ETSI TR 103 450 V1.2.1 (2023-11)

TECHNICAL REPORT

System Reference document (SRdoc);
Technical characteristics and parameters for
Wireless Multichannel Audio Systems (WMAS)

Reference

RTR/ERM-559r1

Keywords

audio, audio-PMSE, IEM, PMSE, SRDOC, wireless microphone, wireless microphone system, WMAS

ETSI

650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00   Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - APE 7112B
Association à but non lucratif enregistrée à la
Sous-Préfecture de Grasse (06) N° w061004871

Contents

Intellectual Property Rights

Essential patents

IPRs essential or potentially essential to normative deliverables may have been declared to ETSI. The declarations pertaining to these essential IPRs, if any, are publicly available for **ETSI members and non-members**, and can be found in ETSI SR 000 314: *"Intellectual Property Rights (IPRs); Essential, or potentially Essential, IPRs notified to ETSI in respect of ETSI standards"*, which is available from the ETSI Secretariat. Latest updates are available on the ETSI Web server (https://ipr.etsi.org/).

Pursuant to the ETSI Directives including the ETSI IPR Policy, no investigation regarding the essentiality of IPRs, including IPR searches, has been carried out by ETSI. No guarantee can be given as to the existence of other IPRs not referenced in ETSI SR 000 314 (or the updates on the ETSI Web server) which are, or may be, or may become, essential to the present document.

Trademarks

The present document may include trademarks and/or tradenames which are asserted and/or registered by their owners. ETSI claims no ownership of these except for any which are indicated as being the property of ETSI, and conveys no right to use or reproduce any trademark and/or tradename. Mention of those trademarks in the present document does not constitute an endorsement by ETSI of products, services or organizations associated with those trademarks.

DECT™, **PLUGTESTS™**, **UMTS™** and the ETSI logo are trademarks of ETSI registered for the benefit of its Members. **3GPP™** and **LTE™** are trademarks of ETSI registered for the benefit of its Members and of the 3GPP Organizational Partners. **oneM2M™** logo is a trademark of ETSI registered for the benefit of its Members and of the oneM2M Partners. **GSM**® and the GSM logo are trademarks registered and owned by the GSM Association.

Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Electromagnetic compatibility and Radio spectrum Matters (ERM).

Modal verbs terminology

In the present document "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

"**must**" and "**must not**" are **NOT** allowed in ETSI deliverables except when used in direct citation.

Executive summary

The present document provides information on Wireless Multichannel Audio System (WMAS), which is one possible new technology for the next generation of audio Programme Making and Special Events (PMSE) equipment employing new wideband modulation techniques to support the transmission of multiple audio channels in one single wideband RF channel.

WMAS:

- implements digital technology for audio PMSE applications and provides one transmission platform required for enabling cognitive sharing operation in future;
- is, in general, frequency neutral and designed to operate in all frequency ranges currently identified for audio PMSE. The harmonised standard ETSI EN 300 422-1 [i.1] already includes requirements for WMAS-based audio PMSE equipment;

- use has not been considered in previous CEPT studies/reports; e.g. ECC Report 191 [i.6], ECC Report 204 [i.7], ECC Report 221 [i.11] and ECC Report 245 [i.12];
- can be considered to have comparable or better compatibility to other systems/services previously studied by the ECC than narrowband PMSE equipment (see clause 7.2.2.1);
- offers a standard mode for higher spectral efficiency (e.g. 3 audio channels per MHz);
- has out-of-band and spurious emissions which are expected to be the same or better than narrowband PMSE systems (see clause 7.2.2.2).

WMAS shares the market with narrowband PMSE systems and operates primarily in multi-channel PMSE deployments, enabling flexible use and assignment of multiple audio channels.

Furthermore, WMAS employs a future-oriented wireless technology, which provides the technical foundation for supporting uncompressed audio transmission for high quality sound productions and for operation in possible new frequency bands and spectrum access mechanisms, e.g. database-driven sharing solutions including Licensed Shared Access (LSA) [i.8]. Hence, a single WMAS-based audio PMSE system is likely to replace several narrowband PMSE systems, but will also enable new applications and markets.

The present document kindly requests CEPT ECC (WGFM) to consider:

- increasing the maximum radiated transmit power limit by 3 dB for WMAS Base Class 1 devices (see Table 2) 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.

Introduction

The present document includes necessary information to support the co-operation under the MoU between ETSI and the Electronic Communications Committee (ECC) of the European Conference of Post and Telecommunications Administrations (CEPT).

Wireless Multichannel Audio System (WMAS) is one possible new technology for the next generation of audio Programme Making and Special Events (PMSE) equipment employing wideband modulation techniques to support the transmission of multiple audio channels in one single wideband radio channel. WMAS will provide a more efficient use of radio spectrum by supporting a higher number of audio channels being transmitted per MHz when compared with current narrowband PMSE systems. In addition, WMAS supports a more flexible approach to audio channel and RF channel parameters to meet requirements defined either by application or RF environment.

Upcoming challenges which will be fulfilled with WMAS based equipment are the following:

- support of uncompressed audio transmission for high quality sound productions,
- support of more efficient use of scarce RF spectrum, and
- support of fast and flexible system setups.

WMAS and current narrowband PMSE systems can operate in the same frequency ranges. The current narrowband PMSE systems are able to use small portions of free gaps in the radio spectrum, whereas WMAS will require a wider free range of contiguous radio spectrum. The RF bandwidth of WMAS can be scaled, depending on the used frequency bands or on the region of operation, for example 8 MHz in EU or 6 MHz in the US. Currently, the maximum bandwidth is limited to 20 MHz.

