



FCC NARROWBANDING MANDATES

White Paper

Executive Summary

The Federal Communications Commission's regulatory environment for Land Mobile Radio (LMR) can appear complex, but is in fact relatively straightforward. Radios built to the Digital Mobile Radio (DMR) standard comply in full with all current regulations and planned future mandates. They also meet the Federal Communication Commission's (FCC) recommendations for users to consider going beyond the current narrowbanding 12.5 kHz legislated requirements. From a regulatory perspective DMR radios have a spectrum efficiency that is at least equivalent to any other technical approach to narrowbanding. DMR radios also have a number of distinct advantages over other technical approaches to achieve spectrum efficiency in a United States specific context. In particular DMR-compliant equipment delivers a doubling of capacity with a minimal impact on licenses, while at the same time delivering backwards compatibility with legacy radio systems.

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Introduction

The published requirements setting out the future of Land Mobile Radio (LMR) narrowbanding regulation in the United States can appear complex. There is also potential for confusion in the Federal Communication Commissions' (FCC) current recommendations to purchasers of narrowband equipment. Narrowbanding requirements are spread through several different FCC documents and because different terms are used in different publications, tying all the relevant paperwork together requires patience. However, when the relevant documents are brought together, the FCC's requirements and recommendations are extremely clear. To help remove any possible uncertainty this paper aims to explain how the rules apply to radios complying with the DMR standard. This paper also gives guidance on how the FCC's current stated narrowbanding requirements and comments apply to DMR.

Note that this paper is limited to narrowbanding requirements in the VHF (150-174 MHz) and UHF (421-512 MHz) frequency bands. It does not address any requirements in the 700 MHz, 800 MHz, 900 MHz or other LMR bands.

The Narrowbanding Rules and 6.25 kHz Efficiency

One of the key areas of possible confusion for purchasers of digital technology today is the FCC position on 6.25 kHz narrowband equivalent efficiency. For this reason it is sensible to say something about this issue first.

The FCC has not yet made any rulings requiring the use of 6.25 kHz efficient technology in VHF and UHF systems to be deployed now or in the future. All the current FCC narrowbanding rules relate to the requirement to migrate to 12.5 kHz efficient systems in the 150-174 MHz and 421-512 MHz bands. Any Commission initiative to require that licensees must operate on 6.25 kHz channels or equivalent spectrum efficiency would mandate the release of a Notice of Proposed Rulemaking, and no industry trade group has suggested that the FCC initiate such a proceeding. The FCC has, however, issued a recommendation that those users intending to migrate to narrowband consider going straight to 6.25 kHz efficient technology¹.

But what exactly does the FCC mean by 6.25 kHz technology or 6.25 kHz efficient technology?

The FCC uses various terms to denote 6.25 kHz efficient technology in the narrowbanding dockets, CFR rules and in other documents in order to avoid having to give a lengthy definition each time.

¹ FCC press release 22 March 2007

² Footnote 4 of the Fifth Report and Order, released August 2, 2002, in WT Docket 96-86

The exact statement of the FCC's meaning of 6.25 kHz equipment is given in Footnote 4 of the Fifth Report and Order², where it states,

'For convenience, we refer to systems or equipment that provide only one voice path ... per 6.25 kHz of spectrum bandwidth as '6.25 kHz systems' or equipment operating in the '6.25 kHz mode'.

So references by the FCC to "6.25 kHz equipment", includes radio systems that deliver the following:

- One voice path or 4800 bps in 6.25 kHz or
- Two voice paths or 9600 bps in 12.5 kHz or
- Four voice paths or 19200 bps in 25 kHz

Sometimes the FCC uses the notation "6.25 kHz (e)" to talk about "6.25 kHz systems" where the "e" stands for efficiency, but it does not always do this.

What does all this mean for DMR-compliant equipment? In the simplest terms it means that DMR-compliant products meet the FCC's definition of "6.25 kHz systems or equipment". This is because the DMR standard specifies two-slot Time Division Multiplexing Technology to split the 12.5 kHz channel into two virtual 6.25 kHz communication paths. This equates to an *efficiency* of one voice channel per 6.25 kHz of bandwidth even though it operates in channels of 12.5 kHz. Moreover to do this requires only one repeater per virtual channel pair and no additional combining equipment.

