)
2. Measurement of multipath fading

2-1. Measuring method

Obtain a delay profile by the pulse compression method.

Advantage:
- S/N ratio is improved
- Transmit power doesn’t have to increase
- Simple measuring system
2-2. Measurement system introduction

TX Side

PC

SDR

GPS ANT

VHF ANT

PA

RX Side

(same measurement system)
3. Future plan
Thank you for your kind attention
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Saab TransponderTech
Development of VDES Radio

Johan Lindborg
2014-01
Cooperation between Saab and Swedish Maritime Administration

• Initial joint research project started late 2013
  – Initial focus on maximizing bandwidth on 25kHz channels (ASM1 and ASM2)
• Will research suitable waveforms
• Performance
• Robustness
• Cost effectiveness
• Focus on real world testing using Software Defined Radio
• Plans for extension rest of 2014
Use of existing Saab R5 product platform

- The R5 AIS transponder is ideal for VDES radio research
  - SDR design concept
  - Commercially available
  - IEC60945 approved, suitable for on board testing
  - Integrates AIS functionality
- May be used as base platform for full scale VDES prototype
  - Can be modified for use of new 25 – 150kHz channels
R5 SDR Platform
Block Schematic overview

- Communication channels realized in FPGA
- Waveforms defined in DSP
R5 SDR Platform
System functional blocks

- Radio front end
  - Downmixing, filtering and sampling
- FPGA
  - Channel decoding, timing, additional filtering
- GNSS Receiver
  - Provides the system with timing for the TDMA radio link
- DSP
  - Signal baseband decoding/encoding
- ARM
  - High level system functions, communications protocol
SAAB VDES radio development
Ongoing research

- Waveforms tests on physical R5 SRD hardware
- Initial tests performed on 25 kHz channels using the R5
  - Root raised cosine filter with alpha 0.35 used for TX and RX phase filtering
  - Single carrier DQPSK (19.2kbps)
  - Single carrier D8PSK implemented in R5 Radio Platform (28.8kbps)
  - 16QAM research ongoing
    - 8x16 QAM a possibility (76.8kbps)

- Conclusions so far
  - DQPSK and D8PSK working within AIS spectrum mask
  - -107dBm sensitivity with DQPSK 19.2kbps reached
Considerations for future development

• Multi carrier QAM will require linear TX design
• Careful consideration of filter design
  – Solve blocking issues with wide SDR receivers
  – Solve AIS/ASM reception during VDES transmission
  – Solve VDES reception during AIS/ASM transmission
• Suitable error correction algorithm must be selected
  – Long VDES packages could be corrected after AIS TX burst interference
• Reasonable trade off between performance and robustness must be made
• Satellite component may present unknown problems
  – New antenna requirements?
• Protocol layer design
Considerations for future development

- Allowed transmission duty cycle on board vessels
  - Shipborne Class A AIS is limited to maximum 5 consecutive slots [133 ms], and total 20 slots [533.33 ms] per minute [one AIS TDMA slot = 26.67 ms]
  - Would seriously limit VDES ship to shore, ship to ship, and ship to satellite throughput from single vessel
    - 0.8% utilization
    - Example: 308kbps data channel gives 2.7kbps useful bandwidth. Before error correcting codes.
  - Transmission may block/reduce CH 70 and CH 16 reception
    - Same can be argued for VHF Voice communication
  - Transmission may block/reduce AIS reception
    - Can be handled with filters and antenna separation, especially if AIS and VDES unit is a one box solution
    - Reasonable reduction of RX performance to be agreed upon
Development of VDE radio
Matters to be defined in the International Standards

• A firm channel plan
• Selection of waveforms
• Radio performance requirements for each waveform
• Number of concurrent transmitters to be defined
• Duplex requirements (concurrent RX and TX)
• One or two box solution optional?
VDES Channel Sounding Campaign

Jan Safar¹, Nick Ward¹, David Haley², André Pollok², Rick Luppino²
¹General Lighthouse Authorities, UK and Ireland
²Institute for Telecommunications Research, University of South Australia

2nd JCG Workshop on VDES
Tokyo, 21th January 2014
VDES uses a variety of communication channels
- Different operating modes: ship-shore, ship-ship, ship-satellite
- Different environments: harbours and approaches, coastal, open sea, …
- Different frequencies: AIS1&2, LR AIS, ASM1&2, VDE1&2, …
- Different bandwidths: 25 kHz, 50 kHz, 100 kHz

Available bandwidth is scarce (≈ 450 kHz)

Efficient use of the spectrum should be top priority

Good knowledge of channel characteristics is essential
- Waveform design
- Receiver design
- System performance modelling

Channel sounding experiments are being prepared (ship-shore)
- Channel captures recorded and post-processed offline
- Each site (ship/shore) will have a PA and can act as Tx or Rx
- Global synchronisation via GPS disciplined oscillators
Transmission

- Time slotted transmission (slot duration 250ms)
- One packet per second duty cycle
- Multicarrier Tx – observation of frequency selective effects
- Test transmissions will cycle through
  - Operating channel/bandwidth
  - Transmit power
- Inactive periods of duty cycle used to characterise interference
Transmit Parameters

- **Operating channel/bandwidth:**

<table>
<thead>
<tr>
<th>Channel</th>
<th>Frequency (MHz)</th>
<th>Bandwidth (kHz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASM1</td>
<td>161.9500</td>
<td>25</td>
</tr>
<tr>
<td>ASM2</td>
<td>162.0000</td>
<td>25</td>
</tr>
<tr>
<td>VDE2 (ship / shore)</td>
<td>157.3125 / 161.9125</td>
<td>50</td>
</tr>
<tr>
<td>VDE1 (ship / shore)</td>
<td>157.2375 / 161.8375</td>
<td>100</td>
</tr>
</tbody>
</table>

