Shure Incorporated
5800 West Touhy Ave
Niles, IL 60714-4608

T 847 600 2000
F 847 600 1212
shure.com

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An Overview of Wireless Multichannel Audio System (WMAS)

Wireless Multichannel Audio System (WMAS) introduces innovative solutions for Programme Making and Special Events (PMSE) applications, specifically targeting wireless microphones and in-ear monitors (IEMs). These systems prove particularly advantageous when a significant number of audio channels are required but the available radio spectrum is limited. Importantly, it should be noted that WMAS serves as an additional option for optimizing spectrum utilization more efficiently, rather than replacing traditional narrowband systems. Like narrowband systems, WMAS also rely on unoccupied spectrum for uninterrupted operation, ensuring interference-free performance.

Moreover, the WMAS concept enables the transmission of higher data rates compared to existing narrowband systems. This enhanced capability opens up new possibilities and applications within the realm of wireless audio technology.

Shure, as a global leader in the PMSE sector, will bring the latest technologies in the market such as WMAS and to ensure global harmonization, Shure kindly urges regulators worldwide to allow WMAS technology.

I. Background

WMAS serves as a versatile audio platform that facilitates diverse audio applications, including wireless microphones, in-ear monitors (IEMs), and talkback systems. These applications collectively fall under the umbrella of audio PMSE. By employing a radio channel with a wider RF bandwidth, WMAS enables the realization of various audio PMSE devices and their corresponding applications. Figure 1, from ETSI TR 103 450[1], illustrates a representative topology showcasing typical audio PMSE devices that can be implemented utilizing WMAS.

[1] ETSI TR 103 450: "System Reference document (SRdoc); Technical characteristics and parameters for Wireless Multichannel Audio Systems (WMAS)"

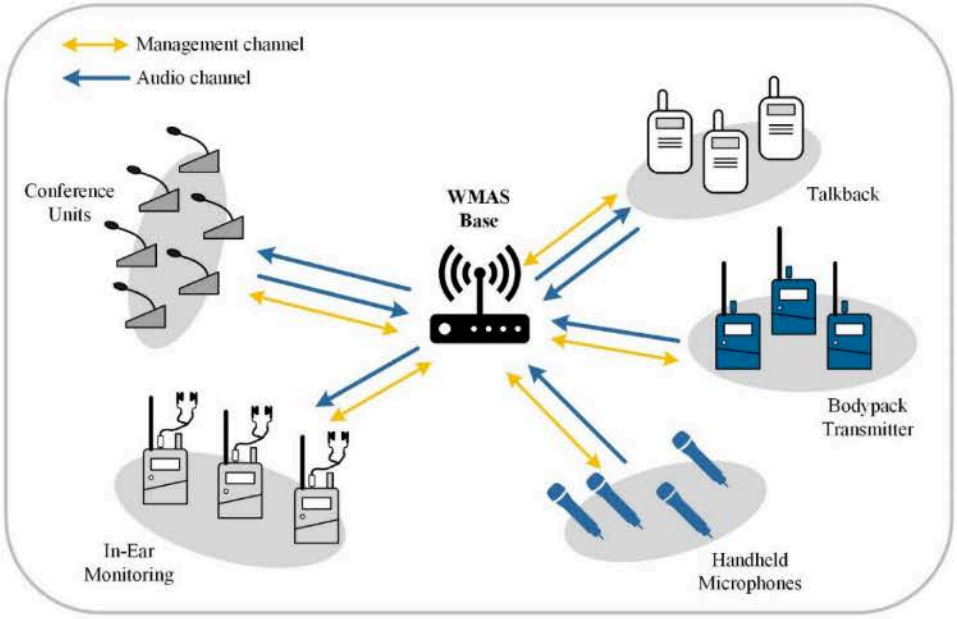

Figure 1: WMAS - a universal audio platform.[1]

Introducing WMAS presents a new opportunity for efficient spectrum utilization. WMAS achieves this by minimizing the minimum channel spacing between adjacent audio channels and strategically locating the resulting intermodulation products (IMDs) within their own radio channel, situated on the left and right edges (as shown in Figure 2). This achievement is made possible by employing a broadband multi-carrier transmission method that combines several audio channels into a broader radio channel. The RF bandwidth of this broadband channel can vary but is limited to a maximum of 20MHz to align with ETSI standardization. The broadband channel should have a capacity of at least three audio channels per 1MHz bandwidth.