Another way of stating this is that when the FCC refers to 6.25 kHz systems it does not only mean Frequency Division Multiple Access (FDMA) technology that only operates in discrete 6.25 kHz licensed channels. It includes systems that offer 6.25 kHz efficiency regardless of the bandwidth of the licensed channel.

Other key technology standards in the United States, such as P25 phase 2 which will be used nationwide in future for public safety systems, also use the same TDMA approach as DMR to meet the FCC narrowbanding mandates and recommendations. So DMR is in the best possible company in its approach to meeting the requirements today and into the future.

Narrowbanding Deadlines for Radio Users

There are three key FCC deadlines which will directly affect license holders:

1. All licensees must migrate to 12.5 kHz technology, or technology that achieves the narrowband equivalent efficiency of one voice channel per 12.5 kHz of channel bandwidth, or 4800 bps per 6.25 kHz of channel bandwidth on or before January 1, 2013³.
2. Beginning January 1, 2011, the FCC will not accept any applications for new systems operating at greater than 12.5 kHz bandwidth, unless that technology meets the spectrum equivalency of one voice channel per 12.5 kHz of channel bandwidth or 4800 bps per 6.25 kHz of channel bandwidth⁴.
3. Beginning January 1, 2011, the FCC will not accept any applications for license modifications that would expand the geographic coverage of existing systems operating at greater than 12.5 kHz channels, unless that technology meets the spectrum equivalency of one voice channel per 12.5 kHz of channel bandwidth or 4800 bps per 6.25 kHz of channel bandwidth⁵.

The main effect of these rulings is that it means that all users currently using 25 kHz based equipment must migrate to a new system at 12.5 kHz efficiency by January 1, 2013, and that they will not be able to get new licenses or modify licenses for 25 kHz systems beyond January 1, 2011.

Equipment built to the DMR standard more than complies with all of these requirements and, as covered above, also meets the FCC recommendation that users consider directly migrating to 6.25 kHz efficient technology.

³ [See Code of Federal Regulations 90.209(b)(5)]

⁴ [See Code of Federal Regulations 90.209(b)(6)(i)]

⁵ [See Code of Federal Regulations 90.209(b)(6)(ii)]

Narrowbanding Deadlines for Equipment Providers

In addition to the FCC rules for users there are also separate rules for manufacturers which users might want to be aware of for background. There are three key requirements in place:

1. After January 1, 2011, equipment operating at a channel bandwidth greater than 12.5 kHz can no longer be manufactured or imported into the US, unless it meets a spectrum efficiency of one voice channel per 12.5 kHz channel bandwidth or 4800 bps per 6.25 kHz of channel bandwidth⁶.
2. Applications for certification received from February 14, 1997, have had to include a spectrum efficiency of one voice channel per 12.5 kHz of channel bandwidth, or 4800 bps per 6.25 kHz of channel bandwidth⁷.
3. Applications for equipment certification received on or after January 1, 2011, must be capable of operating in 6.25 kHz channels or include a spectrum efficiency of one voice channel per 6.25 kHz of channel bandwidth, or 4800 bps per 6.25 kHz of channel bandwidth⁸.

What is the effect of these rules on users? Well, the short answer is none directly today but, as of 2011, new equipment that requires 25 kHz efficiency will no longer be manufactured or imported. This might impact the ability to buy replacement radios for older systems. These rules have, however, driven manufacturers who wish to sell equipment in the United States to bring to market products which offer 12.5 kHz and, more significantly, 6.25 kHz efficiency.

Equipment compliant to the DMR standard meets with all of these requirements. All DMR products available in the US market today have received certification by the FCC that they operate with a spectrum efficiency of one voice channel per 6.25 kHz of channel bandwidth in 12.5 kHz of spectrum bandwidth (utilizing a Time Division Multiple Access (TDMA) protocol). In other words DMR equipment already meets the most far reaching FCC deadline set on manufacturers to produce spectrum efficient equipment. It is also as spectrally efficient, in the terms of the FCC (or from any other viewpoint), as all other available technologies.

