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dPMR Trial

Port of Rotterdam

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Version management

0.1	10-02-2020	Initial Draft
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Contents

Foreword

Communication between ships and shore has taken place traditionally through the use of VHF radio. VHF radio equipment is used for shipping both at sea and inland.

Over the years, the use of VHF radio, and the wish to communicate and be sure that your message is received and understood, has grown. Digitisation in other areas of communication has improved the way to communicate (GSM, LTE etc). But, in the marine bands the introduction of new digital communication channels for data has put pressure on the availability of VHF voice channels.

With the introduction of VDES (VHF Data Exchange System) a problem arises that this would not be an easy task for The Netherlands to contend with. The ITU (International Telecommunication Union) has taken the decision that the frequencies for VDES are available from 1st of January 2017 in the World Radio Conference of 2015. Because The Netherlands has foreseen the same problems as they encountered they sent in a paper to MSC97 to raise awareness of this problem. Due to this, IMO (International Maritime Organisation) agreed that from 1st of January 2024 these frequencies should be freed by Contracting States and VDES could then use these frequencies. In the World Radio Conference of 2019 ITU also decided on the use of frequencies for VDES satellite communication.

During the IALA eNAV Communication (International Association of Lighthouse Authorities) communications workgroup intersessional meeting in Sydney a possible technical way of a more efficient use of VHF frequencies was presented. This should at least have the same performance standards (functionality) as the current VHF radio.

There are multiple ways to achieve this but the technical candidate solution presented is called dPMR (digital Private Mobile Radio), currently used in land mobile communications as a replacement for analogue FM voice communication in both VHF and UHF bands. There was, as far as we know, no specific test done for maritime use of dPMR as a candidate technology to replace analogue VHF radio. Replacing analogue VHF radio needs to be done in such a way that both the “old” and new technology could be used next to each other and therefore an important taskis the possible migration plan.

This new candidate technology could also have a place within Maritime Safety Information and/or Smart Shipping because it is possible to embed small data/text with the voice transmission. This information could contain the intentions of ships or information about hazards.

For situational awareness it is commonly known that eye-sight, VHF radio and radar are the main tools to accomplish this. Next to this, the use of AIS and by transmitting the position of the VHF (digital) radio could complete the picture by showing identification, size, location and which ship is transmitting.

1 Goals

The purpose of the trial was to identify if dPMR could be a possible candidate technology to replace and possibly improve the current voice communication by VHF radio by digitising the voice.

1.1 Inquiry goal 1 current functionality

The first inquiry goal was to identify if:

1. The quality of the speech was equal or better than with current VHF radio under various ranges;
2. Migration strategy from current situation to a mixed and maybe a full digital situation;
3. Possible (harmful) interference of current communication;
4. Possible (harmful) interference of new digital communication;
5. Are multiple systems from different vendors capable of working together;

1.2 Inquiry goal 2 new functionality

Because dPMR is a ETSI standard, there are already extra functionality embedded in this standard that could be used:

6. Could we use position information embedded with the signal;
7. Are we able to identify the transmitting station;
8. Could we send short messages for Maritime Safety Information and/or broadcasting your intention (Smart Shipping);
9. Are there possibilities to check the validity of transmissions;
10. Is there more functionality needed (must have, need to have and nice to have)

1.3 Tracks

To ensure that these goals would be reached there were identified two tracks during the trials.

1. Work together with the users of VHF radio (mariners, operators, skippers, etc) if the quality of the speech and range is enough and if possible new features are an possible asset.
2. Check with national ITU organisation (Agentschap Telecom), waterway users and authorities if dPMR will interfere with the current communication, discuss a possible migration strategy and possible adjustments to the standard to make it more appropriate for maritime.

2 Setup

2.1 Groups

Before the trial started two main groups were identified. One group of users that actively participated to the trial and one group observers that would be informed about the technology and developments.

The group that actively participated to the trial were technicians, VTS operator, skipper and law enforcement agency for frequency (national ITU organisation)

At first, the idea was to have a small group of observers for the trial. After defining this group, and sending out the invitation, there was a lot of additional interest . This group consists of policy makers, managers, advisors and technicians from different governmental and non-governmental organisations. In total, during the day, 40 people visited the trial.