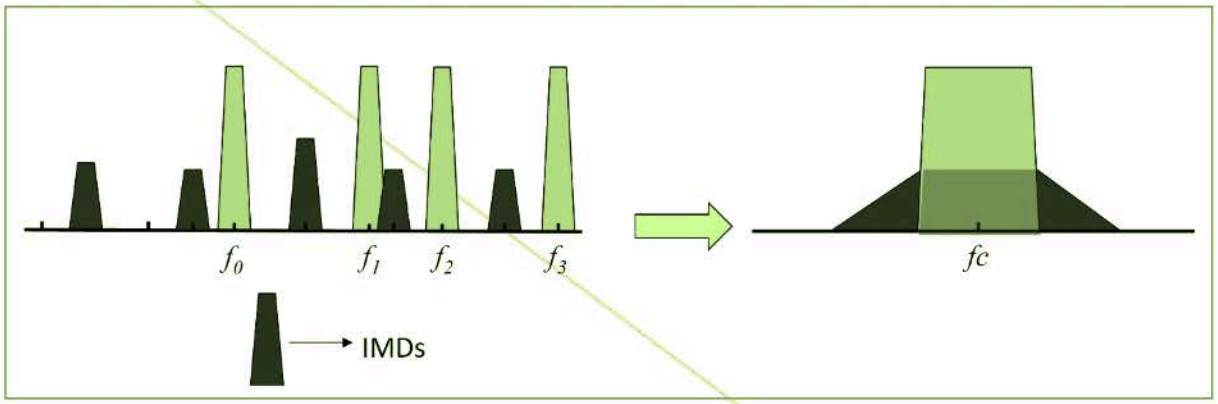

Figure 2: From narrowband channel to broadband channel.

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II.WMAS Technology

WMAS signifies a technological evolution in digital wireless microphones (see Figure 3). In contrast to existing narrowband systems that depend on a single-carrier method featuring a fixed RF bandwidth of 200kHz, WMAS harnesses a multi-carrier approach for wireless transmission. This pioneering methodology empowers the utilization of a diverse spectrum of RF bandwidths, with the ability to accommodate any bandwidth up to 20MHz.

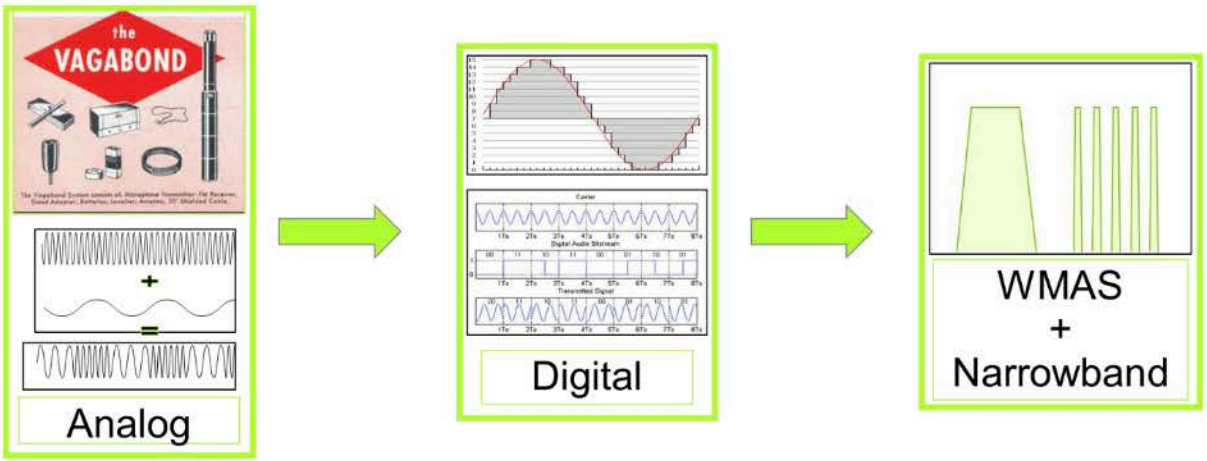

Figure 3: Development of wireless microphones.