⁶ [See CFR 90.203(j)(10)]

⁷ [See CFR 90.203(j)(10)]

⁸ [See CFR 90.203(j)(4) and 90.203(j)(5)]

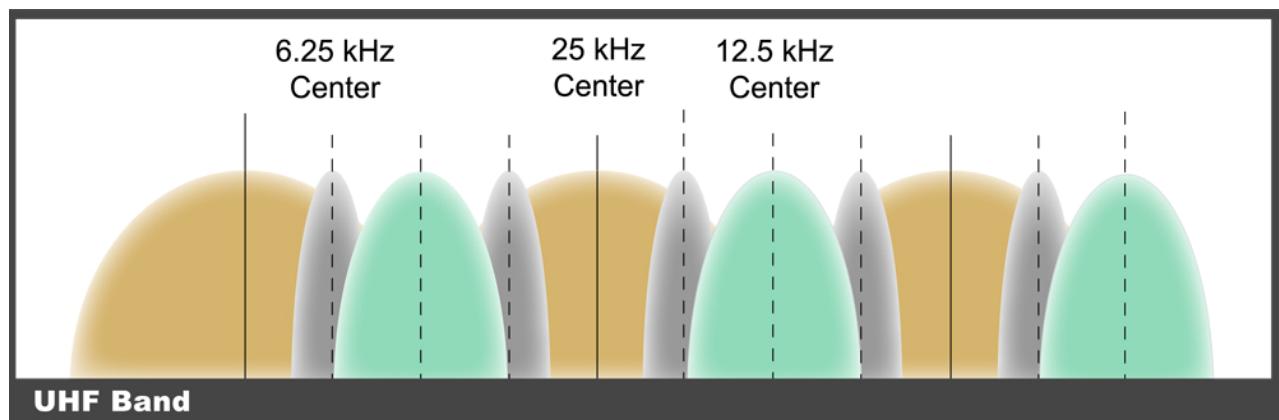
Three Narrowbanding Considerations for License Holders

1. FCC Channel Band Plan & Availability of “Off Center” Channels

In addition to the rules on equipment for users and manufacturers, there are some important practical considerations related to the bandwidth licensing regime that users of LMR in the United States should consider if thinking of migrating to a system with 12.5 kHz or 6.25 kHz efficiency.

The FCC 6.25 kHz LMR narrowbanding channel structure, which encompasses the long term vision for migration to a narrowband future, has a well defined architecture for channel frequency spacing. Under this the center of the channel should remain on the same repeat pattern or “on center” in the spectrum whether a licensee holds licenses with 25 kHz, 12.5 kHz, or 6.25 kHz channel bandwidths. Diagram 1 below shows how 25 kHz licenses, 12.5 kHz licenses and 6.25 kHz licenses fit into this general channel structure⁹.

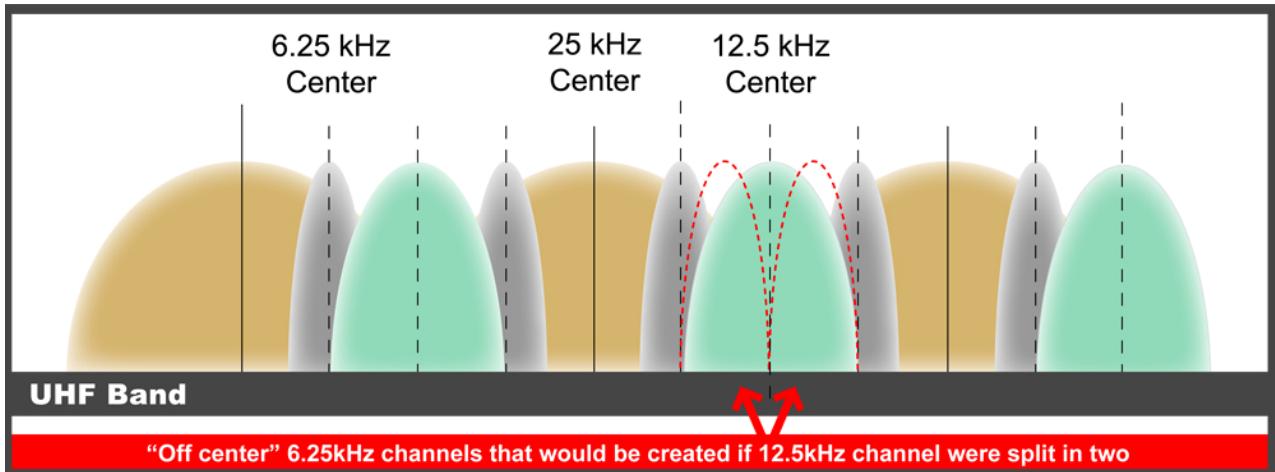
Diagram 1: Outline of FCC channel structure for LMR bands showing unified channel center spacing



Any attempt to split a 25 kHz channel into two 12.5 kHz channels; or a 25 kHz channel into four 6.25 kHz channels; or a 12.5 kHz channel into two 6.25 kHz channels, will result in channel center frequencies that are “off center” and do not fit with the long term planned structure. The “off center” channels that would be created by splitting a 12.5 kHz channel into two 6.25 kHz channels are illustrated in Diagram 2 on the next page.