2.2 Area

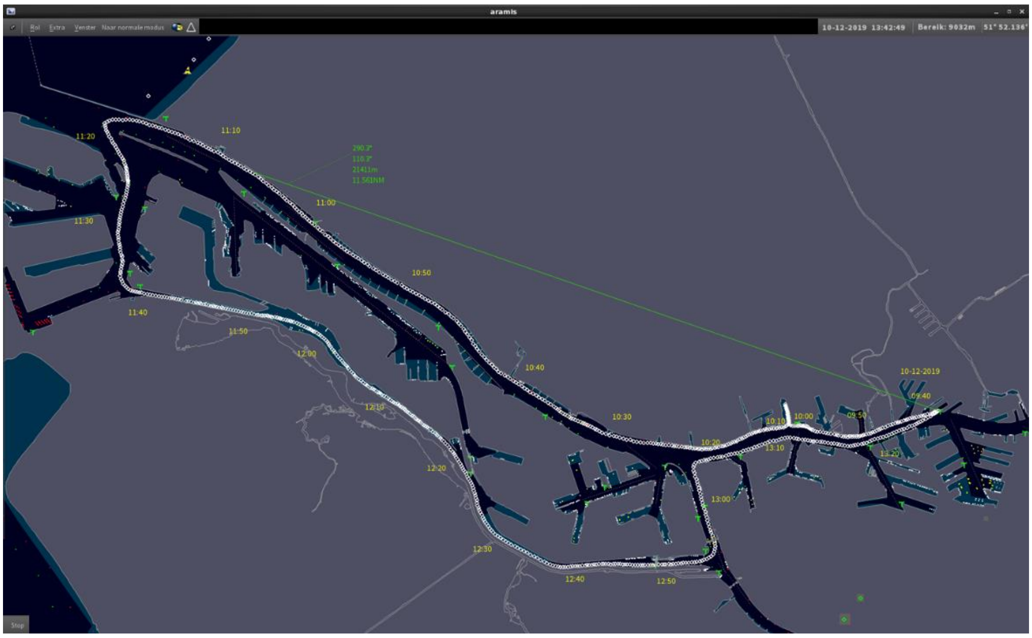
During the planning of the trial a suitable area needed to be chosen. The Netherlands is very flat with almost no mountains, as a result radio signals carry far and will possibly interfere with other signals. Next to this, the complete area of The Netherlands has about 7500 ships sailing on a daily base where most are concentrated around the big ports like Port of Rotterdam. We also have a lot of infrastructure like locks and bridges where communication is needed.

So an ideal place to test interference would be around the Port of Rotterdam.

