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**□** ARM **□** ENG **□** PAP X Input

**X** ENAV **□** VTS **X** Information

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Technical Domain / Task Number 2 2

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CML report to IALA ENAV26

on vocoders for digital voice channels over VHF

# Summary

This paper is a response to the input paper ENAV25-10.2.2 from CIRM. It provides some answers and background information to the issues raised in that paper regarding the selection of an appropriate vocoder for maritime use and other considerations in relation to the digitization of VHF voice channels.

## Purpose of the document

This is an information paper in response to a request for information from ENAV25.

# Background

At ENAV25, CIRM tabled a document which considered the adoption of a suitable vocoder for use in a digital maritime system. This paper is based on the author’s many years’ experience in digital radio and offers this as a background to the technology and the history of its development in other markets. It takes the original CIRM document format and attempts to add information to each section.

# Discussion

*It is CIRM’s view that licensing and patents are important considerations when selecting an appropriate vocoder. Use of technology should not involve patents unless a patent owner was prepared to donate or sell the patent.*

*CIRM notes that two of the most used vocoders for mobile radio at present are AMBE+2 and ACELP. AMBE+2 is used by DMR and dPMR, and ACELP is used by TETRA. CIRM notes that both AMBE+2 and ACELP are covered by patents.*

*CIRM suggest that the Opus audio codec (*[*http://opus-codec.org/*](http://opus-codec.org/)*) may be worthy of further consideration by Working Group 3, as it is open and royalty-free.*

Firstly, it should be noted that dPMR and DMR ETSI standards do not specify a vocoder, instead they leave a socket for a suitable vocoder to be inserted. In both cases a 3600 bps socket is provided for a digital voice channel. In both dPMR and DMR, this 3600bps is used for both the voice data and the forward error correction (FEC) – resulting in an effective voice data channel of approx. 2400bps. It was the two manufacturers interest groups (the dPMR Association and the DMR Association) that chose to use the AMBE+2 vocoder. In the case of the dPMR Association this decision was complex, and at times heated as it considered both performance (as measured by PESQ testing and MOS listening tests) and commercial aspects of the competing technologies (the major competitor in this case was an improved version of RALCWI, currently marketed in its original form by CML Microcircuits). It should be noted that the PESQ automated measuring process had problems with vocoder rates below 4800bps, consistently reporting lower scores than the listening tests in these cases, so PESQ values can only be compared across vocoders of the same bit rate.

The ACELP vocoder used in TETRA is not suitable for this implementation as it needs a 7200bps data channel.

AMBE+2 and ACELP are both covered by patents, but both are made available under licences by their developers under the ETSI FRAND policy (Fair, Reasonable And Non-Discriminatory). Whilst this does impose a cost on each radio produced, it is consistent for all manufacturers; however this may make smaller manufacturers hesitate to enter the market. The licence for ACELP is significantly lower than that charged for the AMBE+2 and is a single one-off charge which makes it much simpler to manage and cost.

CML have successfully implemented AMBE+2, RALCWI and two other Chinese University vocoders on their dPMR hardware for both the ETSI-standard market and for other specialised markets.

CML Microcircuits have extensive experience in vocoder technology from a commercial perspective, with products on the market today supporting RALCW, TWELP, G.729a, ADPCM, CVSD, G.723, G.711 etc. Recently we have also looked at others such as BV32, BV16 and also Opus. In all cases they required significantly higher bit rates that are available in either dPMR or DMR. In the case of Opus, it is advertised to work down to 6000bps, which is still too much, but we tried it out anyway and the quality was very poor. Without a significant amount of work, we concluded that Opus is not suitable.

*On the wider issue of digitization of VHF voice channels, CIRM notes in the Provisional Final Acts of World Radiocommunication Conference 2019 (WRC-19), that Resolution COM6/28 (WRC-19): ‘Considerations to improve the utilization of the VHF maritime frequencies in Appendix 18’ invites relevant international organizations to actively participate in the studies by providing requirements and information that should be taken into account in ITU-R studies. It is CIRM’s view that the following issues need to be considered in the ENAV Committee’s ongoing work on this subject:*

* *A cost benefit analysis covering the entire maritime community, i.e. VHF coast stations, commercial shipping, recreational boating, ports, harbours and marinas etc*

The benefit is the increase in the availability of voice channels; four digital channels can replace one analogue channel. In the case where there are already limited voice channel resources, and where voice channels currently in use may not be available in the future, improving the spectrum efficiency of those channels that are left maybe the only option available. If sufficient existing voice channels can be migrated to digital, this could also free up spectrum for additional data services (localised VDES for instance).