ETSI EN 300 422-1 [i.1] includes specific requirements for WMAS. The out-of-band and spurious emissions of WMAS are expected to be the same or better than narrowband PMSE systems (see clause 7.2.2.2).

WMAS is a new kind of audio PMSE platform, which has been considered in newer CEPT reports, e.g. ECC Report 323 [i.2]. In the following current CEPT studies/reports WMAS has not been considered: ECC Report 191 [i.6], ECC Report 204 [i.7], ECC Report 221 [i.11] and ECC Report 245 [i.12]. Nevertheless, due to its technical properties, WMAS can be considered to have comparable or better compatibility to other systems/services than narrowband PMSE equipment (see clause 7.2.2.1).

1 Scope

The present document describes the necessary technical background information on Wireless Multichannel Audio System (WMAS).

It includes in particular:

- Market information.
- Technical information including expected sharing and compatibility issues.
- Regulatory issues.

2 References

2.1 Normative references

Normative references are not applicable in the present document.

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

NOTE: While any hyperlinks included in this clause were valid at the time of publication ETSI cannot guarantee their long term validity.

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] ETSI EN 300 422-1 (V2.2.1): "Wireless Microphones; Audio PMSE up to 3 GHz; Part 1: Audio PMSE Equipment up to 3 GHz; Harmonised Standard for access to radio spectrum ".

[i.2] ECC Report 323: "Spectrum use and future spectrum requirements for PMSE".

[i.3] Void.

[i.4] ERC Recommendation 70-03: "Relating to the use of Short Range Devices (SRD)".

[i.5] ECC Report 185: "Complementary Report to ECC Report 159, Further definition of technical and operational requirements for the operation of white space devices in the band 470-790 MHz".

[i.6] ECC Report 191: "Adjacent band compatibility between MFCN and PMSE audio applications in the 1785-1805 MHz frequency range".

[i.7] ECC Report 204: "Spectrum use and future requirements for PMSE".

[i.8] ECC Report 205: "Licensed Shared Access (LSA)".

[i.9] ECC Report 207: "Adjacent band co-existence of SRDs in the band 863-870 MHz in light of the LTE usage below 862 MHz".

[i.10] ECC Report 220: "Compatibility/sharing studies related to PMSE, DECT and SRD with DA2GC in the 2 GHz unpaired bands and MFCN in the adjacent 2 GHz paired band".

[i.11] ECC Report 221: "Adjacent band compatibility between MFCN and PMSE audio applications in the 700 MHz frequency band".

[i.12] ECC Report 245: "Compatibility studies between PMSE and other systems/services in the band 1350-1400 MHz".

[i.13] ECC Report 253: "Compatibility studies on audio PMSE at 1492-1518 MHz and 1518-1525 MHz".

[i.14] CEPT Report 32: "Recommendation on the best approach to ensure the continuation of existing Program Making and Special Events (PMSE) services operating in the UHF (470-862 MHz), including the assessment of the advantage of an EU-level approach".

[i.15] CEPT Report 50: "Technical conditions for the use of the bands 821-832 MHz and 1785-1805 MHz for wireless radio microphones in the EU".

[i.16] ERC Report 42: "Handbook on Radio Equipment and Systems Radio Microphones and Simple Wide Band Audio Links".

[i.17] ERC Report 62: "Compatibility analysis regarding possible sharing between the UIC system and radio microphones in the frequency ranges 876 - 880 MHz and 921 - 925 MHz".

[i.18] ERC Report 63: "Introduction of radio microphone applications in the frequency range 1785-1800 MHz".

[i.19] ERC Report 88: "Compatibility and sharing analysis between DVB-T and radio microphones in bands IV and V".

[i.20] Recommendation ITU-R BT.1871-1: "User requirements for wireless microphones".

[i.21] ERC Recommendation 25-10 (2016): "Frequency ranges for the use of terrestrial audio and video Programme Making and Special Events (PMSE) applications".

3 Definitions of terms, symbols and abbreviations

3.1 Terms

For the purposes of the present document, the terms given in ETSI EN 300 422-1 [i.1] and the following apply:

audio channel: representing a monaural audio signal

audio link: point-to-point or point-to-multipoint connection, which can carry one dedicated audio channel or multiple audio channels (e.g. left and right channel of stereo or multiple channels of microphone array)

narrowband channel: RF channel where the bandwidth is significantly smaller than the coherence bandwidth

wideband channel: RF channel where the bandwidth is significantly larger than the coherence bandwidth

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

WMAS Base: unit of a WMAS capable of serving multiple devices for the purpose of audio transmission/reception and device management and control

WMAS Portable: movable device served by a WMAS Base

3.2 Symbols

For the purposes of the present document, the following symbols apply:

dB	decibel

NOTE: Logarithmic unit to express ratio between two quantities.

dBc	power quantity relative to carrier power level
dBm	power quantity relative to 1 mW
f_c	centre frequency
GHz	gigahertz
kHz	kilohertz
MHz	megahertz
mW	milliwatt
$N_{min\ audio\ channels}$	minimum number of audio channels
nW	nanowatt

3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

B	declared channel Bandwidth
BER	Bit Error Rate
CEPT	Commission of European Post and Telecommunications
EIRP	Effective Isotropic Radiated Power
ERP	Effective Radiated Power
EU	Europe
FDD	Frequency Division Duplexing
FDMA	Frequency Division Multiple Access
HD	High Definition
IEM	In Ear Monitor
ISI	Inter-Symbol Interference
LSA	Licensed Shared Access
MoU	Memorandum of Understanding
NB	NarrowBand
OFDM	Orthogonal Frequency Division Multiplexing
OFDMA	Orthogonal Frequency Division Multiple Access
PMSE	Programme Making and Special Events
PSD	Power Spectral Density
RBW	Resolution BandWidth
RE-D	Radio Equipment Directive
RF	Radio Frequency
RMS	Root Mean Square
RX	Radio Receiver
SNR	Signal to Noise Ratio
SSP	Spectrum Scanning Procedure
TDD	Time Division Duplexing
TDMA	Time Division Multiple Access
TV	TeleVision
TX	Transmitter
US	United States
WGFM	Working Group Frequency Management
WMAS	Wireless Multichannel Audio System

4 Comments on the System Reference Document

None.