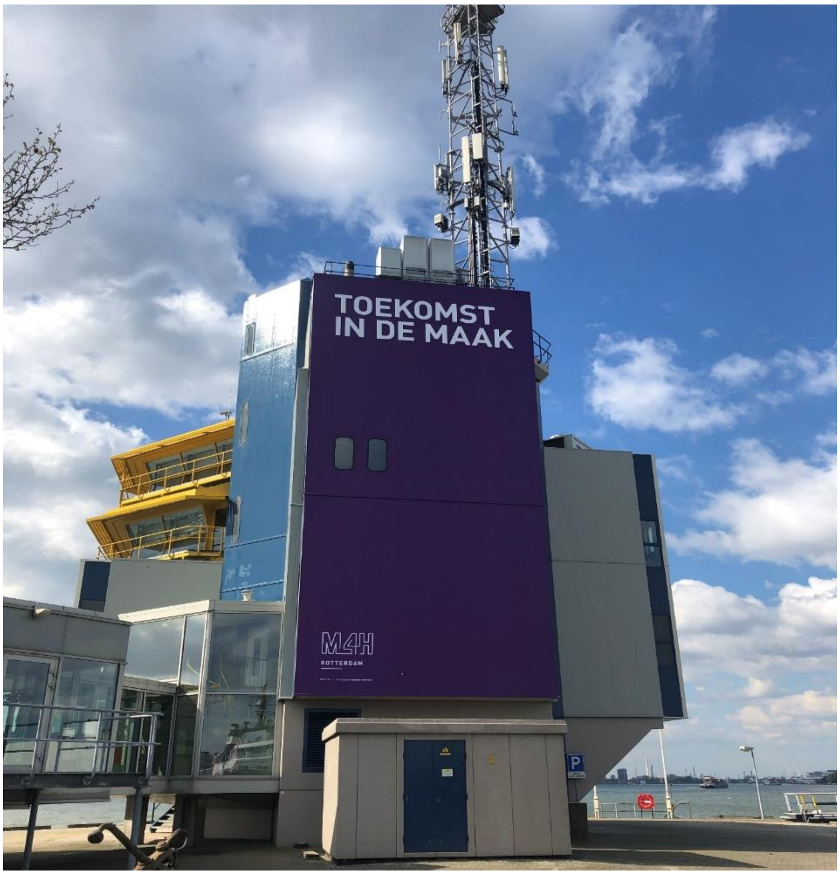
2.3 Locations

For the test we contacted the Port of Rotterdam for their assistance and to use some of their assets and personnel. The Port of Rotterdam was willing to help us with this trial and offered a de-commissioned VTS centre in the middle of the city and one of their assistance vessels. Also they provided us with an experienced VTS operator and crew for the vessel. These employees of the Port of Rotterdam had been working for at least 30 years at the Port on the vessel or VTS centres.

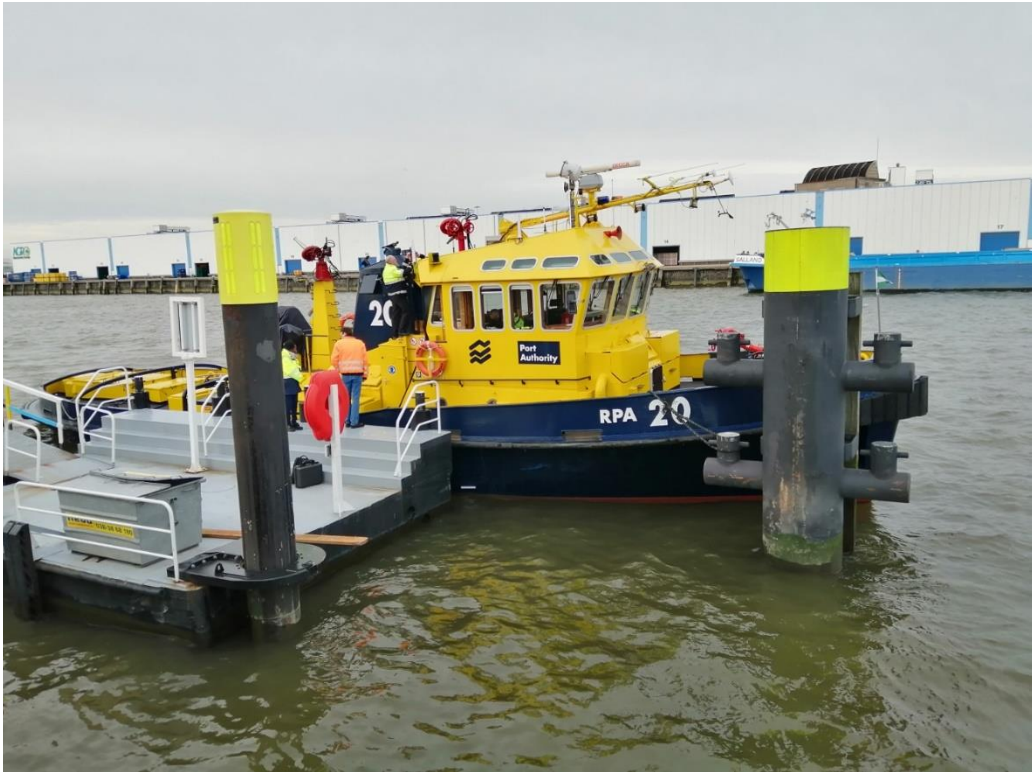
The picture below shows the trial area, VTS centre, vessel and monitoring setup.



On the right side is the VTS centre where one of the antennas was placed on a height of 16 meter. The dots show how the vessel sailed and the time the vessel was on a specific location.



The VTS centre in Port of Rotterdam (text on building say “future made here!)