The standardized definition of WMAS, as provided in ETSI EN 300 422-1[2] "Wireless Microphones; Audio PMSE up to 3 GHz; Part 1", is as follows:

"Wireless Multichannel Audio System (WMAS): wireless audio transmission system using digital wideband transmission techniques for microphone and in-ear monitor system applications, and other multichannel audio PMSE use, e.g., with the ability to support three or more audio channels per MHz"

Additionally, ETSI EN300 422-1 specifies the standardized transmission mask and sets forth the minimum requirements for both transmitter and receiver parameters. Manufacturers retain the flexibility to determine the remaining aspects of the system beyond these defined specifications.

[2] ETSI EN 300 422-1: "Wireless Microphones; Audio PMSE up to 3 GHz; Part 1: Audio PMSE Equipment up to 3 GHz; Harmonised Standard for access to radio spectrum"

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Advancing Audio Transmission

As WMAS allows for the utilization of a wider RF bandwidth, enabling the implementation of more complex multi-carrier transmission methods based on Orthogonal Frequency Division Multiplexing (OFDM). OFDM is a widely adopted and highly flexible technique used in both wired and wireless communications, including Wi-Fi, 4G, 5G, DVB-T, and DAB+, among others.

With OFDM, various channel access methods can be combined to accommodate different users or, in the case of WMAS, individual audio channels (refer to Figure 4). This includes time-based separation (OFDM/TDMA - Time Division Multiple Access), where audio channels are allocated distinct time slots; frequency-based separation (OFDM/FDMA - Frequency Division Multiple Access), where fixed frequencies are assigned to different audio channels; or a combination of time and frequency allocation (OFDM/OFDMA - Orthogonal Frequency Division Multiple Access).

By leveraging the capabilities of OFDM, WMAS can effectively optimize the utilization of available resources and enhance the efficiency of audio channel management.

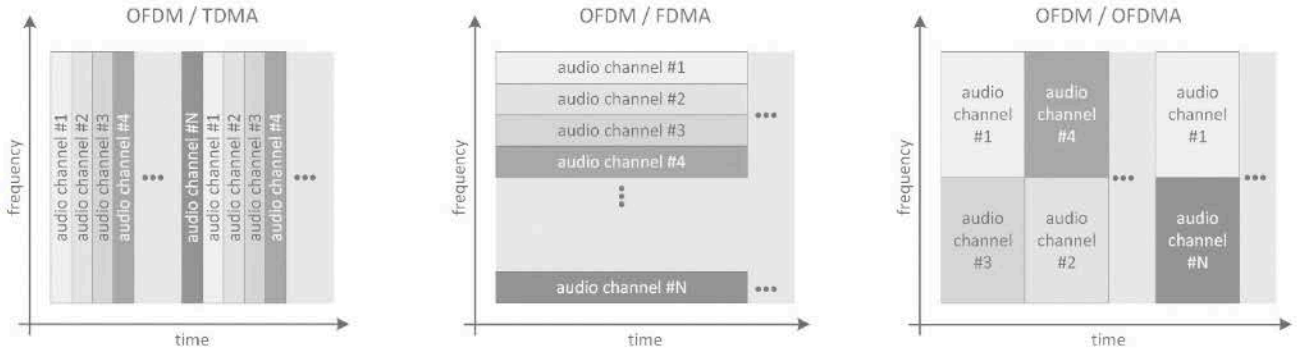

Figure 4: User and audio channel separation for transmission based on OFDM.

This type of data transmission enables, among other things:

- more efficient use of the radio spectrum,
- higher data rates for new audio applications, and
- a scalable architecture.