5 Wireless Multichannel Audio System

A Wireless Multichannel Audio System (WMAS) is a wideband system (modulated bandwidth is significantly larger than the wireless channel's coherence bandwidth) that provides multi-channel audio transmission capabilities. As a wideband system, it is designed for scenarios where an area of contiguous spectrum is available and multiple wireless audio channels are necessary. A single WMAS Base manages all WMAS Portables, such as handheld microphones, body worn microphones, in-ear monitors, or conference units, and provides all audio inputs and outputs for the supported wireless audio channels. All audio mixing and processing may be done by a computer device attached to the WMAS Base, by the WMAS Base itself, by a mixing console or by any equivalent device with audio mixing capability.

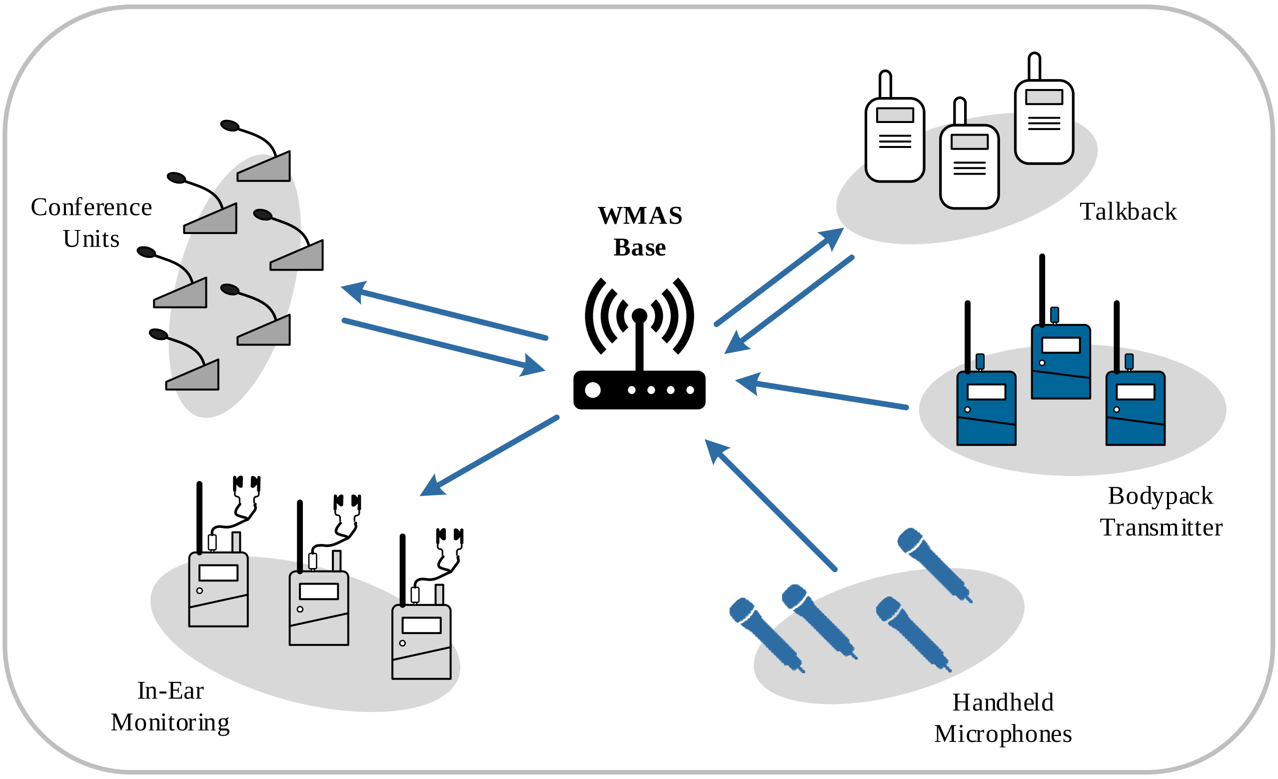

Figure 1: Example of WMAS topology

Figure 1 shows an example of the topology of different WMAS applications:

- handheld microphones and bodypack transmitters, each representing one audio link, which transmits audio data to the WMAS Base;
- In-Ear Monitors (IEM) receiving different audio channels from the WMAS Base station;
- conference units transmitting single audio channels to the WMAS Base and receiving one or more audio channels;
- walkie talkies of a talkback system transmitting and receiving audio channels to and from the WMAS base station.

All audio links of one application share the same physical wideband RF channel. The wideband system may separate the audio channels by time (TDMA) or by frequency (FDMA) and make use of Time-Division Duplexing (TDD) as the multiplexing mechanism. Other channel access methods or duplex systems can be implemented in WMAS as well.