The used vessel of the Port of Rotterdam


The monitoring setup/site of the ITU organisation (Agentschap Telecom)

2.4 Used hardware

The antenna installation on the ship was 0 dB omni-directional antenna (Procom CXL2) with 6 meter RG214 coax cable.

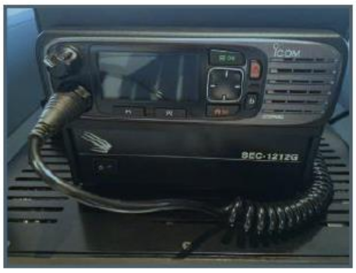
The antenna installation on the VTS centre was a 0 dB onmi-directional antenna (Procom CXL2) with a 15 meter RG213 and 5 meter Ecoflex coax cable between the two cables was a lightning security.

During the test the following equipment was used:

- Mobile station Kenwood NEXEDGE NX720 (VTS centre)
- Mobile station ICOM F5400DP (ship)
- Portable Kenwood NX220.
- Portable ICOM F3400DPT.

The transmit power measurements at the connector of the station were:

- 43 dBm and 30 dBm (Kenwood NEXEDGE NX720).
- 43 dBm, 39 dBm and 36 dBm. (ICOM F5400DP)


Pictures of the equipment.

2.5 Used frequencies

We obtained a trial license from our ITU organisation for the period from the 1st of December 2019 till the end of 1st July 2020. This was done so more trials could take place. Next to this it would provide the opportunity to give different users and interested people to hear and experience the quality of voice and use of the equipment. At the moment, plans are in place to give participants of the VTS-ENAV Symposium (25 May 2020 - 29 May 2020) a chance to experience the digitisation of VHF radio (dPMR).

Although we received a license to use all maritime frequencies the test was made on frequencies used by Rijkswaterstaat only, so as not to affect the normal port operations.

	162.5				162.5				
analogue FM voice	162.500 channel 2038				162.525 channel 2098				
Direct replacement	162.490625 D1	162.496875 D2	162.503125 D3	162.509375 D4	162.515625 D5	162.521875 D6	162.528125 D7	162.534375 D8	
ITU-style	162.487500 I1	162.493750 I2	162.500000 I3	162.506250 I4	162.512500 I5	162.518750 I6	162.525000 I7	162.531250 I8	162.537500 I9

Figure 1: Channel Plan

2.6 Considerations

2.6.1 IALA

1. That any evaluated technologies have a clear migration path from the current analogue voice services to the new digital voice services by allowing both the digital and analogue services to co-exist in the same transceiver for the duration of the entire migration period. This could extend to using the same antenna and other existing physical installation hardware.
2. The channel efficiency should be a high priority, by allowing four (4) or more digital voice channels for each 25kHz maritime VHF voice channel.
3. The digital service includes the capability of transmitting the location of the radio for the entire duration of the digital voice conversation.
4. The digital service allows a Short Message Service (SMS) without the need to set up a digital or other voice call.

5. The digital voice quality be similar to, or better than, the analogue voice service, especially using weaker radio signals at the extent of the radio coverage.

2.6.2 Before trial

6. That the candidate technologies are easy to use by the users and limit the possibility of the users to make mistakes
7. That the candidate technology is independent of other (supporting) technology (like GPS) and manufacturer (no vendor lock)
8. Support the current functionality of VHF radio (DSC / ATIS)
9. Costs of the equipment is around the same as current.
10. Impact on current regulations is minimal (appendix 18)
11. The candidate technology, with most of the requested functionality, should be already be available
12. The candidate technology should be future-proof
13. Could support (Cyber) security for instance to check your own transmissions.
14. Support of Smart Shipping, for instance sending small data packets with the intentions of the ship.
15. Harmonized
16. Should be implemented using open standards

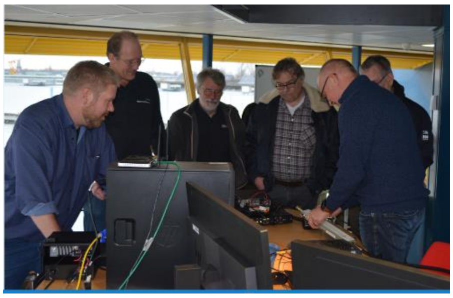
3 Results

3.1 Start trial
Before we started the trial we tested the equipment and installation (antenna and cabling). The first results were that the antennas we wanted to use were not good enough and needed to replace them, which we did.