Experience in the land mobile industry has shown that there is a small initial increased cost for digital equipment, but that quickly returns to close to that of the original analogue equipment as digital implementations are more amenable to cost reduction through higher levels of integration and higher volumes. The marine market can take advantage of the existing knowledge base in the mature land mobile digital market to mitigate any cost increases.

* *The relative merits of TDMA vs. FDMA (e.g. in terms of frequency spectrum efficiency)*

CML has products in both markets so we have no commercial bias either way, and in each case, in their own environment, both schemes will achieve effectively the same spectral efficiency – ie: one voice channel in 6.25kHz of radio bandwidth. For systems that employ a centralised repeater or controller, then there are some commercial and engineering benefits in a TDMA system, however these are negated by its significantly poorer performance in a system with no centralised controller or timing reference, such as two ships communicating at sea and potential interference between them. In the case of FDMA, the system functions much as the current analogue voice FM system does, it will work equally well in terms of spectrum efficiency in a peer-to-peer system at sea or in a repeater controlled system close to land. The absence of a fixed timing controller also means that the FDMA system does not have range limitations forced on it by the digital protocol, unlike TDMA where the propagation delays have to be taken into account in the protocol design to limit interference from one slot to another.

* Management of co-existence of digital and analogue channels

Existing land mobile radios are designed to meet ETSI standards EN 300 113 and EN 301 166 which were specifically written to allow co-existence of analogue and digital systems. One caveat on this is that land mobile have used a 12.5kHz channel spacing for many years, so that a land mobile channel can be directly replaced by a 12.5kHz DMR channel, and with a little effort by two dPMR channels. The case of marine, using 25kHz channels, does make this a bit more complex in the case where a radio is trying to auto-select between an analogue 25kHz channel or one of four digital 6.25kHz channels. CML submitted an input paper to ENAV25 describing the results of lab tests to determine the ability of an analogue FM channel to function with an adjacent 6.25kHz dPMR channel using current equipment on the market today. The conclusion was that the same channel planning criteria could be applied to dPMR as are currently used for analogue FM.

* *Should there be an allocation of a separate channel for digital distress, safety and calling (or should Channel 16 or Channel 70 take on this role)?*

Technically, this isn’t an issue, however operationally, and to ease manufacturing requirements, it may be better to keep Channel 70 as the digital calling channel and add dPMR calling to the existing DSC calling. From a manufacturer’s perspective, the requirement for a second Rx channel for DSC does increase equipment costs so having all calling modes on Channel 16 would have a cost advantage, but as this channel is often blocked by analogue voice traffic, may have operational issues in the real world.

* *What will be the future relationship between Digital Voice and DSC (e.g. could the same technology be used for DSC)?*

That is up to fora like this to decide – but there is a huge installed base of equipment that already has DSC fitted. The dPMR protocol has facilities for emergency calls and signalling built-in (land mobile does not have dedicated distress channel) and is supported on most dPMR equipment in the market today. In addition, dPMR offers 4800bps data rate, a significant increase on DSC 1200bps, at receive sensitivities of better than -120dBm.

* *Could digitisation create an opportunity for SMS on VHF channels and position information with low overhead?*

Yes, short data messages, status messages and full data capability are built-in to the dPMR standard and are supported on many radios in the market today. These features will be tested by the RWS in The Netherlands in the near future.

* *What ITU alignment issues are involved?*

There already exists an ITU plan for 6.25kHz operation and channel numbering which was used by the radios in the recent Rotterdam trials, however this may not be the most spectrally-efficient method and a small modification may be beneficial. See ITU-R REC M.1084-5 Annex 2 and Annex 4, sections 2 and 3.

* *An implementation plan that clearly sets out how digitization would be introduced and the impact of each stage on the maritime community*

Indeed, it does. This is partially covered in ITU-R REC M.1084-5, but may need some expansion. The land mobile industry has taken about 10 years to transition from analogue to digital, but that was mainly driven by commercial rather than mandatory issues. The marine industry is very different in some ways and yet shares many of the same problems.

*CIRM will consider the above issues further and will report back with recommendations.*

# Other issues raised:

RWS in The Netherlands have asked about the ability of dPMR to support ATIS operation on Inland Waterways – the significant difference between dPMR and marine operations is the use of the MMSI in marine operations which demands the use of a 30-bit addressing field, whereas dPMR today can only support 24-bits. ETSI TGMARINE have already been working on the modifications to the addressing protocol to support 30-bit modes, and this should make it suitable for both MMSI and ATIS addressing modes.

# Action requested of the Committee

The Committee is requested to:

1. Note the above.
2. Continue the discussion with CIRM on this issue.

1. Input document number, to be assigned by the Committee Secretary [↑](#footnote-ref-2)
2. Leave open if uncertain [↑](#footnote-ref-3)