Wireless Multichannel Audio System (WMAS) is a wideband system that provides multi-channel audio transmission capabilities by allocating one shared wideband RF channel for all audio channels. The wideband approach offers the following advantages over narrowband systems:

- wideband transmission is more robust against frequency selective fading;
- due to the architecture, more flexibility and scalability are given;
- the efficiency of spectrum use is higher.

In the future, support of HD sound productions will be necessary. Therefore, WMAS may offer different audio quality modes depending on the wireless application and the user's needs. Due to its digital nature and the centralized approach, WMAS provides the technical platform to achieve this required flexibility and scalability, which will always be a trade-off between:

- audio quality;
- robustness;
- working range; and
- number of simultaneously operated audio channels.

6 Market information

PMSE equipment serves the market for the broadcast, creative and culture industries, and the online use of influencers and instructional videos. It is also used in religious institutions who may have requirements similar to a medium to large sized theatre and, as such, shows a significant socio-economic impact within the European market and markets world-wide.

ECC Report 323 [i.2] highlights many applications and deployments of PMSE equipment. WMAS, as a new technology for audio PMSE, fulfils new customer demands towards variable audio quality, transmission quality, reliability, flexibility, scalability, and ease of use.

WMAS shares the market with NarrowBand (NB) PMSE systems and operates mainly in multi-channel PMSE deployments, enabling flexible use and assignment of multiple audio channels. Furthermore, WMAS employs a future-oriented wireless technology, which provides the technical foundation for supporting uncompressed audio transmission for high quality sound productions and for operation in possible new frequency bands, e.g. under database-driven sharing solutions including LSA [i.8].

Hence, a single WMAS-based audio PMSE system could replace multiple narrowband PMSE systems in use at a given location, and will also enable new applications and markets.

An audio PMSE system based on WMAS comprises, for example, a fixed/nomadic base unit and several portable devices, operating as in-ear monitors and/or wireless microphones. In general, the form factors, especially of the portable devices, are assumed to be similar to current audio PMSE equipment on the market. The base unit is likely to have a more compact form factor than multiple rack-mounted narrowband audio PMSE receivers or transmitters, which are currently deployed.

7 Technical information

7.1 Detailed technical description

7.1.1 Radio Interface

WMAS is designed for multi-channel audio applications integrating wireless microphones, IEMs, and other audio applications into one radio interface.

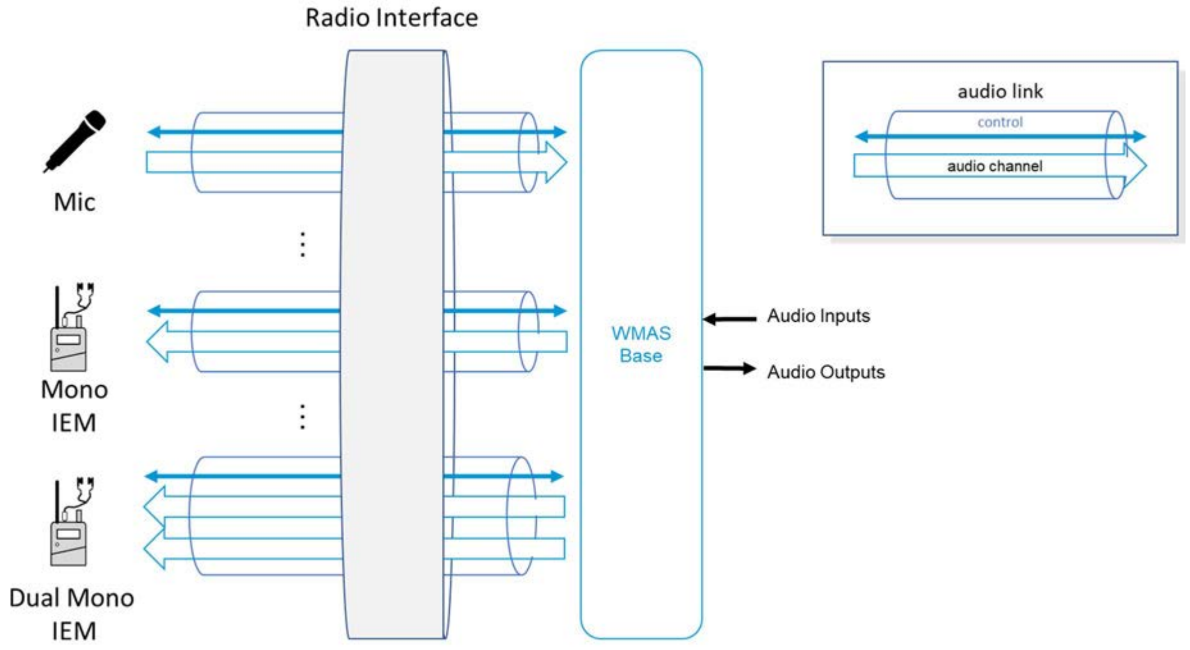

Figure 2: Radio Interface of WMAS

Figure 2 outlines the radio interface of a WMAS that offers multiple audio and control channels integrated in a single wideband radio interface. The direction of each dedicated audio channels is defined by the portable device connected. WMAS can support up to *N* devices. The number of devices depends on the overall capacity of the system governed by the RF bandwidth employed, and the data-rate and latency configuration set for each device.

WMAS make use of a single wideband RF channel, which is shared among the portable devices based on a duplexing scheme and a multiple access scheme.

7.2 Technical parameters and implications on spectrum

7.2.1 Status of technical parameters

7.2.1.1 Current ITU and European Common Allocations

Refer to:

- Annex 10 of ERC Recommendation 70-03 [i.4].
- Recommendation ITU-R BT.1871-1 [i.20].
- ERC Recommendation 25-10 [i.21].