The next test was to test the installation. On the ship this was all good after replacing the antenna but on the VTS centre we encountered a problem with the cabling. This problem with the cabling needed us to replace the cabling in the VTS centre. This was done very quickly by the technical staff of the Port of Rotterdam.

After we had tested the installation again, we didn't found any problems with cabling or antennas.

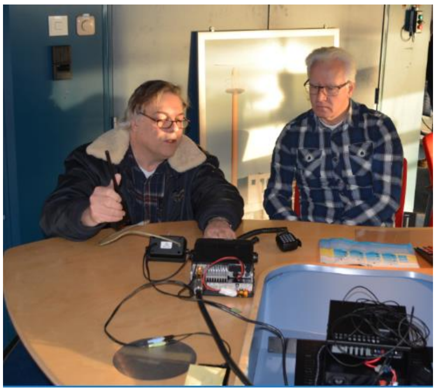
During the testing of the installation both technicians of CML and Koning and Hartman checked the configuration of the stations and tested them. These test passed ok but not all of the envisioned features could not be tested at that moment because of some missing parts. These parts were delivered after the test but did not jeopardise the main purpose of the test.



After everything was tested the scenario's were checked again. The red line in the scenario's was to go sailing and test on different distances with different power levels, digital and analogue communication and two languages English and Dutch. During the test we would record the time, distance, power, language and possible (harmfull) interference. For the last we used the equipment of our ITU organisation and of course informed the VTS operators of the Port of Rotterdam to inform us if something unusual within communication happened.

3.2 Test day
After a short introduction of everyone on the test day (10th of December 2019) we started with a short instruction and roles. The main group would be busy with the trial and two others would accompany the observers. There was a presentation about the trial to the observers and next to that the observers were asked to put their questions and observations on yellow paper and put them on the wall.

3.3 Use of equipment



The use of the equipment was after a short introduction easy. They are similar as VHF radio equipment. For the trial there were buttons programmed to switch between high and low power and change between all channels analogue and digital. Also the display showed which channel you were using, transmitting level, reception level and the station on the ship recorded the voice communications.

Next to the default installation we also programmed an emergency button on the Kenwood equipment. This as a possible feature to show to the observers.

3.4 Voice quality

During the test all voice was recorded on the ship side only. This was because the equipment at the VTS centre did not have this functionality. Therefore only recordings coming from the VTS centre and recorded on the ship are accountable for the test.

Both users on the ship and the VTS centre were enthusiastic about the quality of the digital voice and said that especially on the edges of the transmitting range the sound was clear and less tiring to listen to. Also the interference was much less.

During the test the reception quality of the digital transmissions was higher than on the same range when compared with analogue ones.

A question arose that if the operator could distinguish if the mariner would still be able to operate a ship by the sound of his/her voice was answered: that to determine this would not only be done by the voice quality but also by the sentence structure, response time and ability to response.

3.5 Interference

During the test the ITU organisation (Agentschap Telecom) monitored if the equipment stayed in the standard (ETSI TS 102.658 and appendix 18) and if it caused (harmful) interference. They measured that frequency 162,500 MHz was used for analogue communication and frequency 162,534375 MHz for digital communication (dPMR).

The two positions where the monitoring took place from was about 4 km from the VTS centre (because monitoring next to the transmitter has no use). Locations were Wilhelminahaven/Nieuwe Waterwegstraat and the Karel Doormanweg, both near the waterway.

The monitoring equipment consists of a broadband-onmi-directional antenna at a height of 10 meter connected to a Tektronix RSA realtime spectrum analyser. At the same time this was monitored with a Rohde & Schwarz direction-tracker. This antenna height was 6 meter. During the test no irregularities were discovered. A small note was that some of the communication could not be received due to the lower height of the antennas what could be explained.

On the ship, signals were also monitored with a Rohde & Schwarz FSH-6 spectrum-analyser if they noticed any interference in the spectrum when they were unable to connect to the VTS centre and ship. Also no irregularities were found. A note was that they only sailed on the main fairways and not all the inlets / basins at the Port of Rotterdam.