⁹ This channel structure is defined in the Frequency Tables listed in CFR 90.20 and CFR 90.35

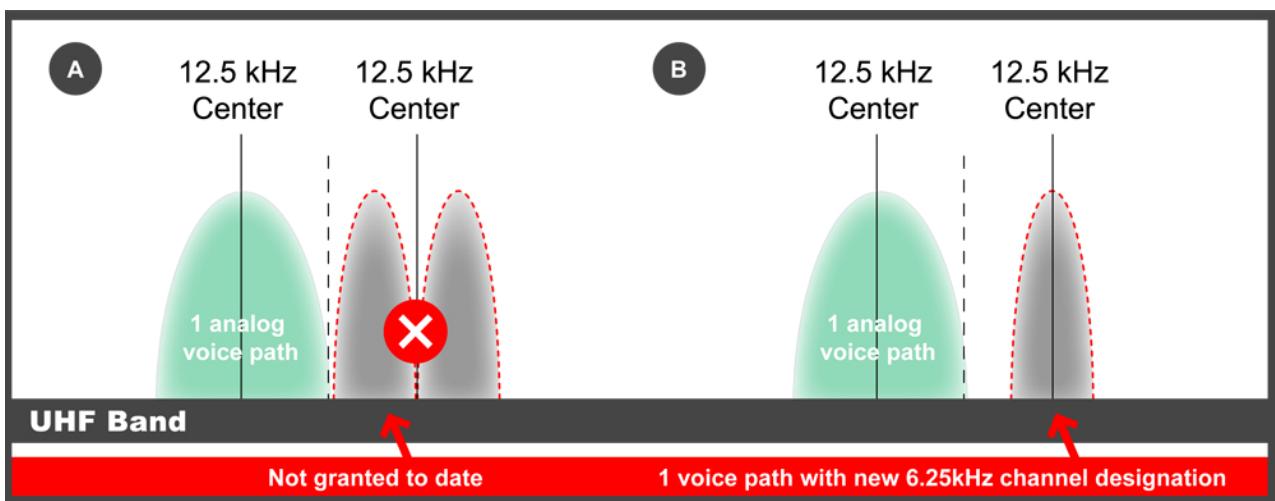
Diagram 2: Effect of request to split an existing 12.5 kHz license.



An entity that wishes to operate using off-center channels can theoretically do so by filing a Request for Waiver with the FCC. While several licensees have requested such a Waiver of the rules to permit a "split" of their existing 12.5 kHz channels into two distinct 6.25 kHz off-center channels, to date, the FCC has not granted any such waivers¹⁰. This is illustrated in Diagram 3a.

A purchaser of equipment should not therefore plan on being able to split a 12.5 kHz license. It is possible, however, to license one new 6.25 kHz channel at the center of an old 12.5 kHz channel and receive a new 6.25 kHz channel designation from an appropriate frequency coordinator, but on its own this does not give any extra capacity to the license holder. This is illustrated in diagram 3b.

Diagram 3: Achieved result of implementation of 6.25 kHz channels in 12.5 kHz licenses



Licensees that select 6.25 kHz technology may achieve increased spectrum capacity by requesting an additional 6.25 kHz channel pair to their license(s) in a separate part of the spectrum, but this requires evidence of frequency coordination to identify new 6.25 kHz channels and license modification to add the new frequency designations.