7.2.1.2 Sharing and compatibility studies for Audio PMSE

Refer to:

- ECC Report 185 [i.5].
- ECC Report 191 [i.6].
- ECC Report 204 [i.7].
- ECC Report 205 [i.8].
- ECC Report 207 [i.9].
- ECC Report 220 [i.10].
- ECC Report 221 [i.11].
- ECC Report 245 [i.12].
- ECC Report 253 [i.13].
- ECC Report 323 [i.2].
- CEPT Report 32 [i.14].
- CEPT Report 50 [i.15].
- ERC Report 42 [i.16].
- ERC Report 62 [i.17].
- ERC Report 63 [i.18].
- ERC Report 88 [i.19].

7.2.1.3 Sharing and compatibility issues still to be considered

WMAS is a development of audio PMSE equipment, which has been considered in CEPT ECC Report 323 [i.2] but not in current CEPT ECC studies/reports; e.g. ECC Report 191 [i.6], ECC Report 204 [i.7], ECC Report 221 [i.11] and ECC Report 245 [i.12]. Nevertheless, due to its technical properties, WMAS can be considered to have comparable or better compatibility to other systems/services than current narrowband PMSE equipment (see clause 7.2.2.1).

ETSI EN 300 422-1 [i.1] already includes specific requirements for WMAS. The out-of-band and spurious emissions of WMAS are the same or better compared to narrowband PMSE systems (see clause 7.2.2.2).

To balance the needs of the various multiple access schemes and use cases, the present document proposes to introduce specific power limits for two different WMAS Base power classes. See clauses 7.2.7 and 9.2.

7.2.2 Transmitter parameters

7.2.2.1 Transmitter Output Power/Radiated Power

For WMAS transmission, the total output power is spread over the wideband RF channel resulting in a lower power spectral density in comparison to narrowband systems. For example, WMAS operating in an 8 MHz wideband channel will have a power spectral density of -2 dBm/100 kHz = -22 dBm/1 kHz, narrowband systems have a power spectral density of 14 dBm/100 kHz = -6 dBm/1 kHz, assuming that both systems have a maximum output power of 50 mW. Therefore, WMAS can be considered to have comparable or better compatibility to other systems/services than current narrowband PMSE equipment if operated with the same transmit power.

For certain use cases, applications, or situations in frequency bands, e.g. IEMs or RF channels with higher noise floors, WMAS Base might require additional transmit output power. This is elaborated further in clause 7.2.7.

7.2.2.2 Transmitter unwanted emissions in the out of band domain

A detailed description of transmitter unwanted emissions in the out of band domain can be found in ETSI EN 300 422-1, clause 4.2.4.2 [i.1].

The WMAS transmission mask, according to ETSI EN 300 422-1 [i.1], is shown in Figure 3. The related methods of measurement are described in ETSI EN 300 422-1 [i.1], clause 5.4.3.

Figure 3: Transmit spectral power mask for WMAS, RBW = 100 kHz

To allow a comparison with the long-time established narrowband transmission masks in ETSI EN 300 422-1 [i.1] for digital systems (shown in Figure 4), the following measuring conditions have to be taken into account:

- RBW = 100 kHz for WMAS vs. RBW = 1 kHz for narrowband systems;
- Detector = Max peak for WMAS vs. Detector = RMS for narrowband systems.

In the following paragraphs, legacy narrowband systems (limited to 600 kHz RF channel bandwidth [i.1]) will be compared to new systems operating in the WMAS regime. These two positions in frequency are considered:

1) wideband noise emitted inside tuning range at $f_c \pm B$;
2) adjacent channel interference at $f_c \pm B/2$.

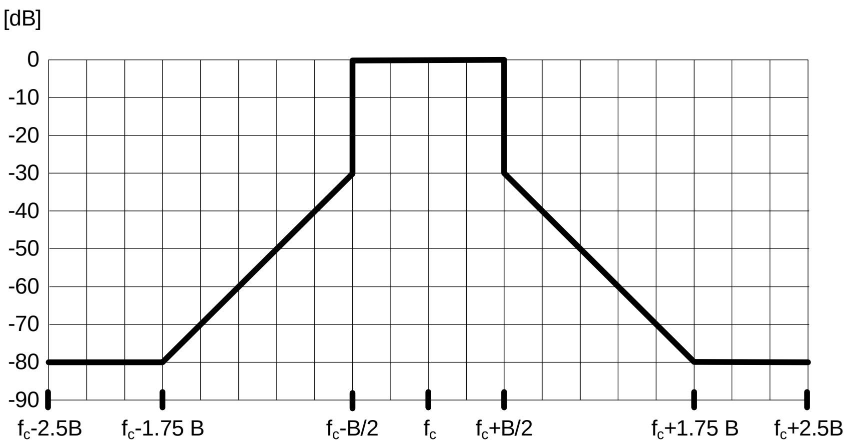

Figure 4: Transmit spectral power mask for equipment employing digital modulation, except WMAS, RBW = 1 kHz

Legacy Systems:

ETSI EN 300 422-1 [i.1] specifies a transmit spectrum mask for digital wireless systems (see Figure 4). This spectrum mask uses an RMS detector. This detector averages receive signals during spectrum sweep.

The spectrum mask allows a maximum in-band wideband noise spectral density of -90 dBc/1 kHz.

Digital narrowband systems are allowed to emit -30 dBc/1 kHz of adjacent channel interference.