Bandwidth Scalability

The availability of a scalable RF bandwidth, adjusted according to the number of required audio channels, enables efficient support for various application scenarios. For instance,

this flexibility allows for the effective combination of WMAS with traditional narrowband systems or the adaptation of the WMAS bandwidth to the current availability of free spectrum. Three corresponding examples illustrating this concept are depicted in Figure 5.

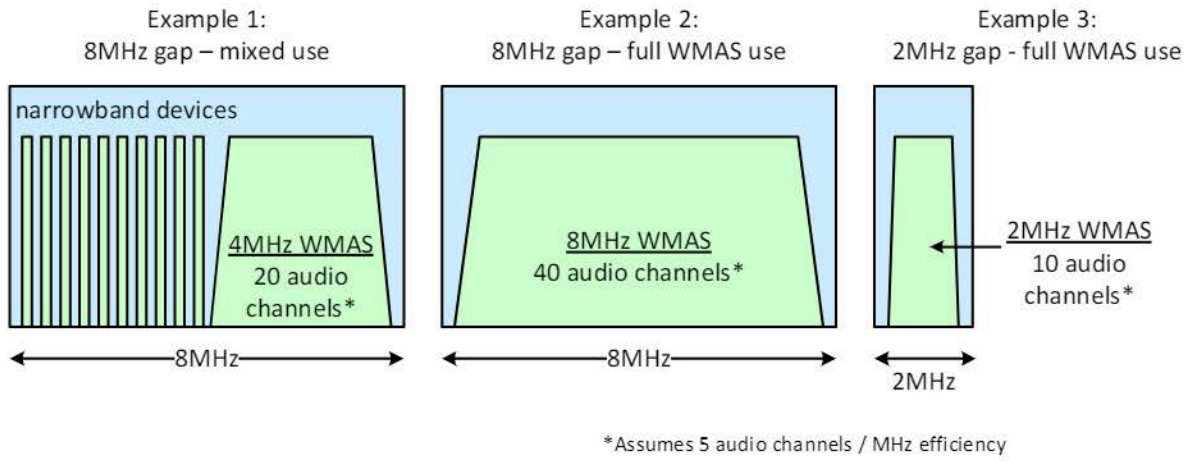

Figure 5: Possible scalability of WMAS.

The efficient operation of WMAS relies on appropriate scaling of various parameters based on the chosen transmission or channel access method. In Figure 5, the showcased examples utilize OFDMA as the channel access method. However, alternative methods involve maintaining a consistent RF bandwidth while adapting other parameters, such as transmission quality and audio latency.

Operational Factors to Consider for WMAS Implementation

When determining the practical application of WMAS, the number of required audio channels relative to the available free spectrum becomes crucial. If only narrow gaps in the spectrum are accessible, narrowband systems typically prove more suitable, especially when a limited number of audio channels is needed. Generally, WMAS finds optimal use in installations that demand a high number of wireless microphones and/or IEMs.
Similar to conventional narrowband systems, successful operation of WMAS necessitates thorough frequency planning. This includes:

- identifying sizable gaps in the frequency spectrum,
- scaling the WMAS RF bandwidth accordingly,
- and ensuring smooth coexistence with narrowband systems.

It is important to note that WMAS does not replace traditional narrowband systems but

rather serves as an additional option for professional applications that require multiple audio channels.
Joint on-site operation of narrowband systems and WMAS within the same channel is not envisioned, as it would entail significant compromises in system properties. A minimum channel spacing between narrowband and wideband systems is imperative to maintain reliable performance.

III. WMAS Regulations in United States and European Union

Recent regulatory developments by the Federal Communications Commission (FCC) in the United States and existing regulations and standardization efforts led by ETSI and CEPT in Europe have paved the way for the integration of this innovative approach for professional audio products.

United States: FCC regulation update (adopted on Feb 15th, 2024) [3]

The U.S. Federal Communications Commission in the United States has just amended Parts 15 and 74 of its Rules for Wireless Microphones in the TV Bands and other bands and frequencies where they are authorized to operate in order to permit the use of newly developed WMAS technology. This technology will enable further improvements in spectral efficiency beyond what has been achieved with narrowband digital systems, and it is well-suited for operation in the TV-UHF band.