¹⁰ Communication from FCC frequency coordinator Enterprise Wireless Alliance (EWA) to members of the DMR Association

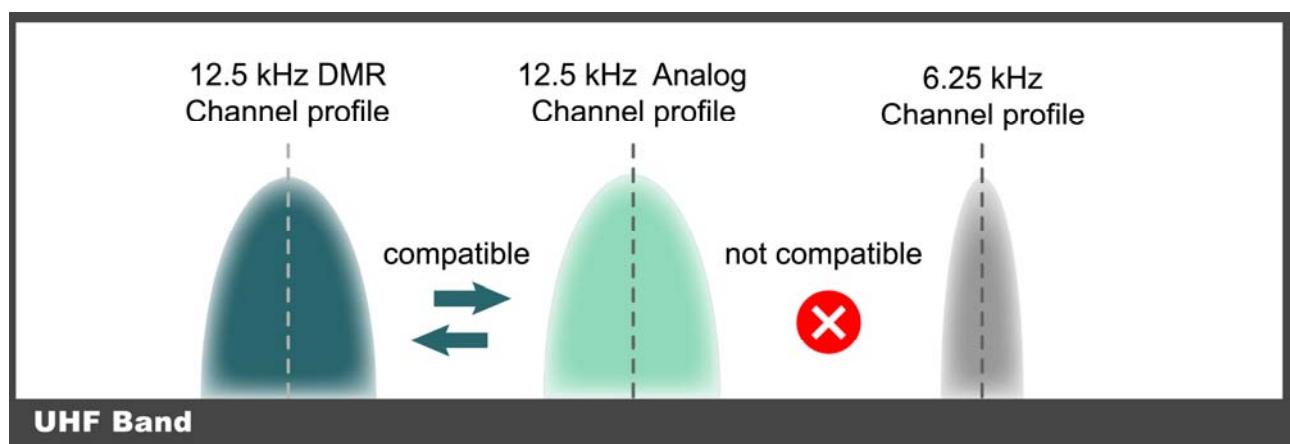
2. Migrating to 6.25 kHz Channels from 25 kHz Channels

Owners of 25 kHz licenses that wish to migrate to 6.25 channels are potentially in a better position than owners of 12.5 channels in that it is possible to squeeze three 6.25 kHz channels in the spectrum previously occupied by a 25 kHz channel while still respecting the FCC's overall desired 6.25 kHz channel structure. For the user of the channels, however, there is the issue that the three "new" channels, if splitting is allowed, are adjacent to each other in the spectrum. This has many potential issues for co-channel interference and service degradation if these frequencies are for use at the same site¹¹. Normal frequency coordination practices by FCC frequency coordinators would not, unless specifically requested by an applicant, recommend contiguous channels in order to maximize system performance¹².

3. Legacy compatibility

Legacy compatibility is one further issue with the 6.25 kHz channel approach to spectrum efficiency that may affect some user purchasing decisions. For new 6.25 kHz designated channels there is no backwards compatibility in spectrum terms with radios which operate on 12.5 kHz channels – which amounts to a very significant proportion of the installed base of LMR radios in the United States. So the owner of new 6.25 kHz channels is not able to use those channels to talk to legacy radios which require 12.5 kHz channels if this is ever required. For example, if contractors with older radios come on to a license holder's site and wish to use the site owner's frequencies. DMR radios, because they operate in 12.5 kHz channels, are in contrast able to talk in analog mode with legacy analog radios that require 12.5 kHz. This is illustrated in Diagram 4 below.

Diagram 4: Compatibility with legacy analog radios operating in 12.5 kHz channels for DMR systems and 6.25 kHz channel based system



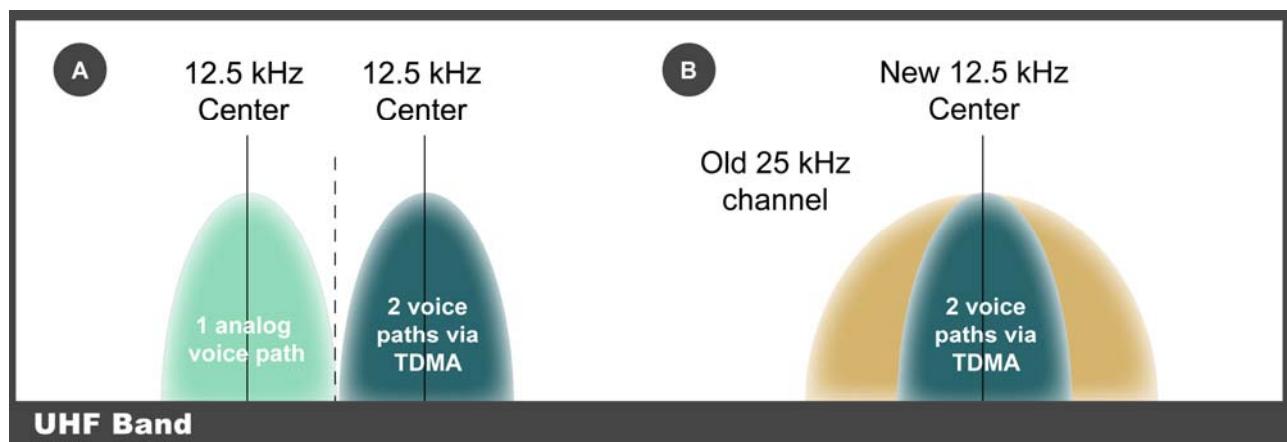
¹¹ ITU-R Report 319 (Characteristics of equipment and principles governing the assignment of frequency channels between 25 and 100 MHz for land mobile services)