WMAS:

In addition, ETSI EN 300 422-1 [i.1] proposes a new WMAS spectrum mask (see Figure 3). The maximum of the mask is normalized to the average power (RMS) of a continuous transmission, which is a special test mode of WMAS. The change from RMS detector to peak detector adds the crest factor of the transmit signal at the corresponding frequency to the spectrum trace.

WMAS spectrum mask allows a maximum in-band wideband noise spectral density of:

- -60 dBc/100 kHz = -80 dBm/1 kHz.

Assuming a typical noise crest factor of 10 dB, the in-band wideband noise using RMS detector will reach the same level as in the spectrum masks of legacy narrowband systems:

- -80 dBc/1 kHz - 10 dB = -90 dBc/1 kHz.

WMAS spectrum mask allows an adjacent channel interference of:

- -40 dBc/100 kHz = -60 dBm/1 kHz.

With a typical signal crest factor of 10 dB, the adjacent channel interference with RMS detector is expected to be:

- -60 dBc/1 kHz - 10 dB = -70 dBc/1 kHz.

This is 10 dB better than legacy analogue systems and 40 dB better than narrowband digital systems.

To make all three transmit masks (Figure 3 to Figure 4) comparable, Figure 5 summarizes the necessary translations of the WMAS transmit mask: conversion from 100 kHz towards 1 kHz resolution bandwidth and peak detector towards RMS detector.

NOTE: The upper limit of the WMAS transmission mask is 0 dBc, measured with peak detector and RMS = 100 kHz. Therefore, it scales down with the change of the detector and the decrease of RBW.

Figure 5: Conversion of WMAS transmit mask towards RMS detector and RBW = 1 kHz

Furthermore, fast transient wideband emissions, which can occur during ramping times, may interrupt coexisting services for short periods of time. These transients are detected significantly more reliably due to the usage of a peak detector during mask measurement.

7.2.2.3 Operating Frequency

It is proposed that WMAS will operate in the same frequency ranges as narrowband PMSE systems.

Frequency accuracy and stability of WMAS are specified in ETSI EN 300 422-1 [i.1] and are identical to legacy narrowband systems.

7.2.2.4 Bandwidth

According to ETSI EN 300 422-1 [i.1], WMAS may use a bandwidth (B) of up to 20 MHz. The relevant spectrum mask is shown in Figure 3 and the correspondent methods of measurement can be found in ETSI EN 300 422-1 [i.1].

7.2.2.5 Transmitter unwanted emissions in the spurious domain

Transmitter unwanted emissions in the spurious domain are emissions on a frequency or frequencies immediately outside the limit of 250 % of the declared channel bandwidth above and below the centre frequency of the emission.

Unwanted emissions in the spurious domain are identical for WMAS and narrowband systems and are specified in ETSI EN 300 422-1 [i.1].

7.2.3 Receiver parameters

All relevant receiver parameters (receiver sensitivity, receiver adjacent channel selectivity, and receiver blocking) and a detailed description are listed in ETSI EN 300 422-1 [i.1].

7.2.4 Channel access parameters

ERC Recommendation 70-03 [i.4], Annex 10, and ERC Recommendation 25-10 [i.21] do not require any channel access parameters.

7.2.5 Duplexing

There are two fundamental duplexing schemes to handle the directions of transmissions from portable to base (uplink) and from base to portable (downlink): Frequency Division Duplexing (FDD) and Time Division Duplexing (TDD).

- FDD requires paired spectrum where one frequency band is used for uplink and the other for downlink. Paired spectrum is usually not available for PMSE applications.
- TDD operates on a single RF channel based on time slots allocated for uplink or downlink transmission. TDD systems benefit from channel reciprocity, so that channel equalizer algorithms are simplified. Nevertheless, TDD requires stringent phase/time synchronization to avoid interference between uplink and downlink transmissions.

7.2.6 Multiple Access Schemes

7.2.6.1 General

As ETSI EN 300 422-1 [i.1] only specifies a spectral transmit mask and some essential RX and TX parameters, but no standardized radio technology, there are a variety of ways to implement a WMAS, each with specific advantages and disadvantages.

Regardless of how the resource elements are allocated for audio channels in a particular system, the following general statements will apply:

- Frequency diversity increases with both the number and frequency separation of subcarriers.
- Output power required for constant SNR scales with the number of subcarriers, but for constant link performance (BER/PER), this increase in output power required is reduced by frequency diversity gain for fading channels.

The RF bandwidth for WMAS is also a key parameter that might impact the choice of how audio channels are allocated within the WMAS carrier. Having a system that is scalable in terms of RF bandwidth allows tradeoffs based on system requirements and spectrum availability. In general:

- Larger bandwidth allows greater frequency diversity.
- Larger bandwidth provides more capacity.
- Smaller bandwidth makes it easier to find sufficient clean spectrum.

7.2.6.2 Time Division Multiple Access (TDMA)

Time Division Multiple Access (TDMA) share an RF channel by dividing it into time slots. The combination with TDD is natural and allows dynamic scaling of resources available for uplink and downlink transmission as well as for each portable individually. TDMA systems are normally designed for operation with fixed RF bandwidth as resource sharing among users and uplink/downlink happens on the time axis.

Portables in a TDD TDMA system can benefit from the full frequency diversity offered by a wideband RF channel as each transmission employs the full RF bandwidth available.

Further, TDMA has the advantage that no portable is transmitting at the same time instance so that intermodulation among the portables of the system is avoided. If only one transmitter is emitting at a given time instance, there is no scaling of transmitter noise with the number of devices.