Highlights from FCC's WMAS regulations:

- Permit licensed wireless microphone users to operate WMAS on frequencies already available for Part 74 licensed wireless microphones in the VHF-TV bands (54-72 MHz, 76-88 MHz, and 174-216 MHz), the UHF-TV band (470-608 MHz), the 653-657 MHz segment of the 600 MHz duplex gap, and in the 941.5-944 MHz, 944-952 MHz, 952.850-956.250 MHz, 956.45-959.85 MHz, 1435-1525 MHz, 6875-6900 MHz and 7100-7125 MHz bands.
- Permit WMAS operating under Part 74 to use up to 6 MHz channels in the TV bands, up to a 4 MHz channel in the 600 MHz duplex gap (653-657 MHz), and up

[3] https://docs.fcc.gov/public/attachments/FCC-24-22A1.pdf

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to 20 MHz channels in other bands, but allow smaller channels when less spectrum is available in a band or is sufficient for an application.

- Permit unlicensed wireless microphone users to operate WMAS on frequencies already available for Part 15 unlicensed wireless microphones in the UHF and VHF TV bands and in the 657-663 MHz segment of the 600 MHz duplex gap with up to 6 MHz channels but allow smaller channels.

- Require WMAS to be capable of operating with at least three audio channels per MHz of spectrum to ensure that spectrum is used efficiently. This is aligned with ETSI's suggestion and FCC's rules for WMAS to be capable of operating with three audio channels per MHz. Simply stated, it is a capability requirement, not an operational requirement.

Output power:

- Permit WMAS to operate on a licensed basis under the Part 74 rules at the same power levels currently permitted under these rules, i.e., 50 milliwatts EIRP in the VHF-TV bands, 250 milliwatts conducted power in the UHF band, 20 milliwatts EIRP in the 600 MHz duplex gap (653-657 MHz), 250 milliwatts conducted power in the 1435-1525 MHz band, and 1 watt conducted power in all other bands.

- Permit WMAS to operate on an unlicensed basis under Part 15 rules in the bands allocated and assigned for broadcast television:

- TV-VHF & TV-UHF

    - WMAS with a bandwidth up to 1 MHz: 50 mW EIRP.

    - WMAS with a bandwidth greater than 1 MHz: 100 mW EIRP.

- In the upper 6 MHz segment of the duplex gap (657-663 MHz): 20 mW EIRP limit consistent with the power level currently permitted for narrowband wireless microphones in this frequency band

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- Unlicensed WMAS is not allowed to operate in the 600 MHz guard band (614-616 MHz) that is allowed for narrowband unlicensed microphones since no party indicated that there is a need to do so.
- Require Part 15 and Part 74 WMAS to comply with the emission mask and spurious emission limits for WMAS specified in the 2021 ETSI wireless microphones standard.
- Update the existing Part 74 and Part 15 wireless microphone technical rules to reference relevant portions of the 2021 ETSI wireless microphone standard (current rules reference the 2011 version)

Table 1 below summarizes the licensing types with the respective allowed output powers in different bans for WMAS.

Table 1: Licensing types for WMAS and output power in allowed spectrum bands.

Licensing Type	Maximum Output Power
Unlicensed operation: in VHF and UHF TV bands	▪ 50 mW up to 1 MHz bandwidth, ▪ 100 mW for bandwidths greater than1 MHz up to 6 MHz
Unlicensed operation: 657 – 663 MHz segment of the 600 MHz duplex gap	▪ 20 mW EIRP
Licensed operation: in most current wireless microphone bands	▪ 250 mW conducted in UHF TV band band (470-608 MHz), ▪ 50 mW EIRP in VHF TV band (54-72 MHz, 76-88 MHz, and 174-216 MHz), ▪ 20 mW EIRP in the 653-657 MHz segment of the 600 MHz duplex gap, ▪ 250 mW conducted in 1435-1525 MHz, ▪ 1W conducted in all other bands (941.5-944 MHz, 944-952 MHz, 952.850-956.250 MHz, 956.45-959.85 MHz, 6875-6900 MHz and 7100-7125 MHz bands)