During the test there were some findings these were:

1. On lager distances, quality deteriorated when sailing. This was probably caused by the horizon / line of sight that current VHF radio also encounters;
2. On a specific area of the fairway the quality deteriorated because of large storage tanks standing between the VTS and vessel. The large storage tanks probably blocked or reflected the signal. (multipath)
3. When the quality deteriorated it presented itself by losing the connectivity or a "metallic/robotized" sound. When it happened with analog VHF communication it caused noise)

During the trial we were not able to test the Adjacent and Nearby Channel Rejections and this was tested later for both the current 25 kHz analogue FM (voice) and 6.25 kHz dPMR(digital voice) channels. This test is to quantify the interference potential of an adjacent / near dPMR channel on an existing analogue voice channel.

Also additional qualitative testing was also done to establish the closest distance an interfering dPMR radio would need to be before affecting the analogue reliever. This is particularly important when it comes to channel planning and migration strategies.

These test were done by using the ETSI specification procedure, measurements were made using two different instruments to perform the SINAD measurement, the 2955R having a flat filter response, whereas the 8903 measurement uses the psophometric filter as defined in EN 300 086. A third set of measurements were made using the TIA procedure.

Two channel plans have been proposed for implementing the replacement of analogue voice with digital voice:

- Direct replacement – where a 25 kHz analogue channel is split exactly into 4 dPMR channels.
- ITU-style, where the channel centre of digital channels is aligned with the channel of the analogue channel, so that the extreme digital channels overlap into the adjacent analogue channels

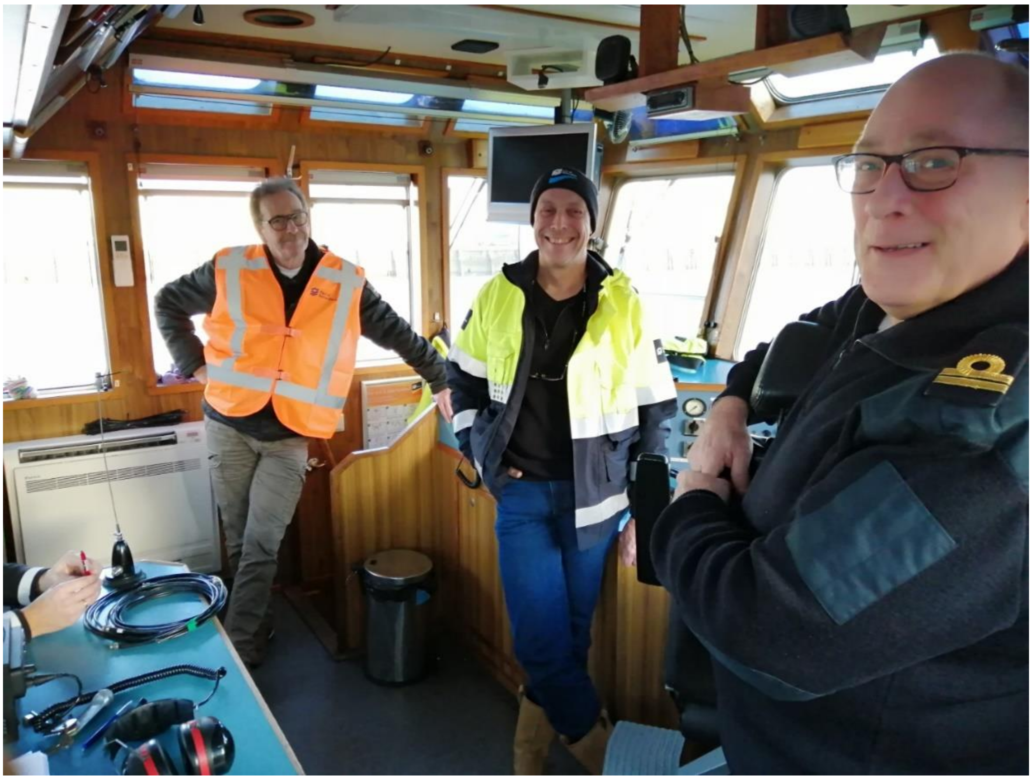
These two schemes are indicated in the channel selections as D5 to D8 and I5 to I9 respectively. This is described in Figure 1: Channel PlanFigure 1.