- **Transmit power:** 12.5 W and 1 W
Measurement Sites
Shore

Trinity House
Harwich, Essex, UK
Measurement Sites
Ship

- **IMO Area Categories**[^1]:
  1. Port areas and approaches
  2. Coastal waters and confined or restricted areas
  3. Open sea and ocean areas
  4. Areas with offshore and/or infrastructure developments
  5. Polar areas
  6. Other remote areas

[^1]: Draft Strategy Implementation Plan, IMO e-Navigation Correspondence Group
Summary

- VDES channel sounding methodology is being developed
  - Capture data in real-world environments
  - Extract and characterise key channel parameters
    - Path loss (power attenuation)
    - Time-of-flight (propagation delay)
    - Frequency offset
- Ship trials are being prepared
- Results could help guide the waveform design process
- Full report to be presented at the March meeting of IALA e-Nav WG 3/4
Thank You!

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Examples of Data Volume of Safety Related Information

LCDR Kinji TAKEUCHI
Japan Coast Guard

22 January 2014
Workshop on International Standardization of VDES
Overview

• Background of Survey
• Examples of Data volume in Japan
  – Weather information
  – Navigational warnings and notices for mariners
  – Live Webcam broadcast by JCG
• Conclusion
Background

• JCG provides safety-related information on its website.

Weather information
• wind speed
• wind direction
• wave height … etc

Navigational warning
• NAVAREA
• NAVTEX
• Local navigational warning

Live Webcam
Background

• It is expected that VDES has enough capability to communicate safety-related information as above.

• Study on data volume for e-Navigation was conducted by the Canadian Coast Guard.

• Japan Coast Guard has conducted a survey on data volume of safety-related information by referring to the result of the CCG study.
Conditions of our survey

• Overview: We surveyed the average data flow of safety-related information per minute.

• Subjects for the survey
  – Weather information
  – Navigational warnings and notices for mariners
  – Live Webcam

• Date: 8th - 17th January, 2014

• Place for survey: the 3rd region of Japan (JCG provide a lot of information in this region).
Weather Information

- There are 19 observation points in the 3rd region.
- Information on each observation points is refreshed every 30 minutes.
- 2 slots (512 bits) is required to send information from each points using ASM (FI 31).
- The calculated data volume per minute for sending weather information is 1.3 slots (324 bits).
Navigational Warnings and notices for mariners

- There were 34 notices for mariners and 38 navigational warnings provided in the 3rd region of Japan on 13th January 2014.
  - 2 NAVAREA, 18 NAVTEX, and 18 local navigational warnings

- CCG’s study assumed the following:
  - Refresh rate: 30 minutes, required slot: 3 slots (768 bits) for each warning or notice.

- Calculated data volume per minute
  - for notices for mariners is 3.4 slots (870.4 bits)
  - for navigational warnings is 3.8 slots (972.8 bits).
Live Webcam

• JCG has installed 9 Live-Webcams in the 3rd region and provide the streaming video on its website.

• Camera specs:
  – Format: Motion jpeg
  – Pixels: 320 x 240
  – Frame rate: 0.7-2.0 fps (automatically adjusted)
Live WebCam

• Result of survey on data the Webcam data flow per minutes
  – Date: 17\textsuperscript{th} January, 2014
  – Sum of data flow (8 cameras): 740.3 kbps
    (which exceeds the maximum data rate of VDES: 307.2 kbps)
    • Max: 212.4 kbps / camera
    • Min: 31.2 kbps / camera

• Decreasing the frame rate and/or number of pixels is required to send video via VDES.
Conclusion

- JCG has conducted a survey on data flow of safety-related information.
- The data flow is as follows:
  - Weather information : 324bits per minute
  - Notices for mariners: 870.4bits per minute
  - Navigational warnings: 972.8bits per minute
  ※VDES has enough capability to send that information.
  - Live Webcam: 740.3kbps (8 cameras)
  ※Decreasing the frame rate and/or pixels is required
### Planed or on-going testbeds for VDES development

<table>
<thead>
<tr>
<th>Name</th>
<th>Location</th>
<th>Time and duration</th>
<th>Status</th>
<th>Contact person(s)</th>
<th>Testbed website</th>
<th>Organisation(s) involved</th>
<th>Funding programme and budget</th>
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<tbody>
<tr>
<td>Korea</td>
<td>in 2014</td>
<td>planed</td>
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<td>Korea Research Institute of Ships &amp; Ocean Engineering</td>
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<td>Sesame</td>
<td>3 years</td>
<td>on-going</td>
<td>Mr. Haugen</td>
<td></td>
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<td>Kongstberg, the Norwegian Coastal Administration, The Maritime and Port Authority of Singapore</td>
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<td>Japan</td>
<td>in 2014</td>
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<td>Lcdr. Takeuchi</td>
<td></td>
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<td>Japan Coast Guard, manufacturers in Japan</td>
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<td>MONALISA</td>
<td></td>
<td>on-going</td>
<td>Mr. Zetterberg</td>
<td><a href="http://www.sjofartsverket.se/en/MonaLisa/">http://www.sjofartsverket.se/en/MonaLisa/</a></td>
<td></td>
<td>CHALMERS, Danish Maritime Authority, SSPA, Likennevirasto, Swedish Maritime Administration</td>
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<td>United States</td>
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<td>Mr. Kautz</td>
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<td>United States Coast Guard, other US government agencies</td>
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<tr>
<td>France or EU</td>
<td>start mid/end 2014</td>
<td>planed</td>
<td>Mr. Fabritius</td>
<td></td>
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<td>TBC, TBC, incl. Space Agency, Satellite</td>
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