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The bandwidth limit for WMAS is summarized in Table 2 below:

Table 2: Bandwidth limits for WMAS

BW Limit	WMAS Systems and available BW	Notes
Bandwidth up to 6 MHz permitted within a single TV channel and up to 20 MHz in other bands, or the available bandwidth if less.	If more than 20 MHz bandwidth is available, users may operate multiple WMAS systems. For example, in 1435-1525 MHz where up to 30 MHz is permitted, users could operate one 20 MHz WMAS system and one 10 MHz WMAS system, or two 15 MHz WMAS systems, etc.	▪ Equipment must be capable of 3 channels/MHz, but this is not an operating requirement. ▪ FCC adopts references to 2021 ETSI EN 300 422-1 standard replacing 2017 version for both WMAS and narrowband analog and digital wireless microphones. ▪ If ETSI revises the EN 300 422-1 standard in the future to allow more than 20 MHz, FCC would consider expanding the bandwidth limit.

The European Union

In Europe WMAS is standardized by ETSI and already specified in EN 300 422-1[4] "Wireless Microphones; Audio PMSE up to 3 GHz; Part 1", in which the WMAS transmit mask and its measurement routines are described. The EN limits the bandwidth of WMAS to 20 MHz without listing a minimum bandwidth.

WMAS is, in general, frequency neutral and designed to operate in all frequency ranges currently allowed by regulations for audio PMSE. The harmonised standard ETSI EN 300 422-1 already includes requirements for WMAS audio PMSE equipment.

[4] https://www.etsi.org/deliver/etsi_en/300400_300499/30042201/02.01.02_60/en_30042201v020102p.pdf

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ERC Recommendation 70-03, Annex 10[5], and ERC Recommendation 25-10[6] are the applicable recommendations in nearly all European countries. Both have already deleted the 200kHz bandwidth limitation for all relevant frequency bands and enable the operation of WMAS under the same output power restriction as for traditional audio PMSE devices.

In addition, a System Reference Document (SRDoc) ETSI TR 103 450 [7] has been approved and sent for discussion to CEPT ECC proposing the following changes:

- increasing the maximum radiated transmit power limit by 3 dB for WMAS Base Class 1 devices by conducting studies as appropriate, and
- harmonization of national implementations and radio interface descriptions in the CEPT member states concerning WMAS operation.

The additional transmit power for WMAS Base class 1 is proposed to balance the needs of the various multiple access schemes and use cases. Exploiting the wideband property of the wireless radio channel might not always be possible.
Increasing the WMAS maximum transmit output power by 3 dB compared to the maximum output power of narrowband devices will reduce the likelihood of reduced WMAS coverage relative to narrowband systems operating at maximum permissible power.
Depending on the implementation, WMAS can benefit from additional power, as operation over wider bandwidths may involve more susceptibility to environmental noise due to having less frequency agility to avoid it.

During CEPT's ECC Working Group Frequency Management (WG FM) meeting on June 7, 2024, it was approved to increase the power limit in 174-216 MHz, 470-694 MHz, and 694-703 MHz to 100 mW EIRP in ERC/REC 70-03 Annex 10, without necessitating additional studies. CEPT will consider more bands beyond VHF/UHF later.

[5] https://docdb.cept.org/download/2464
[6] https://docdb.cept.org/download/2431
[7] https://www.etsi.org/deliver/etsi_tr/103400_103499/103450/01.02.01_60/tr_103450v010201p.pdf

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This adjustment will allow audio PMSE devices (including WMAS) using the core audio bands of 174-216 MHz, 470-694 MHz, and 694-703 MHz to operate with an increased power limit of 100 mW EIRP. This change also aligns with the FCC Part 15 rules for WMAS.

Shure is actively working towards harmonizing WMAS technology regulations worldwide, with the aim of establishing streamlined guidelines that will benefit all stakeholders involved. This starts with removing any bandwidth restriction that may exists for wireless microphones.

As a next step, Shure also recommends that countries allow WMAS technology with at least 100 mW EIRP in 470-698MHz and other bands.