7.2.6.3 Frequency Division Multiple Access (FDMA)

Frequency Division Multiple Access (FDMA) shares an RF channel by dividing it into frequencies. This dividing can be performed as Localized FDMA (a contiguous block of frequencies is allocated to a portable; only a dedicated fraction of the RF channel is employed for a user) or Interleaved FDMA (every x frequency is allocated to a portable; the whole RF channel bandwidth is employed). Due to the smaller transmission bandwidth Localized FDMA cannot make full use of the frequency diversity offered by the RF channel bandwidth available to the system. FDMA systems can be designed to scale the transmission bandwidth with a number of users, but each transmitting device contributes to noise and transmitter intermodulation is to be considered carefully.

7.2.6.4 Orthogonal Frequency Division Multiple Access (OFDMA)

OFDMA is a multi-user version of the digital modulation scheme Orthogonal Frequency Division Multiplexing (OFDM), which can be used in TDMA and FDMA as well. Like in FDMA multiple access is achieved in OFDMA by assigning subsets of subcarriers to individual portables. The OFDM diversity gain and resistance to frequency-selective fading may be partially lost if very few subcarriers are assigned to each user and the same carrier is used in each OFDM symbol. Therefore, adaptive subcarrier assignment based on fast feedback information about the channel or subcarrier frequency hopping is desirable but contributes significantly to system complexity. Each transmitting device is contributing to the noise level.

7.2.7 Considerations on Transmit Power of the WMAS Base

Annex 10 of ERC Recommendation 70-03 [i.4] or national regulation currently limits the output power of audio PMSE equipment regardless of the type of equipment to a fixed value.

A WMAS Base is, in general, designed to serve multiple WMAS portables based on the duplexing and multiple access scheme. In case of simultaneous use of resources at a given time instance, the bandwidth and the power available in the relevant time instance needs to be shared between active devices.

Depending on the selection of multiple access scheme this can result in different link budgets for the communication links from the WMAS base to each WMAS portable compared to the opposite direction. Thus, potentially limiting especially the possible service area of a WMAS base.

Current transmit power regulations (e.g. as specified in ERC Recommendation 70-03 [i.4], Annex 10) did not envisage multiple access schemes in PMSE applications. TDMA-based implementations of WMAS can meet the current regulations, however, other implementations may be constrained by the existing limits.

A WMAS TDD TDMA occupies typically a higher bandwidth (e.g. more than 5 MHz) to exploit the frequency selectivity of the wireless channel and combat fading while delivering at least the same audio data-rate per audio channel and device. The lower fading margin compensates for the higher receiver noise due to the higher bandwidth operation and receiver noise figure.

In general, a higher transmit power could improve the link budget regardless of the multiple access scheme, so that higher modulation coding schemes can be used over the same or extended service areas. Nevertheless, an increased transmit power also increases the risk of interference and receiver blocking potential to other in-band uses and adjacent band services.

To balance the needs of various multiple access schemes it is considered necessary to introduce different power classes for WMAS Base equipment.

Table 2 provides a summary of the proposed power classes and associated radiated power levels for WMAS:

- WMAS Portables power limits are in line with current ERC Recommendation 70-03 [i.4], Annex 10.
- WMAS Base Class 0 power limits are in line with current ERC Recommendation 70-03 [i.4], Annex 10.
- WMAS Base Class 1 power levels represent a 3 dB increase in operating power and is limited to devices that will remain stationary during operation.

7.2.8 Delay Spread and Coherency Bandwidth

The design of WMAS considers the behaviour of the wideband wireless channel, especially the observed delay spread due to multi-path propagation. Multi-path propagation results in frequency selective fading and induces Inter-Symbol Interference (ISI) to the transmission.

Delay spread is a measure of the multi-path richness of the wireless channel, where the maximum delay is τ_{max}.

The coherency bandwidth B_c provides the maximum bandwidth where the channel can be assumed to be frequency flat. Coherency bandwidth is approximately $B_c = 1/\ \tau_{max}$.

A transmission bandwidth below B_c will observe frequency flat fading, while a transmission bandwidth significantly larger than B_c will observe frequency selective fading.

Table 1 provides an overview of typical values of τ_{max} and B_c.

Table 1: Typical values of τ_{max} and B_c

Scenario	τ_{max}	B_c
Indoor Studio	0,5 μs	2 MHz
Indoor Large Event Hall	4 μs	250 kHz
Outdoor Stage	0,5 μs to 1 μs	1 MHz to 2 MHz

7.2.9 Implications on Spectrum Use

7.2.9.1 Introduction

Depending on its implementation, a WMAS could offer several advantages to the user in the effective use of the spectrum by using modern transmission techniques and enabling improved workflows.

The efficiency of spectrum usage or spectral efficiency is defined as the number of audio channels transmitted per MHz of occupied spectrum. A WMAS will have at least one mode, defined as the Standard Mode, which supports a minimum of three audio channels per MHz, defined as:

$N_{\text{audio channels}} = B/1\text{ MHz} \times 3$, where $N_{\text{audio channels}}$ = number of audio channels and B = occupied bandwidth in MHz.

EXAMPLES: B = 6 MHz (TV channel in US) ➔ $N_{\text{audio channels}} = 18$
B = 8 MHz (TV channel in EU) ➔ $N_{\text{audio channels}} = 24$
B = 10 MHz ➔ $N_{\text{audio channels}} = 30$

In comparison to narrowband systems, the increase in efficiency is approximately 50 % assuming that 16 audio links, which make use of 200 kHz occupied bandwidth each, can be placed in one 8 MHz TV channel today. Currently, the number of 16 narrowband audio links placed in 8 MHz free spectrum is the maximum value, where operational robustness can be maintained in typical scenarios.