3.6 After trial considerations/questions

During and after the trial the following additional observations/considerations came out.

1. Be able of shutting down a transmitter remotely
2. Be able to limit the maximum time of one conversation
3. Be able of integration GMDSS (DSC, MSI)
4. Capable of dual watch functionality
5. Identification integration embedded in signal like MMSI, Callsign or ATIS for the entire duration of the digital voice conversation
6. Be able to switch automatically between analog and digital voice transmissions
7. Capable of detection of poor signal

8. Capable of detecting of interference
9. To be able to cope with multicast / diversity
10. Support (half) duplex
11. Possible of to dedicate one digital channel for data only
12. Support multi languages by voice and user interface.
13. Tests were in perfect weather/communication conditions, so how does it operate when not?
14. Must have an interface to connect to other bridge equipment for instance obtaining ships position from it’s centralised positioning system.
15. How can you detect destruction of the signal, like with analogue.
16. Would the repeater and trunking possibilities enhance communication and safety in a Port or traffic dense area?



Happy users

4 Conclusions

4.1 Use equipment
During the test the users had no problem with operating the equipment. There might be some slight adjustments to the user interface when integrating DSC/dual watch functionality

4.2 Voice quality
Both the users and the observers found the voice quality the same or better than analogue. The users reported back that listening to digital voice with the noise reduction made it easier and less intensive to listen. Concluding that with digital transmission of voice, if a mariner is still capable of operating his ship is equal as analogue.

The bad reception or failure of digital VHF that caused a "metallic/robotized" sound of losing the connection are similar of analog VHF where it causes noise. The impact and acceptance of this against the gains has to be analysed and decided.

4.3 Frequencies
In the lab tests, the equipment exceeds the requirements of both ETSI and TIA standards by some margin and the rejection of the dPMR channels in excess of 70dB in the direct frequency replacement format indicates that that the same adjacent channel practices can be applied to both analogue and digital implementations.

In the case of the ITU channel plan, the 61 dB result on channel I5 indicates that this arrangement could be marginal and would need very careful consideration before implementing.

The Walk Test was provided to illustrate the difference in range of the interferers that could be expected in a typical deployment. It shows that the use of channel I5 in close proximity to the wanted analogue channel will produce more interference than the existing analogue channel and so calls into question its usefulness in a real-world scenario. Although channel D5 does interfere slightly more than the analogue, it is not significantly so (only 11 m compared to 10 m). All the other channels showed that they would introduce less interference than the existing analogue channel and so could be deployed using the same (or possibly stricter) channel planning criteria as currently used for analogue channels.

The field test did not show any (harmful) interference.

4.4 Additions
The use of the candidate technology dPMR for maritime use could be a good option. Some possible functionality need to be defined by IMO in their performance standards.

5 References

- dPMR Association . (2012). dPMR Whitepaper Issue 1.3 .
- ETSI TR 102 884. (2013-02). digital Private Mobile Radio (dPMR) General System Design.
- ETSI TS 102 658. (2015-07). Digital Private Mobile Radio (dPMR) using FDMA with a channel spacing of 6,25 kHz.
- IALA ENAV Committee. (2019-04). Digitisation of Maritime Services - digital VHF voice.
- ITU-R M.1084-5. (2012). Recommendation ITU-R M.1084-5 Interim solutions for improved efficiency in the use of the band 156-174 MHz by stations in the maritime mobile service.
- ITU-R M.493-15. (2019). Digital selective-calling system for use in the maritime mobile service.
- ITU-R M.585-7. (2015). Assignment and use of identities in the maritime mobile service.

6 Abbreviations

Abbreviation	**Description**
AIS	Automatic Identification System
AT	Agentschap Telecom
ATIS	Automatic Transmitter Identification System
dPMR	digital Private Mobile Radio
DSC	Digital Selective Calling
ETSI	European Telecommunication and Standardisation Institute
GMDSS	Global Maritime Distress and Safety System
I&W	Ministry van Infrastructure and Water Management
IALA	International Association of Lighthouse Authorities
IMO	International Maritime Organization
ITU	International Telecommunications Union
MSI	Maritime Safety Information
VDES	VHF Data Exchange System
VHF	Very High Frequency