¹² Communication from FCC frequency coordinator EWA to members of the DMR Association

License Requirements for Migrating to DMR

Under FCC rules and procedures DMR-compliant radios do not require licensees to apply for a new license or to channel split in order to achieve 6.25 kHz efficiency or a doubling of capacity. This is true whether the licensee converts a current 25 kHz channel to a 12.5 kHz channel, or uses an existing 12.5 kHz channel. This is because DMR works within the existing 12.5 kHz channel mask and achieves doubling of channel capacity by the use of TDMA with only one repeater required per two virtual channels. Current licenses, however, do need to be modified to reflect the new emission designator(s) and evidence of frequency coordination is required. This is illustrated in Diagram 5a below.

Diagram 5: Effect of using DMR equipment in an existing 12.5 kHz and 25 kHz channel



For holders of 25 kHz licenses that wish to migrate to DMR it is possible through a frequency coordinator, to designate a new 12.5 kHz channel on the center frequency of the old higher bandwidth channel. (This is illustrated in Diagram 5b above). The license modification issued will then reflect the new 12.5 kHz emission designator. For the licensee, a two for one channel capacity increase is gained, and possible interference issues are reduced (in contrast to the increased potential for interference resulting from splitting a 25 kHz license into three adjacent 6.25 kHz channels). However, because of the FCC's reluctance to have "off center" frequencies, it will not be possible to split a 25 kHz channel into two adjacent 12.5 kHz channels and then to achieve 2 times slots in each of these adjacent channels.

Conclusion

It is important for LMR users in the United States to be aware of the regulatory framework and FCC future plans for spectrum use. The next few years will be a period of evolution and purchasers of radio communications equipment should be mindful of the outline of compliance requirements today and for the future. There will be a significant period when many different systems co-exist: buyers need to carefully consider how their communication system will fit in the wider environment.

DMR radios are designed to meet all the FCC requirements in that they offer:

- Full compliance with all current and proposed regulations
- Highest level of spectral efficiency referred to by the FCC
- Smooth migration to digital under current and mandated future FCC licensing requirements which will cleanly double capacity in existing channel licenses

DMR radios also offer:

- Backwards compatibility with legacy systems where required

Buyers of DMR equipment can, in addition, be confident in that the standard is fully open and backed by many major LMR manufacturers. Users can therefore purchase DMR radios and infrastructure with certainty that their investment will give the longest term use as well as all the beneficial features of an industry leading digital LMR technology.

FCC Reference Documentation

There are a number of different FCC documents that have relevant material for the PMR regulatory landscape used as the basis of this paper. There are three key reference sources:

- Code of Federal Regulations (CFR)¹³. The FCC's "Narrowbanding Rules" for the 150–174 and 421–512 MHz bands used for PLMR in the United States are found in this document. It was last revised on October 1, 2008.
- Third Memorandum Opinion and Order¹⁴. The rules in the CFR are based on the decisions adopted by the FCC outlined in this document.
- The Fifth Report and Order¹⁵. There are important relevant definitional terms given in this publication.

¹³ Code of Federal Regulations (CFR) October 1, 2008 Sections 90.209 and 90.203

¹⁴ Third Memorandum Opinion and Order released on December 23, 2004

¹⁵ Fifth Report and Order released August 2, 2002

About the DMR Association

The DMR Association is focused on making DMR the most widely supported 21st Century digital radio standard for the business world. Through a combination of interoperability testing, certification, education, and awareness, the Association seeks to ensure that business buyers of today's digital radio technology gain ongoing value through the competition and choice derived from an open, multi-vendor value chain.



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