7.2.9.2 Flexible Configuration and Dynamic Resource Allocation

An audio channel is generally characterized by its transmission direction (Microphone or IEM) and audio performance (bit rate, latency, and reliability). While in traditional wireless microphone systems the audio performance is fixed or can be just adjusted by selecting one of two modes before an operation, a WMAS allows for flexibility including the individual configuration of each audio channel.

Through its infrastructure, WMAS is able to support new workflows. This allows the operator to assign resources in different qualities as they are needed and seamlessly switch applications as required during operation.

For example, using WMAS, an audio engineer switching between three different musical acts can have all three acts' microphones and IEMs operating, without interference, in one RF channel by allocating the resources appropriately. The act currently on stage would receive resources with the best quality; the act preparing to go on next could be allocated some resources for testing; meanwhile, the act that just finished its set and left the stage would have none of the resources, apart from some intercom quality audio guiding them on their IEMs. This provides a gain in spectral efficiency of 30 % to 40 % by workflow alone as compared to a conventional workflow, which requires active transmitting for all three sets of microphones at the same quality.

7.2.9.3 Integration of Wireless Microphones and IEM

WMAS could operate IEMs and wireless microphones in one RF channel. Conventional technology requires IEMs and wireless microphones to be operated in frequency ranges that are separated to avoid interference, typically using separate TV channels for the IEMs and wireless mics. By operating these two device types in the same TV channel, WMAS could improve spectral efficiency.

7.2.9.4 Remote Control capability

WMAS devices operate under control by the WMAS Base. WMAS devices only transmit if they have an established connection to a WMAS base and are activated by the WMAS base. WMAS devices can be activated and deactivated as required during operation.

Typically, narrowband wireless microphones transmit once switched on, regardless of whether there is a receiver or not. A WMAS system ensures that spectrum is only used when there is an established, active link between the Base and the Portable.

7.2.9.5 Wider Bandwidth Operation

WMAS is capable of operating with wider bandwidths at the same transmit power. This reduces the power spectral density so that earlier re-use of the RF channel over distance becomes possible. This is particularly relevant for areas where there is a high demand for wireless microphones, like on Broadway, because it allows denser WMAS deployments in neighbouring theatres or stages without risk of interference.

Similarly, WMAS operating with wider frequency bandwidth can exploit frequency selective fading offered by the wireless channel. This allows WMAS to be operated with much less fading margin compared to traditional narrowband wireless microphones.

7.3 Information on relevant standard(s)

ETSI EN 300 422-1 [i.1] is the relevant standard and has been updated to include requirements from the RE-D and already includes WMAS.

8 Radio spectrum request and justification

8.1 General

The present document does not include a radio spectrum request. WMAS will utilize the existing bands within ERC Recommendation 70-03 [i.4] and ERC Recommendation 25-10 [i.21].

9 Regulations

9.1 Current regulations

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 [i.1] already includes requirements for WMAS audio PMSE equipment.

ERC Recommendation 70-03 [i.4], Annex 10, and ERC Recommendation 25-10 [i.21] are the applicable recommendations.

9.2 Proposed regulation and justification

The present document kindly requests CEPT ECC (WGFM) to consider:

- increasing the maximum radiated transmit power limit by 3 dB for WMAS Base Class 1 devices (see Table 2) 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.

A wideband channel has a bandwidth which is significantly larger than the coherence bandwidth. For the narrowband channel it is the other way around; i.e. the bandwidth is significantly smaller than the coherence bandwidth. See clause 7.2.8, Table 1.

In case of a narrowband channel, additional power may be needed. 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.

Table 2 provides a summary of the proposed power levels for WMAS where the WMAS Portables and WMAS Base Class 0 are in line with current ERC Recommendation 70-03 [i.4], Annex 10. WMAS Base Class 1 power levels represent a 3 dB increase in operating power and are limited to devices that will remain stationary during operation and with a bandwidth (up to 20 MHz) that does not increase the PSD above that of legacy narrowband equipment.

Table 2: Proposed transmit power limits for WMAS Base and Portable equipment

	Band [MHz]	WMAS Portable Power	WMAS Base Class 0 Power	WMAS Base Class 1 Power (new proposed limit)
e	174 - 216	50 mW ERP	50 mW ERP	100 mW ERP
f1	470 - 694	50 mW ERP	50 mW ERP	100 mW ERP
f3	821,5 - 826	20 / 100* mW EIRP	20 / 100* mW EIRP	40 mW EIRP
f4	826 - 832	100 mW EIRP	100 mW EIRP	100 mW EIRP
f5	694 - 703	50 mW ERP	50 mW ERP	100 mW ERP
f6	733 - 757,5	20 / 100* mW EIRP	20 / 100* mW EIRP	40 mW EIRP
h1	1 350 - 1 400	20 / 50* mW EIRP	20 / 50* mW EIRP	40 mW EIRP
h2	1 492 - 1 518	50 mW EIRP	50 mW EIRP	100 mW EIRP
h3	1 518 - 1 525	50 mW EIRP	50 mW EIRP	100 mW EIRP
j	1 785 - 1 805	20 / 50* mW EIRP	20 / 50* mW EIRP	40 mW EIRP
NOTE: * Restricted to body worn equipment or equipment with Spectrum Scanning Procedure (SSP), except in f3 (body worn equipment only).				

History

Document history		
V1.1.1	July 2017	Publication
V1.2.1	November 2023	Publication